The Action Plan for South American River Dolphins

2010 - 2020

Fernando Trujillo, Enrique Crespo, Paul Van Damme & José Saulo Usma

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Foreword

This Action Plan represents a consensus of a river dolphin group of specialists all around South America. It concerns about the status of the currently recognized river dolphin species *(Inia geoffrensis, Inia boliviensis* and *Sotalia fluviatilis)*, threats to their survival, and measures needed to better understand and address those threats.

The main body of the Action Plan comes from the discussions carried out in a meeting carried out in Santa Cruz de la Sierra, Bolivia, in 2008 with the important objective of evaluating the status of the populations of the River Dolphins in their distribution countries and to build an Action Plan to guarantee their survival. It must be said that the objectives were achieved. More than 40 river dolphin biologists and government officers from Amazonian countries discussed and designed the Action Plan for river dolphins in the Amazon and Orinoco River Basins. This is probably one of the most important facts, that is was mainly carried out by South American cetologists and ecologists, with the support of local, national and international organizations.

Getting to this meeting in Bolivia took a long time and the effort of many people. The background for these objectives was set up a few decades ago when a River Dolphin Workshop was organized in the People's Republic of China in 1986. For the first time a general view of what was going on in Amazonia was given to the scientific community and the general public. This important workshop produced a very important report and associated publications. The set of priorities given there were incorporated two years later to the first version of the Action Plan for Cetacean Conservation compiled by William Perrin (Perrin, 1988). After that, many meetings were organized in different parts of the world in order to get a deep insight of the situation, the conservation of these particular species, which were believed to be the most impacted by human activities. The Action Plan was reviewed by IUCN in 1994 (Reeves & Leatherwood, 1994) and again in 2003 (Reeves *et al.* 2003) always putting emphasis in coastal small cetaceans and river dolphins.

The Action Plan for the Conservation of River Dolphins in South America is divided in several chapters containing the status of the species, with associated papers summarizing the information for each country, the summary and evaluation of threats, the role of protected areas for river dolphin conservation, a summary of the abundance estimations of river dolphin in South America between 2006 and 2009, and the Action plan itself with a special body of legislation and policy, communications, administration and institutional strengthen and education and community participation. Finally there are recommendations for research, education and conservation for these species.

All this means a very important effort of many people. I am proud that this was an initiative when Fernando Trujillo was President of SOLAMAC (2006-2008) and that together with him we could set a policy of medium term to the society. I hope that this is a very interesting and exiting example of long term policies to carry out in the future.

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President of SOLAMAC 2008-2010
IUCN/SSC Cetacean Specialist Group
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We are indebted to the World Wildlife Fund (WWF), Wildlife Conservation Society (WCS), Whale and Dolphin Conservation Society (WDCS) and the Whitley Fund for Nature, for their financial and technical support through the formulation of this Action Plan; to Fundacion La Salle de Ciencias Naturales (Venezuela), Asociación Faunagua (Bolivia), Instituto Nacional de Pesquisas da Amazônia (INPA), Fundación Omacha (Colombia) and the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt for their scientific and technical advise. We are additionally grateful to the Latinamerican Aquatic Mammal Society (SOLAMAC) for their regional support.

Moreover, we are indebted to all the contributions received from the participants to the Workshop for the formulation of this Action Plan, held in Santa Cruz de la Sierra, Bolivia in April 2008. Their participation, enthusiasm and willingness to devote time and thought to our requests for advice and assistance are testimony to their commitment to river dolphins' conservation.

We want to thank WWF through Mary Lou Higgins, Alyce Eymard and Marco Flores for encouraging and supporting a long term regional initiative for river dolphins in South America.

Finally, thanks to María Claudia Diazgranados, Marcela Portocarrero-Aya and Nicholas Panayiotou for their contribution in the editorial process of this document.

Resumen ejecutivo

Los delfines de río son unas de las especies más amenazadas en el mundo. Generalmente habitan en países en desarrollo en Asia y Suramérica, donde una gran diversidad de actividades humanas los pone en riesgo. En Asia por ejemplo, hace dos años la Unión Internacional para la Naturaleza (UICN) declaró al delfín del río Yangtze como Extinto Ecológicamente. La sobrepesca, la contaminación y la dramática transformación de este río por la construcción de la represa más grande del mundo precipitaron su extinción. La situación no es mucho mejor en Pakistán, la India o el río Mekong en Cambodia y Myanmar, donde sobreviven precariamente otras especies.

En Suramérica habitan tres especies de delfines de agua dulce: el bufeo rosado (*Inia geoffrensis*) y el delfín gris (*Sotalia fluviatilis*), ambos en las cuencas del los rios Amazonas y Orinoco, y el bufeo boliviano (*Inia boliviensis*), mayormente en Bolivia en los rios Mamoré, Itenez y Madeira. La situación de estas especies no es tan dramática como en Asia, pero ya se observan amenazas concretas que de no ser controladas pueden llevar a la extinción de nuestro patrimonio natural. Actualmente, los principales problemas para estos delfines están ocasionados por capturas dirigidas para ser usados como carnada, principalmente en Brasil, interacciones negativas con pesquerías y retaliaciones de pescadores que les disparan o los envenenan, contaminación de los ríos por mercurio e hidrocarburos, y fragmentación del hábitat por causa de la construcción de represas. Debido a todas estas amenazas, se hacía fundamental conocer el estado de conservación de estas especies, y por tal razón se creó un programa de estimación de abundancia de delfines de río en Suramérica liderado por WWF y la Fundación Omacha (Colombia) con el apoyo de WCS (Wildlife Conservation Society) y muchas más organizaciones en cada país. Este programa ha recorrido más de 7.000 km de ríos en las cuencas del Amazonas y el Orinoco y ha capacitado cerca de 80 investigadores de nueve países. A través de estos recorridos se identificaron las amenazas más relevantes para las especies en cada país, se generó una red de trabajo importante entre organizaciones e investigadores, y se implementó una estrategia de comunicación global capturando la atención de los gobiernos sobre estas especies. Esto creó el ambiente propicio para diseñar el **Action Plan for South American River Dolphins 2010 - 2020**, que se concretó en Abril del 2008 en la ciudad de Santa Cruz de la Sierra, Bolivia, donde confluyeron cerca de 50 participantes, de 11 países, con representantes de gobiernos, investigadores y la UICN. El Plan tomó dos años para que estar listo y refleja las situaciones y necesidades generales de todos los países. Se identifican las acciones más urgentes para garantizar la supervivencia de estas especies, al igual que sobresale, la necesidad de evaluar y mitigar los impactos de las pesquerías, detener la captura dirigida de estos cetáceos y evaluar las consecuencias de la construcción de represas e hidroeléctricas sobre los ecosistemas acuáticos.

El Plan igualmente resalta la necesidad de generar alternativas económicas para comunidades locales para poder implementar estrategias de conservación que sean efectivas y que motiven a los ribereños y gobiernos a consolidar esfuerzos de manejo en los grandes ecosistemas acuáticos de Suramérica.

En esta estrategia de conservación se hace explícita también la importancia de los delfines de río en el continente como especies bandera, sombrilla y carismáticas que representan la biodiversidad acuática de la región y se convierten en excelentes embajadores de los ecosistemas y de las especies acuáticas de las cuencas Amazónica y Orinocense. Estas particularidades sumadas a su carácter migratorio hacen que las especies adquieran una mayor importancia para la búsqueda e implementación de nuevas estrategias de conservación. Actualmente lo anterior permite que se desarrollen de manera conjunta planes e iniciativas de conservación en Áreas Protegidas (AP), y se deje a consideración la importancia de crear nuevas Áreas de conservación donde los delfines de río sean los protagonistas.

Finalmente, el Plan esboza las principales acciones para los próximos diez años, y se convierte en una iniciativa regional, que cuenta desde sus inicios con el apoyo y participación de los gobiernos, fuentes financiadoras, investigadores y comunidades locales.

Los lineamientos escogidos esperan poder involucrar a todos los actores que de manera directa o indirecta influyen en la conservación de las especies y sus ecosistemas, y con esto poder asegurar la efectiva implementación del Plan.

Resumo executivo

Os golfinhos de rio são umas das espécies mais ameaçadas do mundo. Habitam geralmente países em desenvolvimento da Ásia e América do Sul, onde uma grande diversidade de atividades humanas colocam-nos em risco. Na Ásia, por exemplo, a União Internacional para a Natureza (UICN) classificou o Golfinho do Rio Yangtze como extinto ecologicamente. A sobrepesca, a contaminação e a dramática transformação deste rio pela construção da maior represa do mundo levaram à extinção da espécie. A situação não é melhor no Paquistão, na Índia ou no Rio Mekong no Camboja e Mianmar, onde sobrevivem precariamente outras espécies.

Na América do Sul, habitam três espécies de golfinhos de água doce: o boto-rosa (*Inia geoffrensis*) e o boto-cinza ou tucuxi (*Sotalia fluviatilis*), ambos nas bacias dos rios Amazonas e Orinoco, e o boto-boliviano (*Inia boliviensis*), encontrado principalmente na Bolívia, nos rios Mamoré, Itenez e Madeira. A situação destas espécies não é tão dramática como na Ásia, mas já se observam ameaças concretas que, se não forem controladas, podem levar à extinção de nosso patrimônio natural. Atualmente, os principais problemas para estes golfinhos são ocasionados por capturas intencionais para serem usados como isca, principalmente no Brasil, por interações negativas com pescarias e retaliações por parte dos pescadores, que atiram com armas de fogo e envenenam os animais, pela contaminação dos rios por mercúrio e hidrocarbonetos, e pela fragmentação do habitat através da construção de represas. Com base nestas ameaças, era fundamental conhecer o estado de conservação destas espécies, e, por esta razão, foi criado um programa de estimação de abundância de golfinhos de rio na América do Sul liderado pela WWF (Fundo Mundial para a Natureza – World Wide Fund for Nature) e Fundação Omacha (Colômbia) com o apoio da WCS (Wildlife Conservation Society), e muitas outras organizações em cada país. Este programa percorreu mais de 7.000 km de rios nas bacias no Amazonas e Orinoco, e capacitou aproximadamente 80 pesquisadores de nove países. Através destas incursões pelos rios sul-americanos, as ameaças mais relevantes para as espécies foram identificadas, gerou-se uma rede de trabalho importante entre organizações e pesquisadores, e se implementou uma estratégia de comunicação global, chamando a atenção dos governos sobre estas espécies. Isto criou o ambiente propício para elaborar o **Action Plan for South American River Dolphins 2010 – 2020** (Plano de Ação para Golfinhos de Rio da América do Sul 2010 – 2020), que se concretizou em Abril de 2008 na cidade de Santa Cruz de La Sierra, Bolívia, onde convergiram aproximadamente 50 participantes de 11 países, com representantes de governos, pesquisadores e a UICN. O plano foi concluído em dois anos, e reflete as situações e necessidades de todos os países. Identificam-se as ações mais urgentes para garantir a sobrevivência das espécies, a necessidade de avaliar e mitigar os impactos das pescarias, deter a captura intencional destes cetáceos e avaliar as conseqüências da construção de represas e hidrelétricas sobre os ecossistemas aquáticos. O Plano igualmente ressalta a necessidade de gerar alternativas econômicas para as comunidades locais, para poder implementar estratégias de conservação que sejam efetivas e que motivem os ribeirinhos e governos a consolidar esforços de manejo nos grandes ecossistemas aquáticos da América do Sul.

Nesta estratégia de conservação, explicita-se também a importância dos golfinhos de rio no continente como espécies bandeira, guarda-chuva e carismáticas, que representam a biodiversidade aquática da região e se transformam em excelentes embaixadores dos ecossistemas e das espécies aquáticas das regiões Amazônicas e do Orinoco. Estas particularidades, somadas a seu caráter migratório, fazem com que as espécies adquiram uma maior importância para a busca e implementação de novas estratégias de conservação. Atualmente, o plano permite que se desenvolvam de maneira conjunta planos e iniciativas de conservação em Unidades de Conservação (UCs), e expressa a importância de criar novas áreas de conservação onde os golfinhos de rio sejam os protagonistas.

Finalmente, o Plano esboça as principais ações para os próximos dez anos, e se converte em uma iniciativa regional, que conta desde seu início com o apoio e participação dos governos, fontes de financiamento, pesquisadores e comunidades locais. Espera-se que as considerações envolvam todos os atores que de maneira direta ou indireta influenciam na conservação das espécies e seus ecossistemas, e com isto poder assegurar a correta implementação do Plano.

Introduction

The Amazon and Orinoco Basins constitute probably the largest reservoirs of freshwater of our planet. Occupying more than 6,8 million of square kilometers, the Amazon itself is the largest River Basin in the world (Goulding *et al.* 2001). In this gigantic geographic area thousands of species needed to adapt themselves to the dramatic flooded pulses, and mammals were not the exception. Between all of them, river dolphins are the most remarkable creatures, being able to be in main rivers, tributaries, lagoons, and even in the flooded areas and became the top aquatic predators in these ecosystems. However, their incredible adaptation process to the ecology of the Amazon and Orinoco has been disrupted by the relatively recenthuman activity: negative interaction with fisheries, deliberate hunting, deforestation, water pollution and fragmentation of habitats.

As a result of this situation, river dolphins, both in Asia and South America, became one of the most endangered mammal species in the world. As river dolphins inhabit third world countries the efforts for their conservation has not been easy, especially because most of the negative human practices in the region are the result of no other economic alternatives and the limited presence of governmental organizations and strategies. Conservation of river dolphins should have a holistic approach in South America, regarding how to mitigate negative impacts of human activities and develop sustainable environmental practices.

For more than 20 years, researchers from different countries have recommended the implementation of programs that allow establishing the status of these species in South America. For that reason the Fundación Omacha and WWF developed the First Abundance Estimation Program of South American River Dolphins (2006 – 2009) in order to provide regional information on abundance, densities and population sizes in five different South American countries (Colombia, Venezuela, Ecuador, Peru and Bolivia). Some of the results were already presented at international congresses and scientific papers are under development.

Abundance estimations, negative interaccions with fisheries, impact of gold mining, dams and hidrocarbure projects are among the most urgent recommendations to be evaluated. Since 1986 projects around river dolphins were consolidated in Brazil and Colombia, where long term evaluations have been carried out (Best & Da Silva 1984, 1989ab, Da Silva 1994, Trujillo 1994, Martin & Da Silva 2000, Trujillo 2000, Gómez *et al*. 2008). In countries such as Peru, Ecuador, Venezuela and Bolivia significant efforts have also been made but corresponded to isolated initiatives of researchers doing their thesis (Utreras 1995, McGuirre 1995, Leatherwood 1996, Aliaga 2002). During the last few years important advances has been made in different topics around river dolphins in South America, especially in abundance (Vidal *et al*. 1993, Martin & Da Silva 2004b; Gómez *et al*. 2009), habitat use (Martin & Da Silva, 2004a), interactions with fisheries (Da Silva 1996, Trujillo 2003, Gómez *et al*. 2008, Bonilla *et al*. 2008) and genetics (Banguera-Hinestroza *et al*. 2002, Ruiz-García *et al*. 2007, Caballero *et al*. 2009ab). At the same time, cooperation between researchers is becoming more common and also the standardization of methodologies.

As threats can be different in each country, the IUCN has promoted red data books of endangered species for each one. The consideration of a precautionary approach to not miscategorize the species, and the inclusion of the scientific evidence available have been tools to most of the countries in South America that have followed the instructions from IUCN to produce their own red data books of endangered species. In all cases, the category for *Inia* is Vulnerable and for *Sotalia* varies from DD to Endangered (Tirira 2001, Rodríguez-Mahecha *et al.* 2006, Rodríguez & Rójas-Suárez 2008, Ministerio de Medio Ambiente y Agua, 2009). Despite these local categorizations, the IUCN adopted a different classification at international level, and all river dolphin species are now considered Data Deficient (DD) (IUCN 2008). This situation should discuss and try to evaluate the level of threat regarding the available information.

Due to the high levels of threat for aquatic mammals, the same IUCN has published specific Actions Plans for the conservations of Cetaceans worldwide (Reeves & Leatherwood 1994, Reeves *et al.* 2003). These action plans have been very useful to address specific actions to evaluate the status of endangered species, and has linked efforts of several organizations, governments and international agreements. River dolphins have always been part of these action plans, and in 2000 were considered for the first time at the 52th International Whaling Commission meeting. The state of affairs of these species is particularly critical in Asia, where recently the baiji (*Lipotes vexillifer*) was considered ecologically extint. Several organizations such as WWF, Wildlife Conservation Society, Whale and Dolphin Conservation Society among others have focussed efforts and funding to preserve these species both in Asia and South America. As part of a global strategy, several meetings have been carried out between organizations and researchers in different countries and in many of them there always emerged the recommendation of specific action plans for these species that encourage governments to take actions to conserve these unique animals. For this reason, and after the effort of many people in South America, we held the South American River Dolphins Action Plan workshop in the city of Santa Cruz (Bolivia) in April of 2008. In this meeting of more than 40 researchers and officers of governments from more than eight countries, we deliberated the Action Plan for river dolphins in the Amazon and Orinoco River Basins.

The Action Plan is divided in seven main chapters: 1) the status of river dolphins in South America, with novel papers summarizing the information for each country; 2) an analysis of threats for these species, 3) freshwater protected areas and their role for river dolphin conservation, 4) the Abundance Estimation Program for South American River Dolphins, 5) the Action plan, 6) recommendations for research, conservation, education initiatives and policy and legislation for these species, and finally 7) references.

Chapter 1
Status of river dolphins in South America

Status of river dolphins in South America

1.1. Status, distribution and conservation of the river dolphins *Inia geoffrensis* and *Sotalia* spp. in Venezuela

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Abstract

Little information exists about river dolphins in the Orinoco River Basin mainly in Venezuela. In this article we review the current knowledge of the dolphins *Inia geoffrensis* (Pink River Dolphin), and *Sotalia* spp. (Gray Dolphin) in Venezuela. Information about distribution, abundance, habitat use, mortality, threats, legal status and conservation initiatives are presented. The main threat for this species is the negative interaction with local fisheries and the degradation of their habitat by agrochemicals, mining and industrial effluents. The oil exploitation constitutes a potential threat for both species in the Orinoco River Basin. Other threats are habitat modification and the fish overexploitation. Proposals for the development of conservation strategies are made, integrating conservation goals with the interests of local communities and the inclusion of actions to be taken at local, national and international levels. The category of "low risk" is adopted for these species in Venezuela on the basis of the available information of the Red Book of Fauna of Venezuela.

Key words: River dolphins, Venezuela, *Inia, Sotalia,* conservation.

Resumen

Es poca la información que existe sobre las dos especies de delfines de río de la cuenca del Orinoco especialmente en Venezuela. Este artículo presenta el estado actual de conocimiento de los delfines de río *Inia geoffrensis* (delfín rosado o tonina) y de *Sotalia* spp. (Delfín gris) en Venezuela. Se presenta información sobre distribución, abundancia, uso de hábitat, mortalidad, amenazas, estatus legal e iniciativas de conservación. Las mayores amenazas para estas especies son las interacciones negativas con pescadores locales y la degradación del hábitat debido a la contaminación de las aguas por agroquímicos, minería y efluentes industriales. La explotación de hidrocarburos por su parte, constituye una amenaza potencial para ambas especies en la cuenca del Orinoco. Otras amenazas como la modificación de hábitat y la sobre explotación pesquera también ponen en riesgo la supervivencia de estas especies. Propuestas sobre implementación de estrategias de conservación se presentan, integrando metas conservacionistas con intereses de las comunidades locales, a nivel local, nacional y regional. La categoría de conservación "bajo riesgo" para estas especies en Venezuela, se basa en la información disponible en el Libro Rojo de Fauna de Venezuela.

Palabras clave: Delfines de río, Venezuela, *Inia, Sotalia,* conservación.

Resumo

Há poucos estudos e pesquisas dos golfinhos de rio na bacia do rio Orinoco especialmente na Venezuela. Este artigo apresenta o estado atual dos golfinhos de rio *Inia geoffrensis* (boto rosa) e de *Sotalia* sp. (boto cinza ou tucuxi) na Venezuela. Se apresenta informação sobre distribuição, abundância, uso de hábitat, mortalidade, ameaças, status legal e iniciativas de conservação. A maior ameaça para estas espécies são as interações negativas com pescadores locais e a destruição do habitat devido à contaminação das águas pela atividade minera e os efluentes industriais. O aproveitamento de hidrocarburos constitui uma ameaça potencial para as dois espécies na bacia do rio Orinoco. Ameaças como a diminuição de habitat e sobre exploração pesqueira também apresentam um risco para a sobrevivência destas espécies. Propostas sobre implementação de estratégias de conservação são apresentadas, integrando metas de conservação com interesses das comunidades locais, ao nível local, nacional e regional. A categoria de conservação "baixo risco" para estas espécies na Venezuela se baseia na informação disponível do Livro Vermelho da Fauna Ameaçada da Venezuela.

Palavras chave: golfinhos de rio, Venezuela, *Inia, Sotalia,* conservação.

The Action Plan for South American River Dolphins 2010 - 2020

Introduction

The history of river dolphins in Venezuela is dated back in 1647, when *Inia geoffrensis* was first described, later in 1755 appeared the first written description of *Inia* by P. Löfling, but those manuscripts are missing (Romero *et al.* 1997). Years later, in 1782, the first publication of a description of a cetacean in Venezuelan was presented (*Inia* sp.) (Gilij, 1782). In 1814 Alexander von Humboldt published an encounter with *Inia* and possibly with *Sotalia* (von Humboldt 1814). The presence of *Sotalia* sp. in Venezuela was confirmed for the first time in 1912 (Osgood 1912). Many years later, Trebbau (1975) made observations of *Inia* in the Apure River and mentioned some aspects of their distribution, diet, variation on the patterns of color with age and behavior in the field and in captivity (Trebbau 1975). Pilleri & Pilleri (1982) suggested the presence of both species in Venezuela.

Schnapp & Howroyd (1992) pointed out aspects of the distribution and ecology of *Inia* in the Orinoco and Apure Rivers, and reported values of abundance and density in the Apure and Apurito Rivers. They also recorded inverse relations between the group size of these dolphins and the speed flow of the river.

McGuire & Winemiller (1998) reported aspects of the ecology and distribution of *Inia* in the Cinaruco River in the Santos Luzardo National Park (Apure State) and recorded the mean group size of the dolphins sighted. Carantoña (1999) considered the ecology of *Inia* in the "Caño Guaritico Wildlife Refuge" (Apure River Basin), where were reported values of abundance, local movements, spatial and seasonal distribution and group size, day light activities and mortality causes. A year later, Rodríguez (2000) evaluated the ecology of *Inia* in the Aguaro – Guariquito Nacional Park and based on his observations generated linebase to develop its Conservation Action Plan in Venezuela.

Species and local names

Local names for *Sotalia* sp. vary according to the Basin in which it is found. In the Maracaibo system, that includes the Lake Maracaibo, the strait and the Gulf of Venezuela (Viloria & Barros 2000), is referred as "tonina del lago" (Tonina of Lake). In the Orinoco River Basin it is called "bufeo negro", "bufete", "delfín de río" or "soplón". It has also been called "tonina costera" (Bolaños-Jiménez *et al.* 2008a). *Inia geoffrensis* is known in Venezuela as "tonina del Orinoco", "tonina rosada", "tonina rosada del Orinoco" or "bufeo colorado" (Bolaños-Jimenez *et al.* 2008b).

Distribution

Inia geoffrensis: In Venezuela this species is widely distributed in the Orinoco River Basin. They inhabit the entire length of the Orinoco including its tributaries. The dolphins have been seen mainly in the Delta region upstream at Ciudad Bolivar, Caicara del Orinoco and near Puerto Ayacucho as well as the tributaries including the Apure (Portuguesa, Guanare, Guaritico rivers), Capanaparo, Cinaruco and Caura rivers (Orinoco River Basin), and in the upper Caño Casiquiare and Río Negro in the Amazon River Basin (Amazonas State). There is no geographical or ecological barrier between the populations of both Basins (Romero *et al.* 2001, Rodríguez & Rojas-Suarez 1999, Trebbau & van Bree 1974).

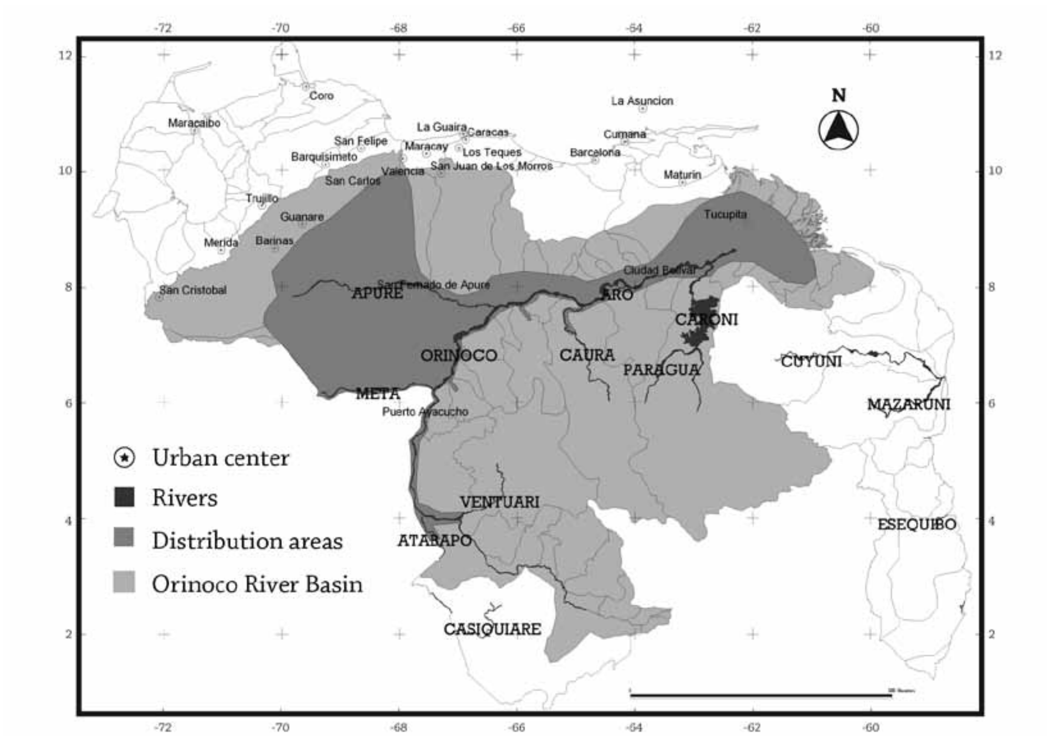

Figure 1. Map of the distribution of *Inia geoffrensis* in the Orinoco River Basin in Venezuela . (Source: Ferrer, 2010).

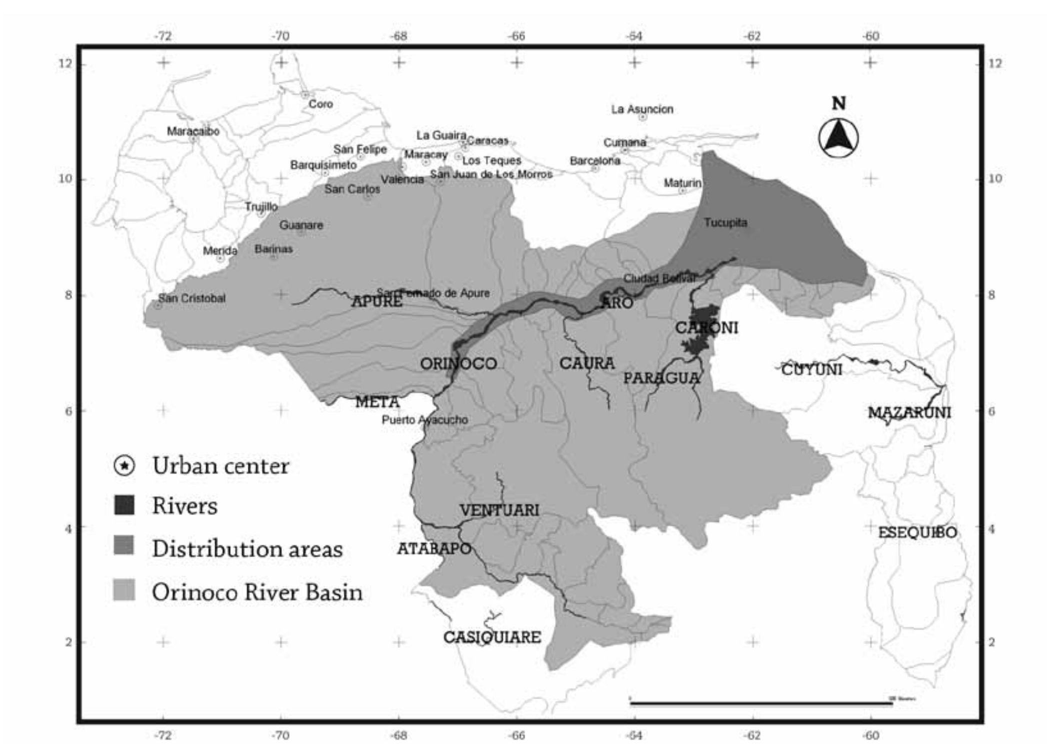

Figure 2. Map of the distribution of *Sotalia* spp. in the Orinoco River Basin in Venezuela. (Source: Ferrer, 2010).

***Sotalia* spp.:** von Humboldt (1814) was probably the first naturalist to document the presence of coastal dolphins that ascended to the mouths of rivers in Venezuela. During his travels in northern South America, between 1799 and 1804, he noted near San Fernando de Apure, the presence of relatively small dolphins with prominent dorsal fins. Since these first descriptions, it is safe to assume that the dolphins described by von Humboldt belonged to the genus later recognized as *Sotalia* (Caballero *et al.* 2007). *Sotalia* occurs mostly in the Orinoco Delta and all along the Orinoco River through the Parguaza rapids located 815 Km upward from the mouth of the Orinoco River (Boher *et al.* 1995, Bolaños-Jiménez *et al.* 2007) (Figure 2).

As mentioned earlier, it is unclear if the animals in the Orinoco belong to the riverine species of *Sotalia*, *Sotalia fluviatilis*, or if these are coastal animals *(Sotalia guianensis)* that colonized the mouth of the Orinoco and migrated up-river (Boher *et al.* 1995).

In the Maracaibo System, the coastal species *Sotalia guianensis* can be found in the Maracaibo Lake and in the area near the strait that connects the lake with the Gulf of Venezuela (Bolaños-Jiménez *et al.* 2008a). The species presence in marine habitats in the Venezuelan Caribbean Sea has been recorded on the basis of strandings (Bolaños-Jiménez *et al*. 2008a) and sightings in northeastern Venezuela (Estévez & Oviedo 2007).

Densities and abundance

***Inia geoffrensis*:** Pilleri & Pilleri (1982) estimated densities values of 0.02 and 0.03 ind/km^2 for *Inia* in the Orinoco River and Caño Casiquiare respectively, while in the Apure the values for the same species are about 1,16 ind/km^2 (Rodríguez & Rojas-Suarez 1999) (Table 1). Schnapp & Howroyd (1992) reported density values of 0,56 ind/km^2 in the Apure River and values of 1,15 ind/km^2 in the Apurito River. For the Aguaro River system, Rodríguez (2000), reported values of 1,29 ± 0,14 ind/km^2 in the summer season, values of 1,44 ind/km^2 in the transition of waters and 0,7 ± 0,18 ind/km^{2}for the winter season. For the Guariquito Apurito system, reported values for the winter season of 0,19 ± 0,16 ind/km^2 and for the summer season of 0,19 ± 0,07 ind/km^2. Escovar (2002), obtained densities of 1,68 ind/km^2 in the summer season and values of 0,85 ind/km^2 for rainy season in the Suripá River. Recent studies carried out by the Fundación Omacha, Fundación La Salle de Ciencias Naturales (FLSCN), Wildlife Conservation Society (WCS), and WWF in May 2006, report values of 1,35 ind/km^2 for islands and 1,57 ind/km^2 for Orinoco River. Those values were the result of a 400 km survey from the town of Mapire (Anzoátegui State) to the Parguaza River rapids (Bolivar State) (Trujillo *et al.* 2006c, Pardo 2007), using the Distance methodology (Buckland *et al.* 1993).

***Sotalia* sp.:** There are limited efforts focused on the estimation of densities or abundance for this species. Values obtained in the survey carried out by Fundación Omacha in 2006 are of 1,15 ind/km^2 in the main channel of the Orinoco River, from the town of Mapire upriver to the Parguasa rapids close to the Colombian border (Trujillo *et al*. 2006c, Pardo 2007) (Table 1).

Habitat use

Inia geoffrensis: Only few studies that were carried out in Venezuela, describe the use of habitat. Trebbau & van Bree (1974) supported

Table 1. Densities values (ind/km²) of *Inia geoffrensis* and *Sotalia* sp. in the river systems of Venezuela.

Locality	Density		Source
	Inia geoffrensis	***Sotalia* sp.**	
Orinoco and Casiquiare Rivers	0,02 – 0,03		Pilleri & Pilleri (1982)
Apure River	1,16		Rodríguez & Rojas-Suárez (1999)
Apure and Apurito River	0,56 1,15		Schnapp & Howroyd (1992)
Aguaro River	1,29		Rodríguez (2000)
Guariquito-Apurito System	0,19		Rodríguez (2000)
Suripá River	1,68		Escovar (2002)
Orinoco River	1,57	1,15	Trujillo *et al.* (2006c), Pardo (2007)

the idea that *Inia* prefers brownish colored, turbid and slowly streaming or temporary stagnant waters. Schnapp & Howroyd (1992) discussed the preference of *Inia* to aggregate following the movements of characids (Characiformes) and catfish (Siluriformes) into the floodplains to spawn and feed. These authors agreed with the idea proposed by Trebbau & van Bree (1974), in which they suggested that *Inia* maybe a sedentary species occupying localized ranges during part of the year. McGuire & Winemiller (1998) carried out a study at the Cinaruco River and reported that the species was found more often in the confluences (35% of the sightings). The presence of rocks and sand banks was associated with a greater frequency of sightings and the sightings increased with habitat heterogeneity.

Rodríguez (2000) found that in the Aguaro-Guariquito National Park, the river dolphins used pool areas formed inside the main channel; these "pools" present low currents. These habitats were seen more frequently in the Aguaro System. Besides, the author concludes that there is not a relation between physicalchemical characteristics of the water and the presence of the dolphins. In this study *Inia* was found exploring habitats with a high range of abiotic conditions and used the same area for long periods of time no matter the changes in the characteristics of the water.

***Sotalia* sp.:** *Sotalia* is mainly seen in the main river where the species has no problem to defeat speed currents. Density values obtained in 2006 (Trujillo *et al.* 2006c, Pardo 2007) showed this preference compared with values for the other stratums equal to 0. This doesn't mean that the species do not frequent those habitats but the low sightings are not enough to make this observation statistically significant. *Sotalia* does not have the ability to penetrate the flooded forest as *Inia,* but it is very common in lake systems that could be nurseries for fish and dolphins (Trujillo *et al.* 2006b). This species is very common in the Orinoco delta (Linares 1998, Linares & Rivas 2004), in the fluvial delta (internal small fresh water tributaries), as it is in the estuarine delta and at the mouth in the Atlantic Ocean (Lasso pers. obs.), but unfortunately there are no recorded data.

Taxonomic status – Genetics

***Inia geoffrensis humboldtiana*:** Pilleri & Gihr (1977) divided the genus in two species: *Inia boliviensis* in the Beni-Mamore River systems of Bolivia and *Inia geoffrensis* in the Amazon and Orinoco River Basins. This last species was subdivided in two subspecies: *Inia geoffrensis geoffrensis* (Amazon subspecies) and *Inia geoffrensis humboldtiana* (Orinoco subspecies). Casinos & Ocaña (1979) considered that there were not enough taxonomic differences to subdivide this taxa in two species and they considered the existence of a unique species with three subspecies *Inia geoffrensis boliviensis, I. geoffrensis geoffrensis* and *I. geoffrensis humboldtiana* (Trebbau & Van Bree 1974, Grabert 1984, Sylvestre 1985, Best & da Silva 1989a, da Silva 1994).

Banguera-Hinestroza *et al.* (2002) obtained data of intra and inter-populational variation at the mitochondrial control region and at the cytochrome b gene of the Amazon River dolphin (*Inia* sp.) from different populations throughout its geographical range. For the mitochondrial control region, the Orinoco individual sample analyzed showed the highest amounts of gene diversity among the pink river dolphins studied in that work (Orinoco, Putumayo, and Bolivia): The mean number of pair wise differences in the Orinoco River Basin was 7.984, meanwhile the same statistic was only 0.912 for the Putumayo River and 0.641 for the Mamore River. In identical sense, the nucleotide diversity was extremely higher for the Orinoco River Basin (1,966%) than for the Putumayo River (0.228%) or for Bolivia (0.160%). For the cytochrome b gene, this trend was also recorded.

For the first statistic, the Orinoco River Basin presented a value of 7.133, meanwhile the values of the Putumayo River (2.747) and Mamore River (0.201) were significantly lower. The same was certain for the nucleotide diversity. The Orinoco River Basin (1.16%) showed a significantly higher value than Putumayo River (0.46%) and Mamore River (0.03%). In recent years additional molecular markers confirmed the fact that the Orinoco population presented the highest levels of gene diversity, or near to the highest levels, of all the pink river dolphins studied until the present (Ruiz-García *et al.* 2007). This was the main fact that provoked that the Orinoco River Basin was postulated like the possible origin and point of dispersion of the current *Inia* forms. Nevertheless, during the previous years a new vision of the gene composition of the Orinoco River Basin *Inia* populations has been reached.

The considerable amount of new mitochondrial control region sequences obtained and the DNA microsatellite results (Ruiz-García 2008, Ruiz-García *et al.* 2008d, 2008e) showed that, at least two different lineages of pink river dolphins are living nowadays in some Orinoco rivers coming from some original Amazon lineages (Ruiz-García 2008, Ruiz-García *et al.* 2008d, 2008e). These two lineages were independently generated by two different migrations from the Amazon to the Orinoco River Basins, one about 4300 years ago and another 5800 years ago. Therefore, the pink river dolphins from the Orinoco River Basin are paraphyletics and recently derived from the Amazon form. Thus, the *humboldtiana* subspecies is not sustained by molecular data. Currently, nine mitochondrial control region haplotypes have been detected. One lineage is composed by the H8, H1, H3, H4, and H2 haplotypes, which included specimens from Meta, Orinoco, Inirida, Guaviare, and Bita rivers, whereas the second lineage is conformed by the H9, H6, H5, and H7 haplotypes, which included dolphins sampled at the Meta, Orinoco, and Arauca rivers. Therefore, both lineages lives intermixed in the same rivers. However, more *Inia* populations must be sampled towards the Orinoco Delta to confirm globally the molecular results commented.

One morphometric study showed that *I. g. humboldtiana* could not be differentiated from *I. g. geoffrensis* (Ruiz-García *et al.* 2006), as well as another study with 50 craniometrical variables with a canonic population analysis, also showed a clear superposition among samples from the Orinoco and Amazon River Basins (Castellanos-Mora *et al*. 2008).

***Sotalia* sp.:** The taxonomic status of *Sotalia* has been controversial. This species has been named with three different scientific names since it was identified by von Humboldt (1814). He was probably the first naturalist to document the existence of *Sotalia* in Venezuelan waters. *Delphinus fluviatilis, Delphinus pallidus* and *Steno tucuxi* (Robineau 1990, van Bree 1974, Hershkovitz 1966) all these are now synonyms of *Sotalia fluviatilis* (da Silva & Best 1994). And names like *Delphinus guianensis* and *Sotalia brasiliensis* by Van Bénéden (1864), synonyms of *Sotalia guianensis* (Hershkovitz 1963, da Silva & Best 1994). Later the number of species was reduced to two subspecies *Sotalia fluviatilis fluviatilis* (the riverine) and *Sotalia fluviatilis guianensis* (the coastal) (Cabrera 1961, Borobia *et al.* 1991).

Caballero *et al.* (2007) presented a formal proposal to recognize each *Sotalia* subspecies (Riverine ecotype *Sotalia fluviatilis* and the coastal *Sotalia guianensis,* Borobia *et al.* 1991, da Silva & Best 1994, Rice 1998) as full species under the GCC (Genealogical/ Lineage Concordance Species Concept), based on diagnostic genetic characters consistent with the criterion of irreversible divergence. Actually, Caballero *et al.* (2007) and Boher *et al.* (1995), suggested that the dolphins reported in the lower Orinoco, 300 km up river, near Ciudad Bolivar, seems to be *Sotalia guianensis*, but to confirm this additional data is necessary. There are no scientific studies that confirm the taxonomic status of *Sotalia* up river Ciudad Bolivar. The species distribution is confined from the mouth of the Orinoco to the Parguaza rapids, just at 815 Km up from the mouth of the Orinoco River. This geographical barrier does not allow the dolphins to reach the Colombian Orinoco.

Although we are aware that populations in the middle Orinoco River and/or the Maracaibo System may later be assigned to another genetic unit, we tentatively refer to the Maracaibo populations as *S. guianensis*, and to the Orinoco populations as *Sotalia* sp, in this paper.

Threats and mortality

The Orinoco River is one of the most threatened aquatic ecosystems in South America. Human activities like gold mining, oil industry, hydroelectric development, overfishing, water pollution, destruction of riparian woods, direct killing of dolphins, conflicts between dolphins and fisheries, incidental catches and the use of dolphins as bait to catch the scavenger catfish Mapurite (*Calophysus macropterus)* are the main threats that river dolphins are facing in Venezuela. This latter type of fishery has been investigated by the Ministry of Environment

Table 2. Threats for river dolphins in Venezuela.

Threats	Location	Description
Direct		
Interactions with fishermen	Orinoco River and most of their white water tributaries.	Competition between dolphins and fishermen for the same resource. This makes fishermen wound or kill dolphins to get them out of the fishing areas.
Bycatch - Accidental killing	Orinoco Delta, Apure River	Incidental catches in nets mostly during dry season is something that occurs every year. The use of nylon monofilament gill nets, and the presence of more fishermen in the rivers, increases the odds of dolphin entanglement.
Use of dolphins as bait	Apure River	The killing and posterior use of dolphins decomposed flush to catch the scavenger catfish Mapurito to be sold in the markets of cities of Colombia, is threatening the populations of the species. Bycatch animals are also used.
Indirect		
Habitat degradation	Aguaro-Guariquito National Park	The expansion of the agriculture and cattle activities are polluting the soils and cutting of trees in order to increase their area. This has been reflected in the conditions of the shores and riparian forest.
Gold mining	Ventuari River	The use of Mercury to extract gold has become the most efficient way to pollute waters. The toxicity of the Mercury is the most powerful way to harm not only waters but fish and top predators too. The Mercury is bio-accumulative element that reposes in the tissues of fish, dolphins, otters and humans, making them ill during a long period of time.
Hydroelectric Dams	Caroni River	The transformation of the habitat and the interruption of river flow, make dolphin populations to segregate, putting at risk their reproductive activities and lowering the male-famale encounters.
Boat traffic and unregulated tourism activities	Caura and Orinoco rivers and the Caño Guaritico Wildlife Refuge	The acoustic pollution affects the communication processes of dolphins. The increase of the number of boats could influence dolphin activities in the future. The conduction of tourism activities, including dolphin watch, with no proper protocol, could cause changing the behavior of the population.

(Bolaños-Jiménez & Hernández, 1996) and is apparently widespread throughout the Orinoco and Amazon River Basins (Trujillo *et al.* 2008, Flores *et al.* 2008).

Rodríguez (2000) found out that in the area of the Aguaro-Guriquito National Park, the main threat for the species is the habitat degradation as a consequence of the effects of the irrigation systems, use of fertilizers or pesticides, deforestation and boat traffic.

In 2005, Fundación Omacha (Colombia) together with Fundación La Salle de Ciencias Naturales (Venezuela) and WWF Colombia, completed a study to evaluate the concentrations of mercury in commercial fish as indicators of the mercury contamination in freshwater ecosystems in the Orinoco (Trujillo *et al.* 2005b). The results showed that the problem of toxicity caused by the mercury is a reality. Fish sampled in the markets in different places of the Orinoco River Basin in Colombia and Venezuela contained mercury in concentrations higher than the limit allowed by the World Health Organization (WHO). Some interesting observation was that some of the fish with high level of toxicity were captured in places far away from the mining areas. This confirms the hypothesis of bioaccumulation of the element in migratory fish and top predators (Trujillo *et al.* 2005b).

At the begging of the 90s the Guri Dam, constructed in the Caroni River, a tributary of the Orinoco in the Guyana Shield apparently caused the depletion of *Inia* (Klinowska 1991). Other dams have been constructed (i.e. Tocoma Dam in the same river) and there is no clue for the future of the river. As it is known construction of dams pose several problems to dolphin populations: reduction of food supply for dolphins upriver, interruption of fish migrations and breaking connectivity between dolphin groups and the reduction of habitat for the popultion for fish because of the reduction of the oxygen levels in water and the reduction of the amount of prey species for dolphins. Also, the flow of the freshwater is reduced and this could affect some of the habitats selected by dolphins to feed and settle (Klinowska 1991).

In Venezuela, there are fishermen that still fish with dynamite. This practice is illegal, but commonly used and may kill dolphins. Actually there is a strong competition between dolphins and fishermen in collecting the fish, angering the fishermen, who attempt to drive away, or sometimes, to kill the dolphins (Klinowska 1991).

Some cases of bycatch and consumptive use of dolphins have been recorded in the Orinoco Delta (Bolaños-Jiménez *et al.* submitted) and the Maracaibo system (Bolaños-Jiménez & Hernández 1996, Sánchez-Criollo *et al.* 2007). Some indigenous communities are using body parts of accidentally caught animals: tooth and genitalia, for religious events and the fat is used for respiratory illnesses (Trujillo 2000).

The use of river dolphins as bait to catch Mapurite (*Calophysus macropterus*), is one of the most high risk activities that could reduce the dolphins populations in a short time. The feeding habits of this fish make fishermen kill dolphins to later decompose and attract these scavenger fish (Flores *et al.* 2008, Trujillo *et al.* 2008). This is the main threatening activity that it is not only occurring in the Orinoco, but in the Amazon region too.

Inia geoffrensis is the target of unregulated dolphin watching operations in several regions of Venezuela, including the Apure, Caura and Orinoco rivers and the Caño Guaritico Wildlife Refuge (Bolaños-Jiménez *et al.* 2008b).

Legal situation - Status and law

Presidential Decree 1485 forbids the capture of several cetacean species, including *Inia geoffrenis* and *Sotalia* (this latter under the specific name *S. fluviatilis*). Any illegal capture of these species could be prosecuted by a Court in compliance of the "*Ley Penal del Ambiente*" ("*Criminal Environmental Act",* 1992).

The distribution range of this two dolphin species in Venezuela includes several protected areas, such as the Santos Luzardo and Turuépano National Parks, the Orinoco Delta Biosphere Reserve and the Tortuga Arrau Wildlife Refuge. Both species are protected under the Law of Protection of Wild Fauna of 1970 and not included in the Official List of species not to be hunted according to legal regulations.

Conservation initiatives

Up till now, the most important initiative for the assessment of threats on a cetacean species in Venezuela was implemented by the Instituto para la Conservación del Lago de Maracaibo of the Ministry of Environment (ICLAM-MINAMB) in looking for solutions for the increase in number of strandings of *Sotalia guianensis* in the Maracaibo system (Pirela *et al.* 2002, Rojas *et al.* 2002, Troncone *et al.* 2002; Bolaños-Jiménez *et al.* 2008a). Also important was the confirmation of the occurrence of *Sotalia guianensis* in coastal areas in northeastern Venezuela (Estévez & Oviedo 2007) and in the eastern side of the Gulf of Venezuela. During the late nineties, dolphin festivals were presented to school children in Ciudad Bolívar as part of sensitizing efforts by local entrepreneurs (Bolaños-Jiménez & Hernández 1996).

The Red Book of the Venezuelan Fauna (Rodríguez & Rojas-Suarez 1999) considers the importance to develop research projects to evaluate the population situation of dolphins as to evaluate the threats that actually are risking the species, and with this information be able to formulate Action Plans to preserve the species. Another proposal is to evaluate the efficiency of Protected Areas System for the conservation of populations and to increase the strength of the activities of control and supervision inside the Protected Areas and outside of them.

It is important to clarify the taxonomic status of *Sotalia* to be able to implement accurate conservation initiatives and to know if the species seen in Venezuela is *S. fluviatilis* and/or *S. guainensis*. Greater conservation effort should also be directed at the unique Maracaibo Lake population of *Sotalia guianensis*, which is threatened by oil production in its environment (Lentino & Bruni 1994). Research on its demographic status, life history and population estimates needs to be undertaken. Finer-scale analysis of genetic variation of *Sotalia guianensis* is needed to determine male-mediated gene flow between these restricted populations. Directed systematic sampling of individuals belonging to the Maracaibo Lake genetic management unit is needed to measure the "immune" status of this population. Further investigation of MHC diversity should be accompanied by a comprehensive toxicological study to detect levels and potential effects of organic hydrocarbons such as polycyclic aromatic hydrocarbons (PAHs) in tissue samples from this population. Even though genetic diversity at the mitochondrial level was found to be high in this genetic management unit at present (Caballero 2006), low levels of polymorphism at the MHC accompanied by high levels of contaminants in tissue samples could indicate vulnerability to habitat degradation, similar to the findings from studies on other cetaceans found in highly polluted areas, for example the beluga (*Delphinapterus leucas*) population in St. Lawrence Estuary (Murray *et al.* 1999).

Conclusions

Populations of river dolphins in Venezuela have been studied since the XVII century but not in a systematic way. These studies have revealed information about the anatomy, behavior, distribution, ecology, habitat use, abundance and taxonomical status of river dolphins in specific rivers of the Orinoco River Basin in the country. This information is not enough and there is a lack of data about the species, their threats and habitats in most of their area of distribution. The main cause of this lack of information could be the small group of qualified researchers with expertise or interest in the species, as well as the lack of funds and programs established in order to deal with river dolphins, their threats and the human communities involved in their conservation.

It is prioritary to consolidate a group of researchers in the area of river dolphins to work together with researchers of aquatic ecosystems and fisheries. Also train new professionals and create an agenda to address future investigations and conservation initiatives in a new set of areas to increase the existing information. Finally, it is important to implement a plan for the acquisition of funds and international cooperation in order to accomplish the objectives of species and ecosystems conservation.

Recommendations

Research

Assessment of the population status, direct captures for mapurite (*Calophysus macropterus*) fisheries, bycatch, and tourism operations should be a priority. Also clarification of the taxonomic status of *Sotalia* in the Orinoco River Basin is needed.

Education

Training seminars for tour operators and local fishermen in areas where dolphin-watching occurs, including San Fernando de Apure, Puerto Ordaz, San Félix, Puerto Ayacucho, and Tucupita, capitals of riverine states.

Conservation

Update of the Presidential Decree 1485 to update the list of species and scientific names. Inclusion of these species in the terms of reference for assessment and monitoring of oil and gas operations. Continuity of the studies in the Maracaibo System. Inclusion of the species in the Convention of Migratory Species of 1979.

1.2 Conservation status of river dolphins *Inia geoffrensis* and *Sotalia fluviatilis* in the Amazon and Orinoco River Basins in Colombia

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Abstract

River dolphins are among the world's most endangered cetaceans, yet relatively little is known about the conservation status of their populations and the threats they face. This article reviews current knowledge of the Amazon River dolphin (*Inia geoffrensis*) and the Tucuxi (*Sotalia fluviatilis*) in Colombia, including interactions with human communities. It draws on twenty years of on-going studies made by the Foundation Omacha and collaborators throughout long term research studies and opportunistic observations in different hydrological systems of the Amazon and Orinoco River Basins. Information about distribution, abundance, habitat use, residency patterns, genetics, mortality, threats, legal status and conservation initiatives is presented. The main threat for this species is the negative interaction with local fisheries and the killing of the Amazon River dolphins (*Inia*) to be used as bait to catch a scavenger catfish known as Mota or Mapurito (*Calophysus macropterus*). Other main threats include habitat degradation and fish overexploitation. Finally, we proposed conservation strategies that will integrate the conservation goals and interests of researchers, local communities, and institutions to develop actions that will be taken at local, national and international levels. The category of "vulnerable" is adopted for these species in Colombia based on the available information the Red List of Mammals of Colombia.

Key words: River dolphins, *Inia geoffrensis, Sotalia fluviatilis,* Colombia, Conservation, Amazon River Basin, Orinoco River Basin.

Resumen

Los delfines de río se encuentran entre los cetáceos más amenazados del mundo, desafortunadamente hoy en día hacen falta estudios para conocer un poco más acerca del estado de conservación de sus poblaciones y sus amenazas. Este artículo presenta el estado de conocimiento actual de los delfines de río *Inia geoffrensis* (delfín rosado) y de *Sotalia fluviatilis* (tucuxi) en Colombia, incluyendo interacciones con comunidades humanas. Lo presentado acá es una recopilación de estudios realizados principalmente por la Fundación Omacha en los últimos veinte años, con ayuda de colaboradores, sobre trabajos realizados en los ríos Amazonas, Orinoco, Meta, Caquetá y Arauca, y de observaciones ocasionales en diferentes sistemas fluviales. Se presenta información sobre distribución, abundancia, uso de hábitat, biología, genética, mortalidad, amenazas, estatus legal e iniciativas de conservación. Se concluye que entre las principales amenazas para *Inia* se encuentran las interacciones negativas con pescadores locales y su uso como carnada para la captura de un pez carroñero conocido como Mota o Mapurito (*Calophysus macropterus*). Otras actividades como la degradación y disminución de hábitat y sobre explotación pesquera, también tienen en riesgo la supervivencia de estas especies. Finalmente se presentan propuestas sobre implementación de estrategias de conservación que integren metas de conservación con los intereses de las comunidades humanas, a nivel local, nacional y regional. La categoría de conservación "Vulnerable" para estas especies en Colombia, se basa en la información disponible del Libro Rojo de Mamíferos de Colombia.

Palabras clave: Delfines de río, *Inia, Sotalia,* Colombia, Conservación, Cuenca del Amazonas, Cuenca del Orinoco.

Resumo

Os golfinhos de rio se encontram entre os cetáceos mais ameaçados do mundo, infelizmente hoje em dia carecem estudos para conhecer um pouco mais sobre eles e suas ameaças. Este artigo apresenta o estado atual dos golfinhos de rio *Inia geoffrensis* (boto rosado) e de *Sotalia fluviatilis* (boto cinza ou tucuxi) na Colômbia, incluindo interações com as comunidades humanas. O que está apresentado aqui é uma recopilação de estudos realizados principalmente pela Fundación Omacha nos últimos vinte anos, com ajuda de colaboradores, sobre trabalhos realizados nos rios Amazonas, Orinoco, Meta, Caquetá e Arauca, e de observações ocasionais em diferentes sistemas hídricos. Se apresenta informação sobre distribuição, abundância, uso de hábitat, biologia, mortalidade, ameaças, status legal e iniciativas de conservação. Concluiu-se que a maior ameaça para estas espécies são as interações negativas com pescadores locais e o uso da *Inia* como isca para captura de um peixe carniceiro conhecido como Mota ou Mapurito (*Calophysus macropterus*). Ameaças como degradação e diminuição de habitat e sobre exploração pesqueira também apresenta um risco a sobrevivência destas espécies. Finalmente, propostas sobre implementação de estratégias de conservação são apresentadas, integrando metas conservacionistas com interesses das comunidades locais, que devem ser em nível local, nacional e regional. A categoria de conservação "Vulnerável" para estas espécies na Colômbia se baseia na informação disponível no contexto das recomendações do Livro Vermelho de Espécies Ameaçadas da Colômbia.

Palavras chave: Golfinhos de rio, *Inia, Sotalia,* Colômbia, conservação, Bacia do rio Amazonas, bacia do rio Orinoco.

Introduction

Rivers in the world are of clean water, food, transportation, energy and part of the culture of many human communities, among others. However, it is of serious concern the current status of many rivers worldwide, the exploitation of resources and the threat and extinction of many species. Large rivers have been devastated, leading to enormous losses in terms of quality of life for people that depend on them, and in terms of diversity and wildlife (Leatherwood & Reeves 1994).

One of the top predators that inhabit some of the largest rivers Basins of the Asian and South American continents are river dolphins, which are considered as the most endangered cetaceans in the world (Reeves *et al.* 2003). River dolphins share resources closely with human communities, such as food and habitat availability. Therefore, conservation efforts in order to preserve river dolphin populations will directly benefit human communities and the quality of aquatic habitats.

There are five species of river dolphins in the world, four of them living exclusively in freshwater ecosystems. Dolphin populations in Asia are critically endangered, with the baiji (*Lipotes vexillifer)* considered functionally extinct (Guo 2006). Dolphin populations in South America, in contrast, are in relatively good condition, though it is of serious concern that threats are rapidly increasing.

River dolphins in South America inhabit two of the largest river Basins in the world: The Amazon and Orinoco. The Amazon River Basin in Colombia covers an area of about 406,000 km^2, which correspond to 5.52% of the entire Amazon River Basin (CABS/CI 2000) and the Orinoco River Basin in Colombia covers an area of 388.101 km^2 which correspond to 37,6% of the entire Orinoco River Basin (FEN 1998). There are two species of river dolphins in Colombia: The Amazon river dolphin (*Inia geoffrensis*), distributed in the colombian Amazon and Orinoco river Basins, and the Tucuxi (*Sotalia fluviatilis*) distributed only in the colombian Amazon River Basin. *Inia,* of the family Iniidae, is the largest of the river dolphins, and *Sotalia* is the smallest of the dolphins in the family delphinidae.

Inia geoffrensis and *Sotalia fluviatilis* are listed as Vulnerable by the red list of mammals of Colombia (Rodríguez-Mahecha *et al.* 2006), however they remain listed as data deficient (DD) by the IUCN red list of threatened species (Reeves *et al.* 2008). It is necessary to compile all information available on their populations, status of their habitat, and threats in order to establish their global conservation status and in this way, to develop effective conservation actions (Reeves *et al.* 2000, 2003, Trujillo 2000, Vidal 1993, Martin & da Silva 2004).

Different threats for river dolphins in Colombia have appeared at different scales and it is of great concern the increase of anthropogenic threats in the Amazon and Orinoco River Basins, such as overexploitation of aquatic resources, pollution of river Basins, construction of water development projects and direct catches of endangered species. Threats are and will continue impacting considerably the aquatic ecosystems, diminishing the habitats and resources available for human communities and wildlife. Educational campaigns and social workshops conducted every year have become an important tool in order to assess the impact of anthropogenic threats and to promote specific conservation actions. However, more economical, personal and political resources are needed to implement these conservation actions that are intended to act in partnership with local communities, this will ensure the protection of the environment and guarantee the availability and quality of aquatic resources in the years to come.

The main objectives of this paper are 1) to compile all the information published and unpublished in Colombia about river dolphin populations, 2) to identify the main anthropogenic threats for aquatic systems and river dolphins in Colombia, and finally 3) to prioritize research, educational activities and management actions fundamental for the conservation of aquatic systems and river dolphins in Colombia. This information is part of an initiative to establish a network of Freshwater Protected Areas (FWPAs), researchers, governments and local communities SARDPAN (South American river Dolphin Protected Area Network) which fully considers the ecological integrity of freshwaters for the conservation of river dolphins in the Amazon and Orinoco River Basins in South America.

Distribution of river dolphins in Colombia

The Amazon river dolphin (*Inia*) and the Tucuxi (*Sotalia*) are widely distributed in main rivers and most tributaries, lakes and confluences of the Amazon and Orinoco Basins in South America, limited by rapids, water falls and small channels (Best & da Silva 1989b, da Silva & Best 1994). In Colombia, *Inia* is distributed in the Orinoco and Amazon River Basins and *Sotalia* is restricted to the Amazon River Basin (da Silva & Best 1996, Trujillo 1997). These river Basins in Colombia form large and complex fluvial networks of about 15,900 linear km (Moreno *et al.* 1989).

Inia geoffrensis is broadly distributed in the Amazon and Orinoco Basins in Colombia, in an area of about 864,500 square kilometers. In the Amazon region, *Inia* occurs in main rivers and in most of their tributaries, such as the Caquetá River (from Araracuara rapids to the mouth of the Apaporis River in the border with Brazil), the Putumayo River (from Puerto Leguizamo

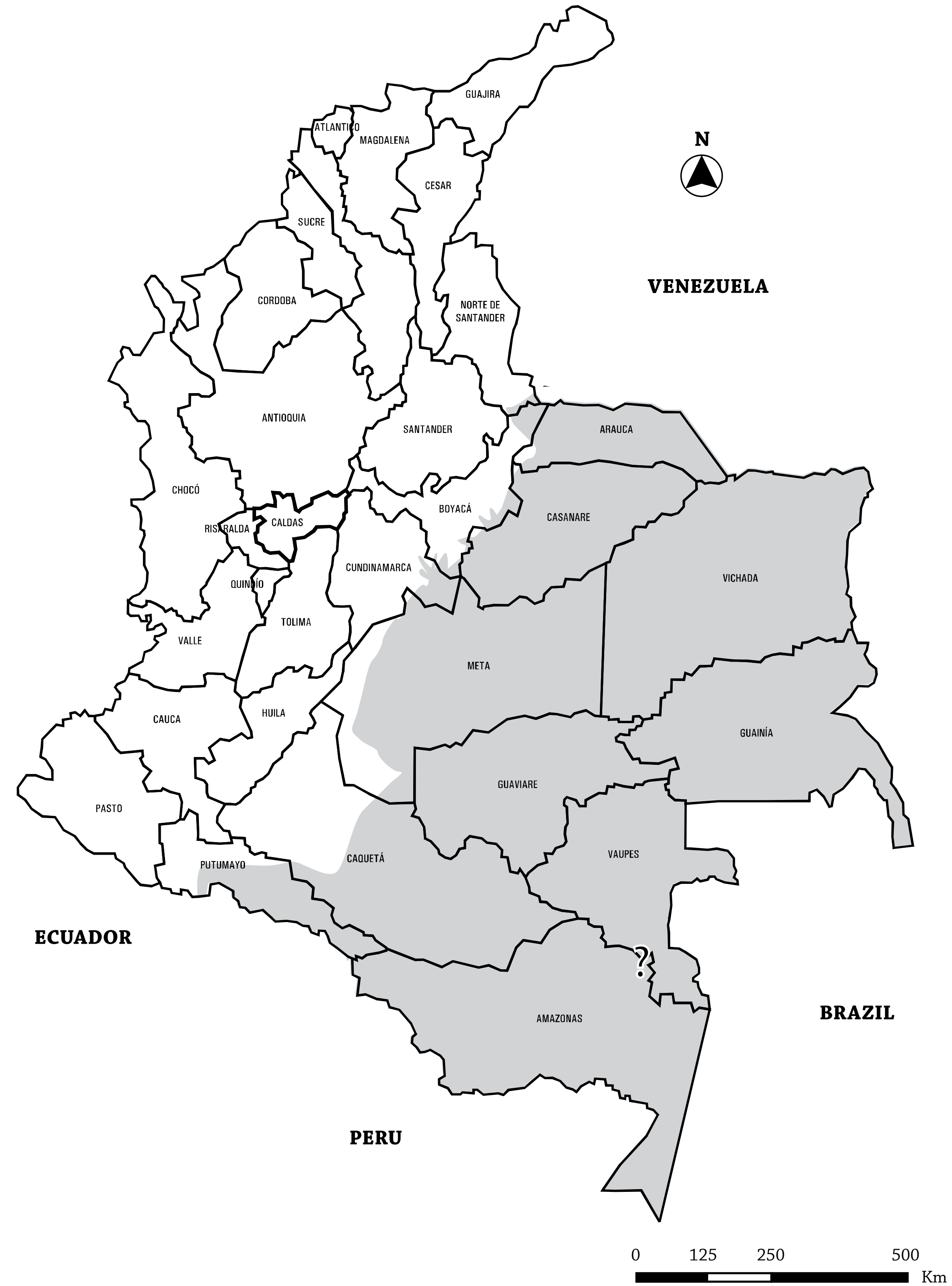

Figure 3. Map of distribution of *Inia geoffrensis* in Colombia.

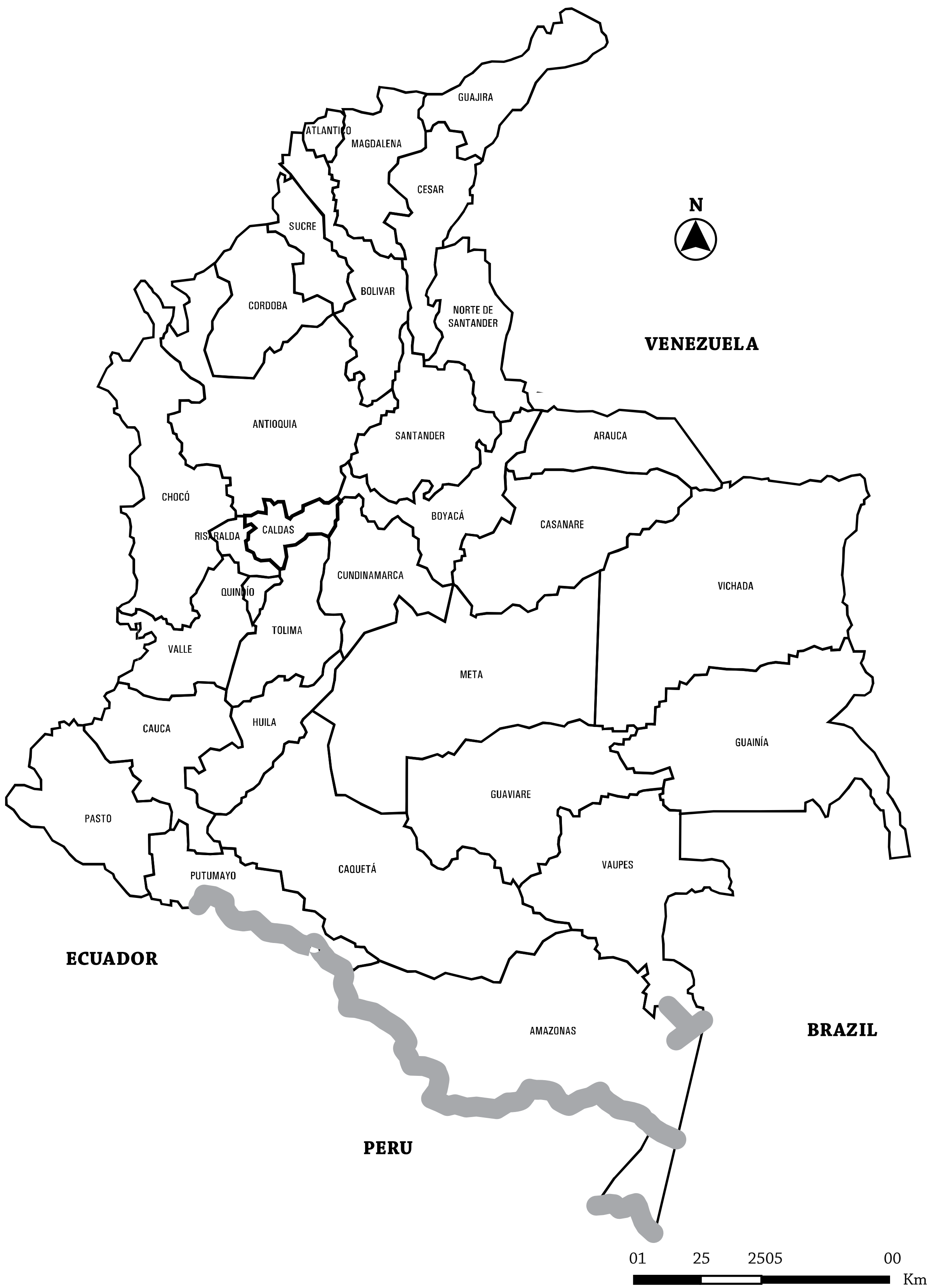

Figure 4. Map of distribution of *Sotalia fluviatilis* in Colombia.

to the east) and in the Amazon River (Table 3). In the Orinoco, *Inia* is also found in most of the main rivers and their tributaries such as Arauca, Meta, Casanare, Bita, Tuparro, Tomo, Orinoco, Vichada, Guaviare, and Inírida (Figure 3). The distribution of *Inia* was suggested to be limited by some rapids (Best & da Silva 1989a), but some observation in Colombia showed that *Inia* is able to cross some rapids during the low water season, when the current is less powerful. This was observed in areas such as the Córdoba rapids, in the Caquetá River, and Atures and La Concordia rapids in the Orinoco River (Galindo 1997, Diazgranados 1998).

Sotalia fluviatilis is distributed in several rivers and tributaries in the Colombian Amazon (Figure 4) such as the Putumayo, Caquetá (downstream from the Córdoba rapids), Amazon, and Apaporis rivers. During the high water season, *Sotalia* dolphins disperse upstream in several tributaries and lakes, and during low water season the species remains in deep waters in the main channels and lakes (Trujillo 1990, 1997). Distribution of this species appears to be limited by headwater rapids and productivity. *Sotalia* have not been observed in the Colombian Orinoco River Basin.

Local changes in the distribution of river dolphins in Colombia have been detected, despite the fact that no major development projects have occurred, compared to Brazil or Venezuela. However, some areas in Colombia might be subject to future macro-projects of high ecological disturbance. For instance, the River Meta has been planned to be transformed into a hydroway and this will alter flooded pulses, and therefore productivity and other ecological processes. In addition, the intense fisheries and the exploitation of timber have increased closer to the Andean region as a consequence of a growing human population. Equally, of serious concern are the low densities of dolphins in the river Meta and the absence of dolphins close to the city of Puerto Lopez (where the Meta River is closer to the Andean region) (Gómez-Salazar *et al.* 2009) were *Inia* dolphins were previously recorded. *Inia* dolphin populations appear to be moving down the river, probably looking for areas less exploited and with more availability of resources (Trujillo *et al.* 2008).

Table 3. Main rivers and tributaries where *Inia geoffrensis* is distributed in Colombia.

Main River	Tributaries	Source
Amazon River Basin		
Caquetá	Yarí, Quinche, El Sol, Cahuinarí, El Bernardo, Mirití-Paraná, Córdoba, Apaporis	Trujillo 1995, Galindo 1997, Trujillo *et al.* 2006
Putumayo	Cará-Paraná, Igará-Paraná, Yuria	Trujillo 1997, Trujillo *et al.* 2006
Amazon	Amaca-Yacu, Loreto-Yacu, Mata-mata, Atacuari	Trujillo 1990, 1992,1997, Vidal *et al.* 1997

Main River	Tributaries	Source
Orinoco River Basin		
Arauca	Caño Limón, Caño Jesús	Trujillo *et al.* 1992, Fuentes 1998
Meta	Manacacías, Yucao, Cusiana, Cravo Sur, Pauto	Diazgranados 1998, Trujillo *et al.* 2006, Pardo 2007
Casanare	Cravo Norte	
Guaviare	Inírida, Ariari, Guayabero, Duda	Meade & Koehnken 1991
Orinoco	Bita, Vichada, Tuparro, Tomo	Meade & Koehnken 1991, Diazgranados 1997, Trujillo *et al.* 2008

Research on river dolphins in Colombia

Residency patterns

The **photo-identification** of individual - specific marks is an important technique in the study of several areas of the biology of aquatic mammals (Wursing & Jefferson, 1990). For river dolphins, dark waters, inconspicuous behavior and irregular breathing activity makes this technique difficult to utlise. In spite of that, photo-ID of *Inia* has been useful (Trujillo 1994, Aliaga-Rossel 2002, McGuire & Winemiller 1998). It seems to have good potential as a non-invasive and inexpensive tool to answer a wide range of questions related to movements, social structure and population estimation. The principal marks used to distinguish cetaceans are scars, wounds and notches; Trujillo (1994) identified coloration patterns as a diagnostic characteristic for identifying *Inia geoffrensis*.

Extended movements have been reported using information from identified dolphins (Leatherwood 1996, Da Silva *pers. Comm.*, McGuire & Henningsen 2007). In other cases, *Inia* dolphins have been observed in the same areas for more than 7 years, suggesting very specific residency patterns (Trujillo 1994, Trujillo 1997). It is necessary to work in synchrony with researchers from other countries in order to understand more about residency patterns of river dolphins, and to track possible long movements.

Coastal *Sotalia* has been photo-identified using notches in dorsal fins (Flores *et al.* 1999). However, those marks are very inconspicuous and because of the shy behavior of riverine *Sotalia*, no photo-identification research has been focused on it. However, the use of digital cameras with long lenses may improve the quality and efficiency of photo-identification for both species.

The use of **molecular techniques** also demonstrated residency patterns of *Inia* dolphins, where the mobility of the animals, or at least of their genes, was limited to the same lagoons where the animals were born or to adjacent lagoons (Ruiz-García *et al.* 2007). This study that was conducted in the bolivian Amazon showed a significant relationship between the genetic distances and the geographic distances among Amazon river dolphins sampled in ten lagoons at the Mamore-Itenez River; a Mantel test yielded a significant isolation-by-distance pattern ($r = 0.89$; $p = 0.001$) which means that the geographical distances explained 80.29% of the genetic differences among the animals of different lagoons (Ruiz-García *et al.* 2007).

Density estimates

Estimates have been obtained in several regions extrapolating from a few sightings of *Inia* and *Sotalia* obtained from small areas during short surveys (Layne 1958, Kasuya & Kajihara 1974, Pilleri & Gihr 1977, Magnusson *et al.* 1980, Meade & Koehnken, 1991, Da Silva & Best 1994, Trujillo 1994, Herman *et al.* 1996). Vidal *et al.* (1994) developed the first rigorous survey methodology for South American river dolphins using a standardized protocol of strip and line transects in the Amazon River, bordering Colombia, Peru, and Brazil. Based on that methodology, here we presented results of surveys conducted in Colombia in order to obtain density estimates of *Inia* and *Sotalia* in selected rivers of the Amazons and Orinoco River Basin (Table 4) (Gómez-Salazar *et al.* 2009).

In Colombia, during August 2006, a survey was conducted in the Meta River from the city of Puerto Carreño (Vichada) to the city of Puerto López (Meta), covering 790 lineal kilometres in 7 days (Pardo 2007). A total of 121 *Inia* dolphins were counted. During 2007 a survey was conducted in the Amazon River in Colombia and in the Yavarí River (Brazil/ Peru), covering a total of 293 lineal kilometres in 7 days. 513 dolphins were counted: 197 *Inia* and 316 *Sotalia.* Results are part of a regional initiative based on standardized methodologies to estimate the abundance of river dolphins in selected rivers of the Amazon and Orinoco Basins in South America.

Sightings, group sizes and population estimates of river dolphins in Colombia

Most of the research in Colombia was conducted during the last 20 years, and it has

Table 4. Densities and standard error for *Inia* and *Sotalia* within region and habitat type using 200m strip-width transects. Data were not obtained in the field (blank spaces) for some categories. The Amazon comprises the river Amazon in Colombia and the Orinoco comprises the river Meta (Gómez-Salazar *et al.* 2009).

	Habitat Type	Channel		Island		Main River		Tributary	
Species/ Region		**D**	**SE**	**D**	**SE**	**D**	**SE**	**D**	**SE**
Inia	Amazons	1.9	0.4	2.1	0.9	2.8	0.7	2.9	0.8
	Orinoco			0.6	0.5	0.4	0.3		
Sotalia	Amazons	3.6	0.9	2.4	1.0	4.3	1.6	1.4	0.7

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been focused mostly in the Amazon, Orinoco, Caquetá and Arauca rivers (Table 5 and 6).

Some information has been published related to the ecology, abundance and behavior of these animals (Layne 1958, Best & da Silva 1989a,b, Smith 1994, Trujillo 1994, Leatherwood 1996, Trujillo 1997, Vidal *et al.* 1997). Long term studies of both species of freshwater dolphins in Colombia started in 1989, and focused on the distribution, abundance, behavior, group sizes and population ecology (Trujillo 1990, 1992, 1994, 1997, Trujillo & Beltrán 1996, Pardo 2007).

In 1993, Vidal *et al.* (1997) studied the distribution and abundance of both *Inia* and *Sotalia* in the Amazon. During the same year Hurtado (1996) and Ojeda (1997) published studies describing the relationship between dolphins and environmental variables. Comparative observations of *Inia geoffrensis* were made since 1992 in the Arauca River, a tributary of the Orinoco (Trujillo, unpublished observations), and since 1996 in the Orinoco, Meta and Bita rivers (Diazgranados 1997, Trujillo 1997, Fuentes 1998, Trujillo *et al.* 2006). Additionally, Galindo (1997) conducted surveys to estimate the abundance of both *Inia geoffrensis* and *Sotalia fluviatilis* in a stretch of the Caquetá River between the Cordoba rapids and the Apaporis River.

All information that has been collected in Colombia has been syntethesized in Table 5 for *Inia geoffrensis* and the maximum number of *Sotalia* dolphins per day and group sizes in different surveyes is presented in Table 6.

In the *Amazon River* the sightings of *Inia* dolphins changed according with the season and the habitat type, being the highest during the low and low to high water periods. The habitat type lake was used more during the high water periods and the habitat type river and main channels during low water periods. Average group sizes were 3.2 dolphins and sizes also changed according with the season (Trujillo 2000). During the high water period, a *Sotalia* dolphin inhabits the main river and channels, in contrary to *Inia* which is mainly distributed in the flooded forest. Group sizes of *Sotalia* vary from single animals in small black water tributaries to groups over 30, especially in lake systems. Vidal *et al.* (1997), estimated the population of this species at 409 (CV=0.13) for *Sotalia* in the Colombian Amazon River, and a density of 8.6 dolphins/Km^2 for lakes.

During April 2002, the density of river dolphins in a stretch of the Amazon river in Colombia was obtained, using the distance sampling methodology (Trujillo *et al.* 2002, 2006a). Density estimates for *Inia* and group sizes were higher in lakes, which are ecosystems highly productive and with high availability of resources all year round (15.8 dolphins/km^2 in the habitat type lake, 3.28 dolphins/km^2 in the habitat type channel, 0.71 dolphins/km^2 in the habitat type tributary, and 0.15 dolphins/km^2 in the habitat type main river). Densities of *Sotalia* dolphins were in general higher than *Inia*, and were also the highest in lakes (26.68dolphins/km^2 in the habitat type lake, 4.12 ind/km^2 in the channel, 3.48 ind/km^2 in the tributaries and 3.02 ind/km^2 in the main river) (Gómez-Salazar *et al*. 2009).

During 2003, photo-identification of *Inia* dolphins was conducted in the peruvian Lake Caballo Cocha in order to estimate density (2.04 ind/Km^2) and the population size (29 individuals +/-18.18) using the mark-recapture tecnique (Gómez-Salazar 2004).

Table 5. Summary of results on surveys to count Amazons river dolphins (*Inia geoffrensis*) in the Amazons and Orinoco basins in Colombia. Data was not obtained (-) in some cases.

Location	Date	Area (linear km)	No. surveys	Number of days	No. sightings	Max. number *Inia* per day	Source
Amazon River Basin							
River Amazon	Feb-Mar-1956	-	-	15	-	14	Layne 1958
	Jul-87	116	12	26	63	12	Trujillo 1990
	Oct-88	40	10	17	57	10	Trujillo 1990
	Dec/93-Jan/95	65	212	120	1420	78	Trujillo & Beltrán, 1996
	May- Jun-1993	120	-	20	172	-	Vidal *et al.* 1997
	Mar/96-Jan/97	74	239	182	963	30	Trujillo 1997
	Mar/97-Aug/98	74	256	220	1034	51	Trujillo *et al.* (unpublished)
Lake Tarapoto and El Correo	Dec/90-Jan/92	40	1329	116	2136	27	Trujillo 1997
River Amazon and Javari	Feb-07	293	5	5	114	60	Gómez-Salazar 2009
River Caqueta	Apr-Jul-1994	1200	248	120	346	45	Trujillo 1995
	May/96-Feb/97	150	229	163	724	22	Galindo 1997
Orinoco River Basin							
Rivers Orinoco, Meta, Bita	Jul/96-Mar/98	150	626	172	833	68	Diazgranados 1997
	Aug/97-Jul/98	150	361	236	654	42	Diazgranados 1998

Location	Date	Area (linear km)	No. surveys	Number of days	No. sightings	Max. number *Inia* per day	Source
Orinoco River Basin							
Rivers Manacacía and La Hermosa	June/July 2004	-	16	-	23	83	Holguín & Barbosa 2005
River Meta	Agosto /2006	790	7	7	31	45	Pardo 2007
River Meta, Yucao and Cusiana	Nov-06	30	5	4	20	27	Trujillo *et al.* 2006
River Arauca	1992-1995	60	119	76	386	53	Trujillo & Beltran 1995
	Jan/97-Apr/98	120	221	117	554	70	Fuentes 1998
Short surveys							
Putumayo River	Sep-97	460	6	7	17	36	Trujillo (unpublished)
River Inírida	Jul-97	130	4	5	7	16	Trujillo (unpublished)
	May-98	130	3	4	7	8	Diazgranados 1998
River Guaviare	May-98	50	3	3	10	30	Diazgranados 1998
River Guayabero	Jun-97	125	2	3	4	9	Trujillo (unpublished)
River Tomo	Jul-98	11	2	3	3	10	Diazgranados 1998
River Meta	Nov-97	485	4	6	14	18	Diazgranados 1998

Table 6. Summary of results on surveys to count Tucuxi dolphins (*Sotalia fluviatilis*) in the Amazons and Orinoco River basins in Colombia. Data was not obtained (-) in some cases.

Location	Date	Area linear (km)	Average group size	Max. number *Sotalia* per day	Source
Amazon River Basin					
Tarapoto and El Correo lakes	1988	13	2.8	10	Trujillo 1990
	1990	13	3.73	35	Trujillo 1990
	1991-1992	13	3.6	32	Trujillo 1992
River Amazon	1994-1995	60	4.3	75	Trujillo & Beltrán 1996
	1996-1997	76	4.3	82	Trujillo 1997, Ramos 1999
	1993	116	3.9	-	Vidal *et al.* 1997
Amazon River/ Yavarí River	2007	293	3.1	93	Gómez-Salazar *et al.* 2009
Caquetá River	1994	60	4.2	52	Trujillo 1995
	1996-1997	60	3.8	39	Galindo 1998
Putumayo River	1997	45	3.2	16	Trujillo (unpublished)

During surveys conducted in the *Caquetá River,* 60 *Inia* dolphins were estimated in the area and the majority of dolphins were seen in pairs and alone. For surveys conducted in the *in the Orinoco, Meta and Bita Rivers,* the maximum number of dolphins reported by day was 65 and most groups were composed of of 4-7 individuals. From the confluence of the Manacacias River (Department of Meta and the tributary of the Meta River) to La Hermosa (Department of Casanare) in the Meta River 83 *Inia* dolphins were sighted during June 2004. During November 2006, in the Meta River from Puerto Gaitán (Meta) to the Cusiana River (Tributary of the Meta River) 27 individuals were sighted in the area, with a density of 0.06 dolphins/km^2 in the main river, 0.13 dolphins/km^2 in the Islands, 0.15 dolphins/km^2 in the channels, and 0.28 dolphins/km^2 in the tributaries (Trujillo *et al.* 2006).

In the Arauca River, surveys conducted between 1997 and 1998 presented 544 sightings of dolphins, and a maximum of 70 *Inia* were observed per day. Similarly to the observation in the Orinoco, Meta and Bita rivers, groups of 4-7 dolphins were the most common.

Surveys conducted in the Meta and Putumayo rivers have the highest values of sightings of dolphins per day. The case of the Inirida River, a black river type, is different. The Inirida is influenced by the Guaviare River (white type) and has the presence of several other lakes.

Habitat use

Based on a scheme of a hypothetical section of a River Basin, density estimates for *Inia* and *Sotalia* for each location and habitat surveyed in Colombia were plotted (Figure 4) (Gómez-Salazar *et al.* 2009). Density in the center of main river was obtained through off-shore line transects and densities in the other habitat types were obtained through 200m strip-width transect surveys, and values are presented for each 50m width strip. Results show that river dolphins prefer areas closer to the shore, as also observed in other studies. Thus, river dolphins occur at higher densities near river margins than in the center of the river, especially those that have low currents with high prey abundance, and in confluences and lakes because of high productivity and fish migrations (Martin & Da Silva 2004; Martin *et al.* 2004, Trujillo 2000, Vidal *et al.* 1997, Aliaga-Rossel 2002, Leatherwood 1996).

Habitat preferences also vary according to the water seasons. In the same year, variation of 11-15m may occur in the vertical level of the Amazon River Basin, and hundreds of kilometers in the horizontal plane. These changes affect dissolved oxygen, fish migrations, habitat availability and productivity and consequently, distribution of river dolphins (Martin & Da Silva 2004, Trujillo 2000).

Data collected from 1996 to 2005 was used to evaluate group sizes and group composition (adults and calves) during hydroclimatic seasons and nine habitat types in the Colombian Amazon. 2,987 groups were registered of dolphins during all these years, with a group size between 1 and 26 individuals. More than the half of sightings (n=1,545), took place in the main river (Amazon River), and the habitat with the fewest sightings was channels (Herrando *et al.* 2005). The hydroclimatic seasons and types of habitat affect directly the group sizes of *Inia* and *Sotalia* in the Colombian Amazon. Both factors interact, revealing spatial and temporary adjustments in the size of the groups (Herrando *et al.* 2005, Trujillo 2000).

Most *Inia* dolphins were sighted in the main river (58.1%) during the low water period, followed by islands and in lakes such as El Correo and Caballo Cocha (22.7%). By the end of October, when the water level started to rise, individuals and groups of dolphins were also present in Tarapoto Lake and connecting channels. During this period aggregations of dolphins were seen regularly (14.6%) at the confluences of the Loreto Yacu-Amazons and Atacuari-Amazons rivers. As the water level increased, during the low to high water period, lakes became the most important habitat for dolphins, and rivers were even less frequented than streams. At that time, rivers appeared to be used by dolphins as a route for moving into their preferred habitats. The presence of *Inia* in lakes was sometimes associated with an increase in the number of fishermen and fish activity suggesting that prey availability was one of the key factors in explaining their presence in these particular areas (Trujillo 2000).

During the high water period, most sightings were conducted in lakes (57%), and groups of juveniles and calves were reported regularly in Tarapoto and El Correo lakes. At the end of this period, in August, dolphins were again present in the main river (25.6%), especially

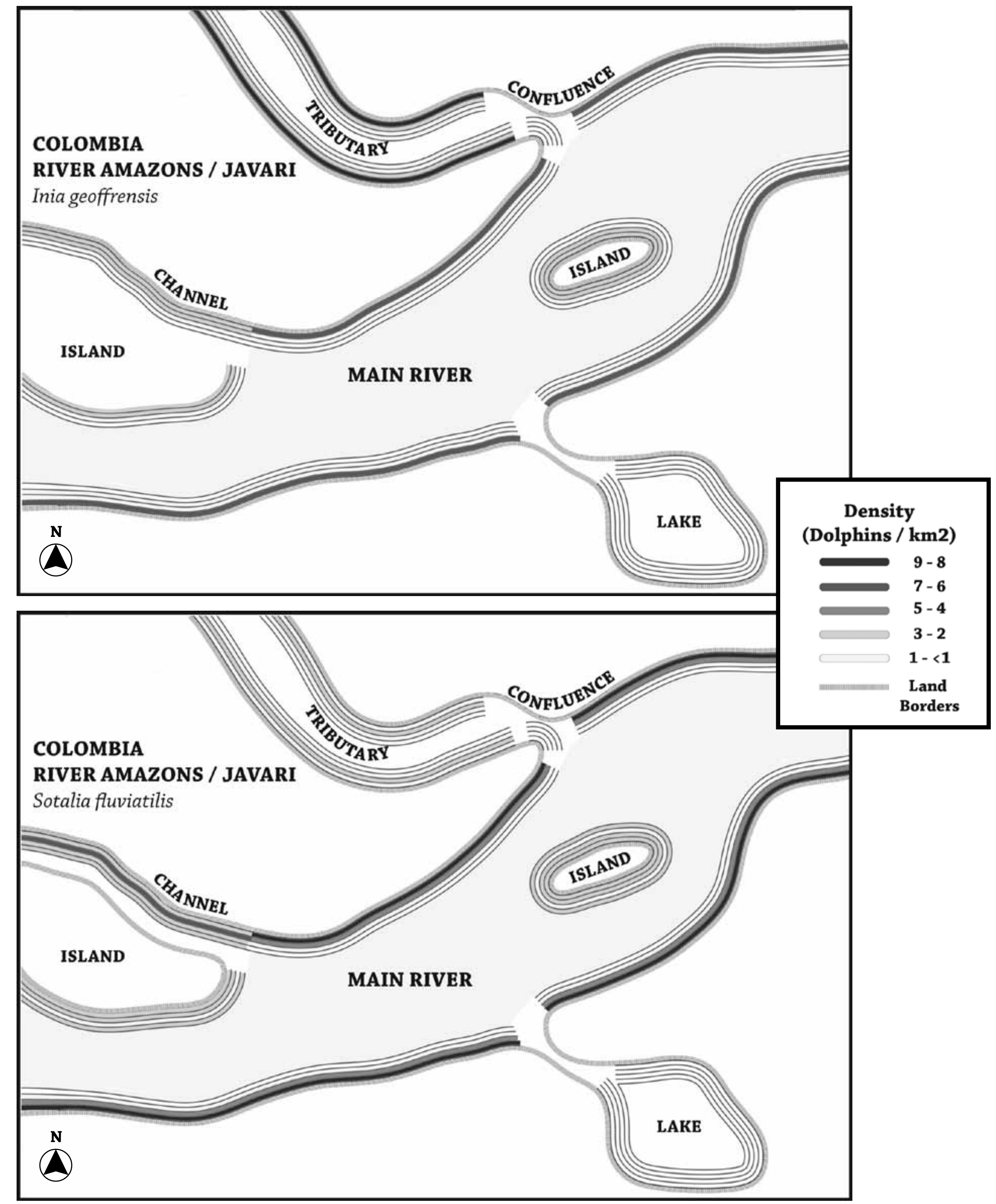

Figure 5. Density of river dolphins presented for each 50m width strip. Data were not obtained on the field or estimated for some habitat types (light fonts) (Gómez-Salazar *et al.* 2009).

around islands. As the level of the water receded during the high to low water period, dolphins were more often seen in the main river than in other habitats. Lakes were still used by dolphins, but movements from Tarapoto to El Correo Lake were noted as a response to the decreasing water level. In contrast, observations in Caballo Cocha Lake were almost the same during all the hydroclimatic periods, with little variation in the number of dolphins.

The presence of certain individuals during all sampling periods in Caballo Cocha Lake (Peru) and Tarapoto Lake (Colombia), suggests the possibility of residency patterns of individuals forming permanent groups (Trujillo 2000, Gómez-Salazar 2004). High productivity of lakes and high availability of resources allows them to act as nursery areas, demonstrated by the high densities of calves in this habitat throughout the whole year. In the lakes, group sizes increase during the dry season, fish are concentrated, and it is easier for them to acquire these resources. Therefore, they use more time in social and reproductive behavior. Lakes are key habitats to take into account for conservation strategies.

In the Orinoco region, surveys were conducted from 1996 to 2004. In contrast to the Amazon, the highest numbers of dolphins were registered at confluences during the low water and low to high water periods. Regular observations of groups of *Inia* were made at the confluence of the Meta and Orinoco rivers. This confluence appears to have a high concentration of fish and dolphins are usually seen feeding. The main river was the second type of habitat in importance during these two periods, with groups of dolphins located especially at two major bends in the river (Figure 5). At high water and high to low water periods, dolphins were more often seen in the main river; with little variation in the areas they used (Figure 4). Confluences were still important, mainly for the transit of dolphins from the Orinoco River to the Meta and Bita rivers. Compared with the Amazon, dolphins occurred more frequently in the same areas in the Orinoco, with some variations when the rivers Meta and Bita were accessible (Trujillo & Diazgranados 2004).

Taxonomic status and Genetics

A considerable amount of molecular phylogeography and population genetics results have been obtained, especially for *Inia geoffrensis* in the Amazon River Basin (including Colombia, Peru Ecuador and Brazil) using different molecular markers, including the mitochondrial Control Region and the cytochrome *b* genes (Banguera-Hinestroza *et al.* 2002), MHC genes (Martinez-Aguero *et al.* 2006), ten autosomic and Y chromosome introns (Ruiz-García *et al.* 2008a), other mitochondrial markers (Ruiz-García *et al.* 2008b), ten DNA microsatellites (Ruiz-García *et al.* 2008c,d) and RAPD (Romero & Ruiz-García, 2008, Ruiz-García & Romero, 2008) as well as for morphometrics (Ruiz-García *et al.* 2006, 2008e) and craniometrics (Castellanos-Mora *et al.* 2008, Ruiz-García *et al.* 2008f), but also initial information on the population structure of *Sotalia fluviatilis* has been described from analyses of Control Region sequences and MHC genes (Caballero *et al.* 2009a, Caballero *et al.* 2009b, Caballero *et al.* 2009c).

Inia geoffrensis. For decades, the taxonomy of *Inia* has been confusing. Hershkovitz (1966) claimed that *Inia* was a monotypic species. Some years later, Pilleri and Ghir (1977) proposed the division of the genus into two different species: *Inia boliviensis* (d´Orbigny 1834), distributed at the Mamoré and Itenez Basins in Bolivia, and *Inia geoffrensis* at the Amazon and Orinoco River Basins. The second species was subdivided in two subspecies: *Inia geoffrensis humboldtiana* at the Orinoco River Basin (Pilleri & Gihr 1977) and *Inia geoffrensis geoffrensis* at the Amazon River Basin (Van Bree & Robineau 1973). Nevertheless, Casinos & Ocaña (1979) refuted the existence of two *Inia* species and recognized three subspecies: *Inia geoffrensis boliviensis, I.g. humboldtiana* and *I.g. geoffrensis,* because the differences found among these three taxa were of clinal nature. However, conversely, Pilleri & Gihr (1981), Grabert (1984) and da Silva (1994) again recognized two species (*I. boliviensis* and *I. geoffrensis*) based on coloration, length-mass ratio, cranial characters including number of teeth, brain size, cephalic index and shape of the sternum. Therefore, molecular population genetics analyses were undertaken to resolve this taxonomic problem in the last few years. For this, the molecular population genetics and evolutionary biology laboratory from the Faculty of Sciences of the Pontificia Universidad Javeriana at Bogotá, D.C. (Colombia) carried out an extensive molecular genetic analysis of *Inia*. Five expeditions were undertaken (2002-2005) to obtain samples of Amazon river dolphins in the rivers of Colombia, Peru, Ecuador, Brazil and Bolivia. More than 10,000 km were covered for these Amazon rivers and about 230 dolphins were sampled.

For the first time, Banguera-Hinestroza *et al.* (2002) obtained molecular data for 96 pink river dolphins, 400 base pairs (bp) from the mitochondrial control region and 600 bp from the mitochondrial cytochrome-*b* gene, and these results showed important insights about the taxonomic status of this river dolphin for populations of the Colombian Orinoco, Colombian Amazon and Bolivian Amazon. The main results obtained in that work were: 1- The Colombian Amazon (Putumayo River) and the Colombian Orinoco samples were highly differentiated from the Bolivian sample for both mitochondrial genes studied (net genetic divergence of 6.53% and 5.32%, and F_{ST}= 0.969 and F_{ST}= 0.917, respectively, for control region and 2.48% and 2.98%, and F_{ST}= 0.91 and F_{ST}= 0.81, respectively, for cytochrome-*b*). Nevertheless, the differences between the Colombian Amazon and Orinoco were significant but considerably weaker (net genetic divergence of 2.50% at control region and 0.06% at cytochrome-b gene). 2- For the Orinoco and the Amazon *Inia*, the haplotypes found showed a paraphyletic phylogenetic relationship. Therefore, this was the first evidence of the inexistence of two fully supported *Inia* subspecies at the Colombian Amazon and Orinoco Basins, contrary to what was previously believed. 3- The Bolivian population showed evidence to be, at least, a different Evolutionary Significant Unit (ESUs) (Moritz, 1994). As a consequence, this pioneer work identified one ESU for the Bolivian Amazon River Basin and another ESU distributed across the Orinoco River and the Amazon River Basins. This is extremely important for conservation purposes. Similarly, other molecular work (Martinez-Aguero *et al.* 2006) showed a different distribution of the haplotypes for a MHC (Major Histocompatibility Complex) gene (DQB1) among pink river dolphins from Bolivia and other points of the Amazon and the Orinoco Basins. Several morphometric and craniometric studies have agreed quite well with these first molecular studies. Ruiz-García *et al.* (2006) showed, by using a canonical population analysis with 12 biometric variables, males from the Colombian Amazon and the Colombian Orinoco were insignificantly differentiated, but the Bolivian males differed significantly from the males of the other two areas. Females showed a more flexible morphology and no clear evidence of significant differences were found among the three geographic areas studied. An additional craniometric study (Castellanos-Mora *et al.* 2008, Ruiz-García *et al.* 2008f) determined no differences for a global set of 50 cranium variables for 28 Colombian Amazon skulls and 16 Colombian Orinoco skulls; however, one Bolivian cranium drastically diverged from these other *Inia* skulls, supporting the results obtained from a molecular perspective. Nonetheless, two evolutionary aspects were unsolved until recently. What are the origins of *Inia*? It was suggested that the Orinoco River Basin was the original place from where *Inia* disperses to other river Basins because of the highest gene diversity levels found at the Orinoco ((Banguera-Hinestroza *et al.* 2002). This was corroborated using polymorphic RAPD (Romero & Ruiz-García 2008). Additionally, we suspected that the temporal split between the Bolivian and the other Amazon form was carried out about 5-6 million years ago. However, recent molecular work contradicted these suspicions. Ruiz-García *et al.* (2008b) showed, via a median joining network using mitochondrial control region haplotypes of almost 200 individuals from Colombia, Venezuela, Peru, Ecuador, Brazil and Bolivia, that an ancestral and very common haplotype is found throughout most of the western and central Amazon and from this all the other haplotypes were originated. Clearly, from the Amazon haplotypes were originated in two different points in time. The time split with regards to the Amazon haplotypes is very recent. Applying a molecular clock to this haplotype network with the rho statistic (Saillard *et al.* 2000), the time split among the Bolivian haplotypes and the Amazon ones was substantially lower than that assumed in the first molecular works (less than 500,000 years ago). Similar results were obtained from the analyses of ten autosomic and Y chromosome introns. The split among the Bolivian form and the remaining forms were less than one million years ago (Ruiz-García *et al.* 2008a). Similar results were obtained when several DNA microsatellites were analyzed in these different *Inia* populations (Ruiz-García *et al.* 2008c) when different mutation rates were estimated for these molecular markers (about 50,000-500,000 years ago for the split among the Bolivian and the Amazon forms). A recent study of the historical demography of *Inia* in different Colombian, Peruvian and Bolivian rivers puts in evidence some traces of recent historical expansions for microsatellites as well as for mitochondrial DNA. Therefore, the taxonomic status of *Inia* is now easy to understand. It was not a Miocene or Pliocene event that generated the current *Inia* forms. All the processes that generated these forms occurred during the Pleistocene. The ancestral form is what we found in the western and central Amazon. From this form, about 50,000-500,000 years ago, was derived the Bolivian form, which is completely isolated from a reproductive point of view and must be considered at least as a different ESU, although its separation is more recent than that previously believed. On the other hand, the Orinoco lineages were generated twice from an ancestral Amazon lineage very recently (14,000-30,000 years ago) in an independent manner. Thus, each form constitutes a unique taxa and no subspecific denominations are required.

Sotalia fluviatilis. Since this species was documented by Alexander von Humboldt, its taxonomy has been controversial. Since 1800, this species has received more than five taxonomic denominations; Gervais named the species, in 1853, *Delphinus fluviatilis*. The same author, in 1855, named it *Delphinus pallidus,* and, in 1856, Gray described three individuals originally named *Steno tucuxi,* those individuals were later reclassified within the *Sotalia* genus by Flower in 1883. However, it was Gray, in 1866, who defined the genus *Sotalia* for the first time based on a cranium from French Guyana and the specimen was named as *Sotalia guianensis* (Hershkovitz 1966). Additionally, van Bénéden, in 1875, defined the dolphins restricted to Guanabara Bay in the Rio de Janeiro state as *Sotalia brasiliensis.* Hershkovitz (1966) determined that *Sotalia fluviatilis* was synonym of *Sotalia pallida* and *Sotalia tucuxi*. Recently, however, diverse studies have been developed showing a clear perspective of the *Sotalia* taxonomic status. Monteiro-Filho *et al.* (2002) analyzed 22 homologous cranial landmarks and showed shape differences among riverine and marine populations of *Sotalia* to be highly significant (P < 0.00001). They suggested that they constituted two different species: *Sotalia fluviatilis*, for the riverine ecotype and *Sotalia guianensis* for the marine ecotype. Several years later, Cunha *et al.* (2005) reached the same conclusion. By studying mitochondrial DNA control region and cytochrome *b* sequences and applying a nested-clade phylogenetic and a molecular variance analyses, they showed that marine and riverine ecotypes formed divergent monophyletic groups. Recently, Caballero *et al.* (2007) conducted a study to re-valuate the taxonomic status of the genus *Sotalia.* Results of this study confirmed the differentiation between the “costero” (now named Guiana dolphin (IWC)) *Sotalia guiannesis* (recently known as *Sotalia fluviatilis guianensis*) and the “tucuxi” or riverine *Sotalia fluviatilis* (recently known as *Sotalia fluviatilis fluviatilis*). Additional mitochondrial and novel nuclear genetic evidence supported both subspecies as full species based on the criteria of the GCC (Genealogical/Lineage Concordance Species Concept), and proposed a divergence time of 1.0 – 1.2 mya for these species. Divergence is considered as irreversible, from evidence provided by ecological adaptations to the two different habitats – marine and riverine. There is a physical isolation of both species with a little overlap in the mouth of the Amazon River and Amazon estuary. Hybridization could not be excluded, but to date, there is no conclusive evidence.

Sotalia fluviatilis it is now a unique riverine species presented in Ecuador, Peru, Colombia and Brazil.

High genetic diversity was determined when analyzing an initial set of 26 samples from Colombia, Brazil and Peru for a portion of the mitochondrial control region. Some differentiated haplotypes were detected in Peruvian and Brazilian samples, from locations in the extremes of the species distribution. Female mediated gene flow seems to be relatively high along the main river system, so maintaining connectivity would be the key to conserve healthy populations (Caballero *et al.* 2009a, Caballero *et al.* 2009b). An initial study of two MHC loci (DQA and DQB) described two alleles found in Amazonian populations. These are shared with coastal populations. This was expected due to the mode of evolution of these genes (Caballero *et al.* 2009c).

Anthropogenic threats for river dolphins in Colombia

Incidental mortality

Incidental catches were an important threat for *Inia* in the Colombian Amazon (Beltrán & Trujillo, 1992, Kendall *et al.* 1998). New fishing techniques have been introduced in the Amazon River Basin during the last few years, especially the use of nylon monofilament gill nets (da Silva and Best, 1996), that in the context of a growing human population mean more negative interactions between dolphins and fisheries.

In 80 linear km surveyed in the Amazon River, 30 dolphins were found dead (22 *Inia* and 8 *Sotalia*) over a period of 10 years (1990-2000). The causes of death for *Inia* were entanglement (19), impact with a boat (1), harpoon (1), and not determined (1). In 1993, the community of Puerto Nariño agreed to forbid the use of nets in lakes and small tributaries with the aim of conserving both dolphins and fisheries. Since then, surveys have regularly been made along the study area and local communities have been encouraged to provide information about dead dolphins. Mortality of dolphins has been reduced to one or two deaths each year in the Colombian area (Kendall *et al.* 1995, Trujillo 1997).

Castellanos (2007) evaluated the impact of fishing nets in the populations of *Inia*, using the parameters of age and craniometrical relations. Juveniles and calves were the individuals more affected and most of the nets were placed in lakes and small tributaries, where in theory they are forbidden. It was recommended to work with fishermen communities in different areas of the Amazon and Orinoco Basins, to develop agreements and stop the use of nets in lakes, confluences and small tributaries.

During the last fourteen years, fishermen perspectives about river dolphins in the Amazon have been changing. They consider dolphins as competitors for resources, when they remove or injure fish that are in the nets. As a response, fishermen may shoot, poison, or hit dolphins to discourage their loitering next to the nets. There is an increase in demand for fish in the region, in turn encouraging people to increase the effort put into large catfish fisheries (*Brachyplatystoma filamentosum, B. flavicans,* and *Pseudoplatystoma* sp.). However, other elements have been identified as being responsible for a decrease in the capture rate of fish: overexploitation due to more people using long drift nets, and damage to the fish produced by the fish known as "carnero or candiru" (*Vandellia cirrhosa)* (Bonilla *et al.* 2008).

During September 1996 and February 2000, 14 dolphins were found dead in the Orinoco study area. The causes of mortality were shooting (5), entanglement (5), harpooning (1), and not determined (3). In addition, ten other dead dolphins were reported by the Navy and local fishermen. Shooting of river dolphins was also reported by Lamb (1954) and Leatherwood (1996). There is great concern regarding deaths due to shooting, because Giant Otters (*Pteronura brasiliensis*) and Spectacled Caimans (*Caiman crocodylus*) have also been found dead for the same cause. Three of the four individuals found shot had nylon net marks on their snouts, flippers and the tail, suggesting that some fishermen shoot dolphins which get caught in their nets, as other fishermen reported. As in the Amazon, negative interaction with fisheries appears to be the main threat to dolphin populations in this area.

Other threats include direct hunting of dolphins. During the 1950s, '60s and '70s, several Amazon dolphins were captured alive in Colombia. They were initially taken for zoological collections in the United States and Europe, and later in the '70s by illegal poachers (Layne 1958, Caldwell *et al.* 1989, Gewalt 1989).

Tucuxi are extremely vulnerable to monofilament nets (Da Silva & Best 1994) and they are particularly vulnerable to negative

interactions with fisheries. In the Amazon, ten Tucuxi were found dead mainly due to entanglement in monofilament nets (Trujillo & Beltrán 1992, Trujillo 1997, Galindo 1997). This kind of net is becoming more common in the Amazon, despite the fact that it is forbidden in lakes and small tributaries.

Direct hunting of river dolphins

Cultural beliefs around river dolphins are predominant in the Amazon and Orinoco Basins and it protected them from direct exploitation for a long time. However, back in the 1980s, organs of *Inia* were sold at the black markets as aphrodisiacs or to cure diseases (Trujillo 1992, Da Silva & Best 1989). The proportion of dolphins that were used for that purpose was not calculated and there are no reports of the continuity of that market.

In Colombia, dolphins were killed in order to sell their body parts (including eyes, teeth, genital organs and oil), which were used as aphrodisiacs and amulets in Leticia (Amazonas) and Puerto Carreño (Vichada) (Trujillo 1990, Diazgranados 1997). The oil was used to treat respiratory diseases. There are reports of sporadic consumption of dolphin meat by fisherman in some areas of the Orinoco such as Puerto Carreño and Amanaven. In the Orinoco, there are also records of the use of dolphin oil, and bottles of oil that can be found in markets in Puerto Carreño (Colombia) and Puerto Ayacucho (Venezuela)(Trujillo & Diazgranados 2002).

Overexploitation of the resources has also generated a new phenomenon that is appreciable in different aquatic environments changing the target species for smaller ones down in the food web (Myers &Worm, 2003). During the last 8 years, the Mota fish (*Calophysus macropterus*) have appeared in the national market of Colombia, replacing the capaz fish *(Pimelodus grosskopfii)* that inhabited the Magdalena river in Colombia but it was depleted. To catch the mota fish, river dolphins and caimans are being captured in the Brazilian Amazon to be used as bait to attract and fish the scavenger fish (Trujillo *et al.* 2005, Trujillo *et al.* 2006, Gómez-Salazar *et al.* 2008) and captures of dolphins are increasing resulting in serious threats (Da Silva & Martin 2007).

This activity takes place in the Brazilian Amazon where different links make part of the base for distribution and commercialization of the fish: starting with the dolphin hunters, the Mota fishermen, the different gathering centers along the Amazon River, and it finishes with the ship carriers that transport the Mota fish to Leticia and later to the principal cities of Colombia. Consumers of the Mota fish in the principal cities of Colombia are not aware that they are eating a scavenger species that comes from the Amazon River Basin (instead of the Magdalena river) and they do not know that river dolphins and caimans are being killed in order to fish it (Gómez-Salazar *et al.* 2008). Actually the fishermen and traders of the Mota fish confirm that almost 80% of their production is Mota fish.

This kind of fishery is drastically reducing the populations of river dolphins in the Amazon region of Brazil. Approximately 600 hundred river dolphins are being killed per year to be used as bait for this fishery, which is widespread in Brazil (Loch *et al.* 2009). It is of serious concern that this activity may also occur in other countries. If the killing of river dolphins spreads from Brazil to other countries, population sizes will likely decline within a few years.

Initiatives to stop this killing and to implement alternatives of bait have being presented to fishermen and traders since 2005, but no results have been seen yet. Foundation Omacha in partneship with the Fisheries Institutions in Colombia and Brazil are designing new strategies and campaigns to deal with this issue.

Habitat degradation

About 40% of the 400,000Km² of the Colombian Amazon is protected within National Parks and Reserves. However, much of the remaining 60% is under pressure due to the encroachment of ranchers and settlers (Moreno *et al.* 1989). The ongoing construction of new roads to open up areas in the Amazon and Orinoco regions encourages migrants to move into the eastern plains and forests of Colombia. According to Andrade (1992), settlement has increased since the 1980s in the Amazon. As a result, every year, thousands of hectares of forest are cut down for timber and farming. Burgess (1993) estimated that 0.85% of Colombia's forest cover was cleared annually between 1981 and 1990. The annual deforestation rate of the Amazon in Colombia is estimated to be 2.2% per year (Myers 1989).

Cattle ranching, in particular, involve clear-cutting and the replacement of forests with vast areas of pasture. For example, Myers (1989) estimated that 14,500 square km of forest were cleared for cattle ranches by 1985, just in the Caquetá Department (state). Some regions, such as Guaviare, are under pressure from the growth of the international cocaine market, with large plantations of coca in the middle of the forest (Myers 1989). In many cases trees are removed from the riverbanks destroying their benefits in the ecosystem, such as the prevention of erosion by their roots and the availability of seeds and fruit needed to support fish populations.

Rice farming has been developing over the last 10 years, and also constitutes a threat to natural ecosystems. Colombian and Peruvian people remove floating grass (*Paspallum* sp.) from around islands in the Amazon River to gain access to crops, but this takes away the natural protection against erosion and inhibits normal succession processes on such islands. It also leads to the loss of the high biomass concentrations provided by the grasses, which are important for both fish and dolphins (Goulding 1989, Jiménez 1994).

Dams are also a threat to river dolphins due to population fragmentation (Reeves & Leatherwood 1994). In Colombia the construction of small-scale dams for supplying local power has been proposed. This would involve a series of dams and hydroelectric plants, with at least one dam on the Colombia-Venezuela frontier at the Atures rapids near Puerto Ayacucho. As these rapids are passable for *Inia* only during one season of the year, a dam would affect dolphin movements. This will also alter flooded cycles, and therefore, productivity in the river systems.

Another water development project has been proposed by the Colombian government to recuperate the navigability in the Meta River by the construction of a hydroway that will allow the transportation of large vessels all year round. If this goal is accomplished by the government, this river will become the connection between Bogotá, D.C. and the main cities of the interior of Colombia with the Atlantic Ocean. The environmental problems of this project would affect the changes in the water level of the river, which will impact the productivity and therefore, the availability of resources for communities and wildlife. This project also plans to build at least three big ports on the shore of the Meta River and in the confluence of the Meta with the Orinoco River. This will cause the fragmentation of populations and degradations of the environment.

Pollution

Levels of pollution related to human activities vary throughout the Amazon and Orinoco in Colombia. The Arauca and Casanare rivers are occasionally affected by oil spills resulting from guerrilla attacks on the main pipeline and accidental discharges. Caño Limon pipeline has been bombed and mined 473 times since it was completed in 1986. There were 47 attacks in the first 6 months of 1997. The 1.5 million barrels of oil that were spilled in the bombings have caused irreparable pollution to the aquatic ecosystem. They constitute the sixth largest oil spill in history and the largest for continental waters (Viña *et al.* 1992).

Mining activities also pollute rivers such as the Putumayo, Guaviare and Taraira in Colombia, where unknown quantities of mercury have been discharged during gold mining. Both military patrols and guerrilla presence have controlled mining to some extent. The amount of mercury discharged annually in Brazilian gold mining areas is estimated at 120,000 kg/yr., mainly in the form of methylmercury. This presents a serious threat to people and to dolphins and otters, as they are the top predators in the aquatic ecosystem (Martinelli *et al.* 1988, Rosas & Lehti 1996, Gutleb *et al.* 1997). Some researchers have pointed out that mercury pollution extends far beyond gold mining areas because of the dispersion of sediment and fish migrations (Villas Boas 1997).

During 2004 and 2005, the concentration of mercury in the tissues of commercial fish in the Orinoco River Basin was conducted, showing that there is a problem of toxicity caused by mercury in the Orinoco watershed (Trujillo *et al.* 2005). Samples of tissue where taken in Colombia in Puerto Lopez (Meta River), San Jose del Guaviare (Guaviare River), Puerto Carreño (Orinoco River) and Puerto Inírida (Inirida, Guaviare and Orinoco Rivers). The Venezuelan samples were obtained from the confluence of the Ventuari and Orinoco River, the Orinoco River and in the Apure River. Fish with high concentrations of mercury in their tissues (concentrations that are in excess of 5 times the amount allowed by the World Health Organization) were found in this region, despite the fact that samples were collected in areas far away from the mining centers.(Trujillo *et al.* 2005, Trujillo *et al.* 2008). The top predators of the food webs, such as river dolphins and humans, consume these species.

Other sources of pollution include pesticides (DDT is still used in some parts of Colombia) which are applied to rice crops; chemicals such as sulphuric acid and acetone, used in illegal drug production; and hydrocarbons, sewage and solid waste discharges from towns and river ports. In the Orinoco, cotton and watermelon crops are commonly planted on the riverbanks and on emergent islands during the low water season, and in the Meta River, for instance, farmers use chemicals such as DDT (Diazgranados, 1997).

Boat traffic

Acoustic pollution also affects the communication processes of dolphins (Gordon & Moscrop 1996). *Inia* avoid areas with increasingly heavy cargo and passenger traffic, but no serious research has been conducted to examine this potential threat (Trujillo, *comm. pers*). The increase of the number of boats, both commercial and recreational vessels, and their size and speed on most of the rivers, could influence dolphin activities in the future. For example, in the study area in the Orinoco,

Table 7. Threats for river dolphins in Colombia.

Threats	Location	Description
Direct		
Interactions with fishermen	Rivers Amazon, Putumayo, Caquetá, Meta and Orinoco	Competition between dolphins and fishermen for the same resource. This makes fishermen to wound or kill dolphins to get them out of the fishing areas.
Bycatch - Accidental killing	Rivers Amazon, Putumayo, Caquetá, Meta and Orinoco	Incidental catches especially during transitional seasons and mainly in monophylament nets. Juveniles and calves are more suceptible
Deliberate killing	Rivers Putumayo, Meta and probably in the Amazon	The killing and posterior use of dolphins decomposed flesh to catch the scavenger catfish Mota
Indirect		
Habitat degradation	Rivers Meta, Casanare, Amazon, Putumayo and Caquetá	Due to deforestation and overfishing
Indirect		
Pollution by Mercury	Rivers Amazon, Meta, Inírida, Caquetá, and Guaviare	There is only gold mining in the rivers Caquetá and Inírida but high concentrations of mercury has been found on fish in most rivers of the Amazon and Orinoco basins, especially in those that are migratory
Hydro ways	River Meta	There are plans of modification of the flooded pulses for the river Meta to make navigation possible along the year
Boat traffic and unregulated tourism activities	Rivers Amazon, Meta, Putumayo and Orinoco	There is a steady increase on boat traffic in several rivers of the Amazon and Orinoco basins

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there is continuous boat traffic between Puerto Carreño and Puerto Paez-El Burro (Venezuela). Each day approximately 20 speedboats (with 45 to 200HP out-board engines), cross the Orinoco and Meta rivers up to 100 times per day. This area is only about 1 km^2 and appears to be very important for dolphins, with regular sightings of groups of up to 40 animals. Most boat drivers admitted to having collided with dolphins on at least one occasion.

A study conducted in the Colombian Amazon suggests that there are differences in the response of the dolphins to the boat traffic, and, in the short term, there is an influence of the boat traffic on the dolphin's shallow water behavior that includes activities as feeding, reproduction and resting (Mejia 2001, Acosta 2002). Moreover, *Sotalia* dolphins appear to respond more evasively than *Inia* to the offshore engines.

Tourism

There has been a growing awareness that cetacean tourism, like tourism of all kinds, may act as a conservation strategy. However, intensive, persistent, and unregulated vessel traffic that focuses on animals while they are resting, feeding, nursing their young, or socializing can disrupt those activities, and possibly cause long-term problems for populations (Reeves *et al.* 2003). Nevertheless, organized ecotourism created accordingly with results about the status of the populations, may be used as a helpful strategy to point some attention on these ecosystems through charismatic species that may act as key species for the conservation of river Basins. At present, river dolphins has a huge potential in the Colombian Amazon, and 90% of about 28.000 tourist per year agreed that one of the main motivations to travel to the Amazon is dolphin watching (Trujillo, 2009), generating almost US$ 6 million per year (Hoyt & Iniguez 2008, Trujillo 2009). However, the legislation is not clear about these activities in Colombia, and if this activity is recommended without a monitoring and controlled program, it may become another threat instead of a solution.

Legislation and red list categories

Sotalia is listed in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). *Inia* is listed in Appendix II of CITES and it is also listed in Appendix II of CMS (Convention on Migratory Species). The UICN red list of threatened species listed *Inia* and *Sotalia* as "Data Deficient" (Reeves *et al.* 2008). In the Red Book of Mammals of Colombia (Rodríguez-M. *et al.* 2006), both species are listed as Vulnerable.

Many organizations and international agreements may play an important role in the conservation of *Inia*, including the World Heritage Committee (WHC), the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (NPWH), the Ramsar Convention and the Amazon Cooperation Treaty (Best & da Silva 1989b).

The management and conservation of cetaceans and sirenians are covered in the Decree 1608 of 1978 under Article 5 of the Code of Natural Resources of the Colombian Government. The law also contains a chapter controlling the hunting, sale and scientific catch of wild animals. However, the implementation of this legislation is limited by infrastructure deficiencies, including (i) the lack of formal procedures for enforcement, (ii) the lack of appropriate enforcement agencies and (iii) limited expertise within those agencies that do exist.

Recently, Colombia implemented the New Penal Code that include for the first time, penalties in money and jail for people that threaten endangered species such as river dolphins. In the same way, two regional Action Plans for Aquatic Endangered species have been published in Colombia, including river dolphins (Trujillo *et al.* 2008b).

Conservation initiatives in Colombia

Protected areas

The Amazon River dolphin is in theory fully protected in part of its habitat by Natural Parks and Natural Reserves in Colombia. There are 5,898,375 hectares of protected area covering both the Amazon and Orinoco regions where the species occur (Table 8). Additionally, an important percentage of remaining territory corresponds to Indigenous Reserves (129 reserves and special territories), where exploitation of natural resources occurs in a more rational basis (Caja Agraria *et al.* 1990).

Action Plans

Some action plans has been developed during the last three years that included river dolphins. The first one corresponded to an action plan for aquatic threatened species in the Amazon region: river dolphins, manatees, otters, turtles and black caimans (Trujillo, *et al.* 2008a). Some of the recommended actions were undertaken through a partnership between several organizations around a project called FACUAM (Actions for the use and conservation of threatened aquatic fauna in the Colombian Amazon). The same year that the Action Plan for the Conservation and Management of endangered species in the Biosphere Reserve El Tuparro in the Colombian Orinoco was published and included among the endangered species is the river dolphin (Trujillo *et al.* 2008b). The implementation of this plan has been developed during the last two years, where meetings with governmental entities and tourist guides were held. Protocols of dolphin watching were formulated and socialized with boat drivers and tourist guides in the region. Also, scientific studies of photo/identification are being carried out in the area of Puerto Carreño (Vichada). This Action Plan is included in the "Regional Action Plan for the Biodiversity of the Orinoco River Basin in Colombia (PARBO, 2005).

Table 8. Existing protected areas where river dolphins occur in Colombia. P.N.N. corresponds to Natural Parks and R.N.N. to Natural Reserves.

Name of the Park	Area (ha)	River System
P.N.N. Amacayacu	293,500	Amazon
P.N.N. Cahuinarí	575,500	Caquetá
P.N.N. Chiribiquete	1,280,000	Apaporis, Mesay, Yarí
P.N.N. La Macarena	630,000	Guayabero, Ariari, Duda
R.N.N. Nukak	855,000	Inírida
P.N.N. La Paya	422,000	Putumayo
R.N.N. Puinawai	1,092,500	Inírida
P.N.N. Tinigua	201,875	Guayabero
P.N.N. Tuparro	548,000	Orinoco

At present, the National Action Plan for Aquatic Mammals in Colombia is being designed by governamental and NG organizations, and includes most of the recommendations of the South American River Dolphins action Plan.

Cultural beliefs

Some local beliefs and legends help to protect dolphins in the Amazon. Such beliefs are being diluted as new settlers move in, but there are some areas where indigenous communities maintain cultural traditions and attitudes to resource exploitation (Kendall & Trujillo 1992; Kendall 1999). For example, most indigenous communities have strong taboos against eating dolphin meat, perhaps because dolphins are often thought to be magical creatures that can transform into humans and vice versa. Killing or injuring a dolphin can bring sickness and other misfortunes; on the other hand shamans sometimes invoke dolphins to eliminate illness.

Fishermen have different attitudes toward the tucuxi and the bufeo. They argue that the tucuxi is friendly and helps fishing by driving the fish toward the nets, while bufeo is considered to be a serious competitor.

In the Amazon, the dolphin-watching tourism industry has been growing rapidly during recent years. Regional and national educational campaigns to conserve river dolphins increased primarily because local communities and tourists have become interested in aquatic fauna and secondly because it allowed the renewal of indigenous beliefs about the aquatic world. This is important as many families have started to produce traditional woodcarvings of animals, especially dolphins, as an alternative source of income.

Education

Along research studies, educational programs to encourage the protection of dolphins and their habitat have also been carried out in the Amazon, Caquetá, Orinoco and Arauca study areas and at the national level as well (Trujillo 1990, Galindo 1997, Diazgranados 1997, Fuentes 1998). This educational work included discussions, consultations, workshops and meetings in local communities (particularly with fishermen, tourist guides, the relevant authorities and children). Outside the project areas, education efforts were directed primarily at schools and the media. During the last six years a concerted national campaign has been made by the Foundation Omacha distributing school exercise books over the whole country. These exercise books have pictures of dolphins on the cover and biological and conservation information inside. Additionally, the most important editorial scholar in the country made a book series for the first five degrees of basic school based on endangered species in general, and river dolphins in particular.

The Foundation Natutama has created an interpretation center in the town of Puerto Nariño, in the Amazon region. It has developed a strong education program involving local schools and researchers from the community while at the same time, educating an important number of tourists that leave the Amazon with a clear perspective of the importance of river dolphin and aquatic conservation. Celebrations such as the "Day of the Dolphin and other aquatic creatures" in Puerto Nariño, Colombian Amazon, every February 2nd, are initiatives from the Foundation Omacha that complement those education efforts with schools and local communities.

Conservation status of river dolphins and general remarks

River dolphin populations are vulnerable in Colombia and it is necessary to continue monitoring closely the status of the populations.

For instance, density estimates obtained in the river Meta were very low, and it is of serious concern that the local distribution of river dolphins in the upper part of the Meta river is changing, probably due to human disturbance. In addition, the possibility of future macroprojects such as hydroways may change rapidly the conditions in aquatic systems.

In addition, management plans in many riverine systems in Colombia are necessary in order to avoid the overexploitation of fisheries and other aquatic resources, which may disrupt local comunities and wildlife in general. Negative interactions with fisheries and direct hunting of river dolphins can cause the decline of river dolphin populations within a few years, therefore, it is of particular interest to promote alternatives and conservation actions.

Important steps for conservation of these species have been adopted by the government and local communities with recognition of their ecological, social and economic importance. River dolphins have become emblematic species to promote the conservation of aquatic ecosystems in the Amazon and Orinoco, and have encouraged the evaluation of fisheries, pollution by mercury and even promotion of designation of protected areas (RAMSAR sites) in aquatic ecosystems.

Long term education efforts have also allowed a positive change in the attitude of local people toward the dolphins, and in some cases have promoted economic alternatives such as dolphin watching in the Amazon with production of US$ 6.6 per year (Hoyt & Iñiguez 2008).

Conservation efforts for river dolphins in Colombia are strongly connected with holistic approaches in the Amazon and Orinoco, always involving local communities and proposing economic alternatives.

Scientific research in Colombia has covered the most important rivers both in the Amazon and Orinoco River Basins over 20 years of continuous research. However, it is necessary to develop a standardized program, and to publish results using statistically robust methodologies.

The river dolphin program in Colombia has been useful to train more than 45 scientists. These scientists have in turn, applied these research techniques in their respective countries: Venezuela, Ecuador, Peru and Bolivia.

The communication strategy around river dolphin conservation has encouraged the support of the Government to propose and implement Action Plans in Colombia.

Recommendations

Research

- To estimate population parameters (population size and density) and to conduct genetic studies in the Putumayo and Guaviare rivers.
- To evaluate the effect of tourism and fisheries in river dolphin populations. This can be investigated by conducting standardized research on aspects related to residency patterns, social structure and acoustics, in order to increase the knowledge in the ecology of this species, and to evaluate the human disturbance at different levels.
- To monitor the density and population size of river dolphins in key areas where conflicts with fisheries or other serious threats occur.
- Evaluate the effect of climate change upon river dolphins and their prey.

Education

- Consolidate an education program around river dolphins in Colombia and replicate initiatives at the interpretation center in Puerto Nariño (Fundación Natutama).

Conservation

- It is necessary to have an action plan for fisheries both in the Amazon and Orinoco (working together with Venezuela, Brazil and Peru) and to include river dolphins and other aquatic species.
- Undertake a public campaign to stop the trade of the mota fish (*Calophysus macropterus*) until the deliberate killing of river dolphins stops.
- Develop alternative baits to catch the mota fish.
- Develop and consolidate economic alternatives such as dolphin watching and wood carving.

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1.3. Ecology and conservation status of river dolphins *Inia* and *Sotalia* in Peru

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Abstract

Information on the ecology and conservation status of river dolphins found in Peru, *Inia geoffrensis geoffrensis* and *Sotalia fluviatilis fluviatilis,* is patchy. Results of studies conducted in the Pacaya-Samiria National Reserve between 1991 and 2000 form the basis of information for this paper. Encounter rates for *Inia* and *Sotalia* in the Pacaya-Samiria Reserve were within the range of encounter rates for these dolphins elsewhere in South America. Studies to monitor river dolphin population size should take into account the high degree of yearly, intra-seasonal, and daily variability of river dolphin counts and sampling should occur frequently. The majority of *Inia* and *Sotalia* were seen within 100 m from shore. Most large groups were seen in confluences areas or around mid-channel islands or bends in rivers. *Inia* were found in rivers as shallow as 2.3-m, and *Sotalia* in rivers as shallow as 3.5-m. *Inia* and *Sotalia* were found in lakes as shallow as 1.5-m. River width was related to the abundance of

Sotalia, but not of *Inia*. *Inia* were more common in blackwaters than in whitewaters, and *Sotalia* abundance was not associated with water type. Encounter rates were highest in confluences, intermediate in lakes, and lowest in rivers. *Inia* occurred in higher densities than *Sotalia* in all lakes, confluences, and most rivers. Neonates of both species were absent from the Marañón River and from tributaries <50 m. In general, encounter rates of dolphins in rivers and lakes did not differ among seasons. *Inia* were seen most often as single animals and *Sotalia* were seen most often as singles/pairs. Eleven dead dolphins were examined. Intentional poisoning was the likely cause of death for seven of the dolphins. Mating and calving were observed to occur year-round, with *Inia* calving peaking somewhat during falling water, and *Sotalia* calving increasing slightly during high and low water. Major threats to river dolphins in Peru are entanglement in fishing equipment and poisoning by fishermen. As of 2000, river dolphin populations in the study area of the Pacaya-Samiria Reserve appeared to be relatively healthy. Studies indicate that population numbers were stable between 1991-2000.

Resumen

Inia geoffrensis geoffrensis y *Sotalia fluviatilis fluviatilis* se encuentran en Perú, donde la información sobre su ecología y estado de conservación es dispersa. Los resultados de estudios realizados en la Reserva Nacional Pacaya Samiria entre 1991 y 2000 son la base para la información de este artículo. Las tasas de encuentro *Inia* y *Sotalia* en el Pacaya Samiria se encuentran dentro del rango para estos delfines en otros lugares de Suramérica. Los estudios de monitoro de las poblaciones de delfines de río, deben tomar en cuenta la alta variabilidad anual, intra-estacional y diaria que se presenta en los conteos de delfines de río y el muestreo debe realizarse de manera frecuente. La mayoría de individuos de ambas especies fueron observados dentro de un rango de 100 m con respecto a la orilla. Los grupos de mayor tamaño fueron vistos en las confluencias y alrededor de los canales o curvas de baja corriente cercanos a las islas. *Inia* fue encontrada en ríos a profundidades de 2.3 m, y *Sotalia* en ríos a profundidades promedio de 3.5 m. Ambas especies fueron encontradas en lagos con profundidades de 1.5 m. El ancho del río está relacionado con la abundancia de *Sotalia*, pero no con la de *Inia*. *Inia* es más común en aguas negras que en aguas blancas, y la abundancia *Sotalia* no está asociada con el tipo de aguas. Las tasas de encuentro fueron más altas en las confluencias, intermedias en los lagos y más bajas en los ríos. Las densidades de *Inia* fueron mayores con respecto a los valores para *Sotalia,* en todos los lagos, confluencias y en la mayoría de los ríos. Tanto en el río Marañón como en tributarios de un ancho menor a 50m no se vieron neonatos de ninguna de las dos especies. En general, las tasas de encuentro de delfines en ríos y lagos no difiere entre las estaciones hidroclimáticas. Se observaron con mayor frecuencia individuos solitarios de *Inia* y para el caso de *Sotalia* se observaron individuos solos o en parejas. Once individuos muertos fueron examinados. Envenenamiento intencional fue la causa de muerte de siete de estos individuos. La época de reproducción y nacimiento de crías ocurrió a lo largo del año, con *Inia* el pico de nacimiento de crías se observó durante la época de lluvias, y para *Sotalia* los nacimientos se incrementaron durante la época de de aguas altas y bajas. Las mayores amenazas para los delfines de río en Perú son el entallamiento en redes de pesca y el envenenamiento por pescadores. Para el 2000, la población de delfines de río en el área de estudio del Pacaya Samiria es aparentemente buena. Entre 1991 y el 2000 los números poblacionales se encuentran estables.

Resumo

Inia geoffrensis geoffrensis e *Sotalia fluviatilis fluviatilis* são encontrados no Peru, onde informações sobre a ecologia e o status de conservação destes golfinhos de rio são dispersas. Resultados de estudos realizados na Reserva Nacional Pacaya-Samiria entre 1991 e 2000 formam a base das informações para este artigo. As taxas de encontro para *Inia* e *Sotalia* na Reserva de Pacaya-Samiria estiveram dentro dos limites de taxas de encontro para estes golfinhos em outros locais da América do Sul. Estudos para monitorar tamanho populacional de golfinhos de rio deveriam levar em conta o alto grau de variabilidade anual, intra-sazonal e diária das contagens de golfinhos de rio e amostragens deveriam ocorrer frequentemente. A maioria de *Inia* e *Sotalia* foram vistos dentro de 100 m da margem. A maioria dos grandes grupos foram vistos em áreas de confluência, ou ao redor de ilhas dentro dos canais ou nas curvas dos rios. *Inia* foi encontrada em rios a profundidades rasas de 2.3-m, e *Sotalia* em rios a profundidades rasas de 3.5-m. *Inia* e *Sotalia* foram encontrados em lagos a profundidades rasas de 1.5-m. A abundância de *Sotalia* foi relacionada com largura dos rios, mas não para *Inia*. *Inia* foi mais comum em águas pretas do que em águas brancas, e a abundância de *Sotalia* não foi associada com o tipo de água. Taxas de encontro foram mais altas em confluências, intermediárias em lagos e mais baixas em rios. *Inia* ocorreu em maiores densidades do que *Sotalia* em todos lagos, confluências e na maioria dos rios. Neonatos de ambas as espécies foram ausentes no Rio Marañón e em seus tributários <50m. Em geral, taxas de encontro de golfinhos em rios e lagos não diferiram entre estações. *Inia* foram avistados com mais freqüência como indivíduos solitários e *Sotalia* foram avistados mais frequentemente como solitários/em pares. Onze golfinho mortos foram examinados. Envenenamento intencional foi provavelmente a causa da morte de sete dos golfinhos. Acasalamentos e nascimentos foram observados durante o ano todo, com nascimentos de *Inia* com pico levemente durante a vazante, e nascimentos de *Sotalia* aumentando ligeiramente durante águas altas e baixas. A maioria das ameaças aos golfinhos de rio no Peru são captura em redes de pesca e envenenamento por pescadores. Como no ano de 2000, populações de golfinhos de rio na área de estudo da Reserva Pacaya-Samiria parecem estar relativamente saudáveis. Estudos indicam que os números populacionais foram estáveis entre 1991-2000.

Introduction

Information on the ecology and conservation status of river dolphins in Peru is spacially and temporarily patchy. Kasuya & Kajihara (1974) conducted brief surveys of the Amazon River and other rivers near Iquitos in the 1970's. A 3-month river dolphin survey of the Ucayali River was conducted in 1991 by Sokolov & Yaskin (1996).

The majority of research on river dolphins in Peru comes from several related studies that were conducted upriver from Iquitos, by graduate researchers of Dr. Bernd Würsig of the Marine Mammal Research Program at Texas A& M University, USA. The Pacaya-Samiria Reserve (Fig. 6) was studied because it offered a relatively pristine environment in which to obtain baseline data. This long-term research project of the ecology and conservation

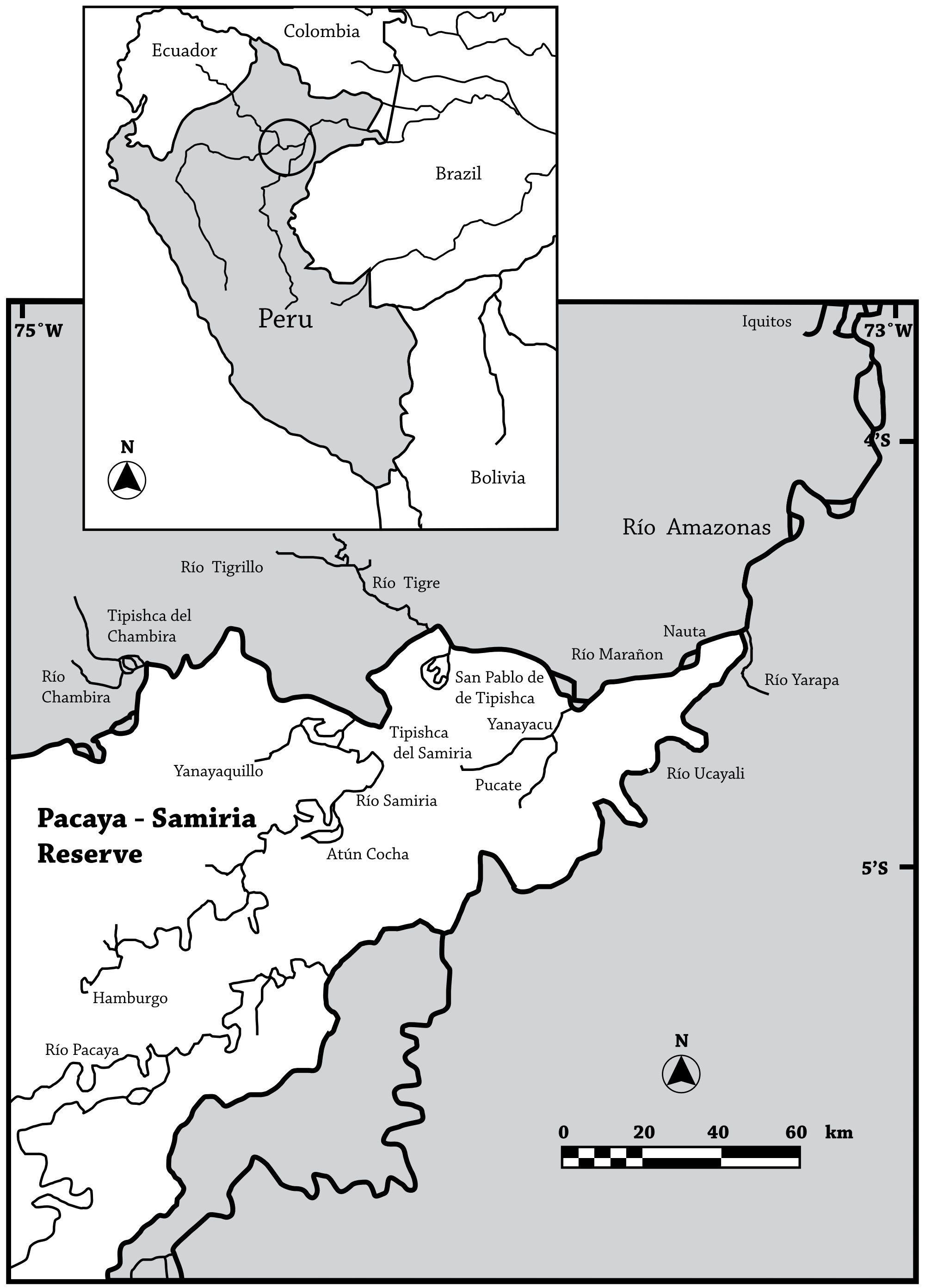

Figure 6. Map of the Pacaya-Samiria National Reserve, Peru.

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status of river dolphins in and around the Pacaya-Samiria National Reserve was initiated between 1991 and 1993 by the late Dr. Stephen Leatherwood (1996, Leatherwood *et al.* 2000), and continued 1994-1995 (Henningsen 1998), 1997-1998 (Zúñiga 1999) , and 1996-2000 (McGuire 2002, McGuire & Aliaga-Rossel 2007, McGuire & Henningsen 2007, McGuire in review). Results of these studies are synthesized in McGuire 2002, which will form the basis of information for this paper.

Species and local names

Two species of freshwater dolphins are found in Peru: *Inia geoffrensis geoffrensis,* (family Iniidae) and *Sotalia fluviatilis fluviatilis* (family Delphinidae). Although the Portuguese names (boto for *Inia* and tucuxi for *Sotalia*) have been designated as the official common names for the species (Leatherwood & Reeves 1983), in Peru, these dolphins are most commonly referred to as the bufeo rosado and the bufeo gris. The genus names will be used in this paper.

Status of population

Distribution

Inia and *Sotalia* are found in a variety of freshwater habitats in Peru, although *Inia* are found farther up Amazonian headwaters of the Marañón and Ucayali rivers than are *Sotalia.* Both species are found in the Pacaya-Samiria National Reserve. For a thorough review of river dolphin distribution in Peru and elsewhere in South America, see da Silva 1994.

Distribution and relative abundance according to habitat type: Rivers, lakes, and confluences of various sizes and water types were sampled in the Pacaya-Samiria Reserve. *Inia* and *Sotalia* encounter rates were highest in confluences, intermediate in lakes, and lowest in rivers (McGuire 2002). *Inia* occurred in higher densities than *Sotalia* in all lakes, confluences, and rivers, except the Marañón River. Other researchers also have noted that *Sotalia* are more common than *Inia* in the mainstems of the Amazon and Marañón rivers (Best & da Silva 1989*b*, Leatherwood 1996, Vidal *et al.* 1997, Leatherwood *et al.* 2000). These differences may be in part due to differences in species detectability, bioenergetics, prey distribution, abundance, and ease of capture (*i.e.*, prey capture may be facilitated by river current, turbidity, and channel width).

Rivers: *Inia* encounter rates were highest in blackwater rivers that ran parallel to, and have multiple connections with, the whitewater Marañón River. This ensuing mix of white- and blackwaters may result in higher than average productivity within these rivers. There also may be a greater diversity and abundance of fish from the proximity of the two water types, as the physical connections between these rivers and the Marañón affords dolphins increased access to blackwater and whitewater prey and habitats. Compared to other rivers surveyed, *Inia* encounter rates were lowest in the Marañón River, and this could be in part due to difficulty detecting them in the wide, turbulent water. *Sotalia* encounter rates were similar for wide rivers, and were lower in narrow rivers (<50m width).

Lakes: Oxbow lakes are remnant channels of the main-stem rivers where meanders have been cut off from the river current at one or both ends. These lakes are important spawning and feeding habitats for many fish (Lowe-McConnell 1975, 1987), and fish biomass is often higher in lakes than in nearby rivers (Bayley 1988, Guerra 1995). Lakes may be bioenergetically favorable habitat for fish and dolphins, as these animals do not have to expend energy swimming against currents. Dolphin densities were higher in lakes than in rivers; however, densities were not as high in lakes as in confluences. In the Pacaya-Samiria Reserve, *Inia* and *Sotalia* were found in lakes as shallow as 1.5-m mean depth. The relationship between lake depth and dolphin abundance varied according to lake and species, and results suggest that the flux of water levels is more important than the absolute depth. The degree of stability of the lake hydrograph may have a strong effect on dolphin density; for example, the Tipishca del Samiria had the smallest seasonal flux in water levels and the greatest densities of dolphins of both species. Larger lakes have more of a buffering capacity because they do not experience the same variability in surface areas with depth changes as shallower lakes, and may provide refuge to fish and dolphins during low water periods when shallower lakes and rivers become dry. *Inia* occurred in higher densities than *Sotalia* in all lakes. *Sotalia* were most often found in areas of deep water, and *Inia* were most often found in the lake mouths.

Confluences: Confluences are convergence zones between two or more water bodies (rivers, lakes, channels) that have been found to contain very high river dolphin abundance (Magnusson *et al.* 1980, Best and da Silva 1989*a*, Smith 1993, Leatherwood 1996, Vidal *et al.* 1997, Diazgranados *et al.* 1998, Henningsen 1998, McGuire & Winemiller 1998). Confluences offer high fish abundance, and predators of fish often migrate to confluences just before the migration of their prey species in order to capture them in the bottleneck created by the confluence (Lowe-McConnell 1975). The complex currents found in confluences may disorient prey species and facilitate prey capture. High densities of *Inia* and *Sotalia* occurred in all sampled confluences of the Pacaya-Samiria Reserve; however, *Inia* were more likely to persist throughout a sampling day, while *Sotali*a occurrence was more variable (McGuire 2002). There was no correlation, (positive or negative) between the occurrence of *Inia* and the occurrence of *Sotalia* in confluence areas.

Distance from shore: Knowledge of the distance that dolphins are typically seen from shore during surveys has implications for deciding how best to survey for these animals in wide rivers like the Marañón and Amazon. The majority of *Inia* and *Sotalia* in the Marañón were seen within 100 m from shore. Strip- transects that sample disproportionately near-shore will therefore positively bias population estimates, especially for *Inia,* which were found near shore more often than were *Sotalia*. The distance from shore at which dolphins are normally found is also important for assessing threats to these animals, as most human fishing, boat traffic, and waste discharge occurs near shore. Dolphins may be found closer to the shore in large rivers because these near-shore habitats may provide greater prey availability, greater ease of prey capture, bioenergetic benefits of reduced current or closer proximity to smaller lakes and tributaries.

Association with islands, confluences and river bends: Most large groups (>5 dolphins) of *Sotalia* and all large groups of *Inia* were seen in confluences areas or around mid-channel islands of the Marañón. In the Samiria River, all large groups of *Inia* and the majority of large groups of *Sotalia* were associated with either confluence areas or bends of 90º or more. Leatherwood (1996) investigated of the association of dolphins with confluences, beaches, and bends in the Samiria River, and found that dolphins had an affinity for these habitat features. He postulated that this association is probably due to greater availability and ease of capture of prey, greater security from predators or strandings, nutrient dynamics, hydraulic refugia provided by countercurrents and eddies, and increased access to other habitats.

Association with river depth and channel width: The association of dolphin abundance and absolute river depth was examined separately from season because there was variation in depth within seasons (seasons were classified according to a combination of relative depth and month of the year). The relationship between *Inia* abundance and depth was not statistically significant in any of the rivers. The relationship between *Sotalia* abundance and depth was only significant in the Marañón River, where *Sotalia* abundance increased with decreasing depth. *Sotalia* may leave shallower bodies of water for the deeper waters of the Marañón during the dry season. The body structure of *Sotalia* makes them less flexible and less maneuverable in shallow water than *Inia*, and *Sotalia* have been shown to feed primarily on schooling fish found in open waters (Da Silva 1983), many of which move to rivers during the dry season. Other factors such as depths of nearby rivers and lakes, river currents, human activity, and distribution and abundance of prey probably affect dolphin abundance as well. It is not clear what the minimum mean depth requirement is for river dolphins; *Inia* were found in rivers as shallow as 2.3-m mean depth and *Sotalia* in rivers as shallow as 3.5-m mean depth. River width was related to the abundance of *Sotalia,* but not *Inia.*

Association with water type: Both dolphin species were found in blackwaters and whitewaters. *Inia* were more common in blackwater than in whitewater, although *Inia* encounter rates were highest where black- and whitewaters mix; these mixed waters may be areas of high primary productivity and fish abundance. In blackwater rivers, dolphin abundance was not associated with pH, temperature, or depth, although *Inia* were found in higher densities in areas of greater water transparency. *Sotalia* abundance was not associated with water type in rivers of equal width. It is difficult to generalize about dolphin distribution and abundance with respect to water type, as differences in water type were confounded with differences in river width, water depth, boat traffic, and current.

Seasonal distribution, abundance, and habitat association: In general, encounter rates for *Inia* and *Sotalia* in rivers and lakes did not differ among seasons (high water, falling water, low water, and rising water) once differences in seasonal sampling effort and the variation within season encounter rates were accounted for. Within-season variability was usually greater than between-season variability. For example, during a 5-day period, the water level of one lake had dropped by about 2 m, and the number of dolphins had decreased by 32 *Inia* and 20 *Sotalia*. Dolphins may respond to changes in water depths and fish abundance, but perhaps not on the scale likely to be detected with the broad classification of season. There were statistically significant seasonal differences in occurrence of dolphins in confluences. During low water, both species persisted longer in the confluences throughout the sampling day, and occurred in higher densities than in any other season. Dolphins were less likely to be in confluences during high water relative to other seasons, and when present, were in lower densities than in other seasons. Confluences, with their deep water and high year-round density of prey, appear to provide important refuge to dolphins during low water periods when many shallow lakes and small tributaries are dry.

Taxonomic status and genetics

Based on morphology, distribution, and fossil evidence, Best & Da Silva 1993 described *Inia* as monotypic with three subspecies: *I. g. boliviensis, I.g. geoffrensis*, and *I.g. humboldtiania*, occurring in the Bolivian Amazon, the Amazon River Basin, and the Orinoco River Basin, respectively. Genetic studies of the phylogeny of *Inia* have been conducted by Mateos and Hurtado 1998, Banguera-Hinestroza *et al.* 1998, 2000, Hamilton 2000, Hamilton *et al.* 2001 & Ruiz-García *et al.* 2001. Based on analyses of mitochondrial genes, Banguera-Hinestroza *et al.* 2000 argued for two species of *Inia*- a monophyletic *Inia boliviensis*; and *Inia geoffrensis*, with two subspecies, *I. g. geoffrensis* and *I. g. humboldtiania*. A related study used mitochondrial genes and morphological differences to conclude that *Inia geoffrensis* and *Inia boliviensis* are two distinct species (without subspecies) that separated 4.5-5.3 million years ago due to geographic isolation by extensive waterfalls located between the Amazon system and Bolivian rivers (Ruiz-García *et al.* 2001). Based on mitochondrial genes and fossil evidence, Hamilton *et al.* 2001 proposed that *Inia* entered an inland South American seaway from the north, radiated to the south, and populations were eventually isolated into the present day taxa as the inland sea dried.

Sotalia fluviatilis is monotypic, with marine (*S. f. guianensis)* and riverine (*S. f. fluviatilis*) ecotypes that differ in morphology and coloration (Da Silva & Best 1996), although Caballero *et al.* (2007) proposed that each subspecies be recognized as a separate species.

Abundance

Population estimates of *Inia* and *Sotalia* are scarce, in part because of the vast range of these species (the Amazon River Basin and the lower Orinoco River Basin), and in part because of challenging logistics and survey methods. Most studies have reported results in terms of relative dolphin densities or encounter rates (Layne 1958, Magnusson *et al.* 1980, Best & Da Silva 1989a, Borobia *et al.* 1991, Da Silva 1994, Da Silva & Best 1996, Herman *et al.* 1996, Leatherwood 1996, Trujillo 1992, Vidal *et al.* 1997, Galindo 1998, Henningsen 1998, Reeves *et al.*1999, McGuire 2002, Martin *et al.* 2004), as true densities are often difficult to obtain due to the complex habitat, elusive behavior, and patchy distribution of river dolphins.

Encounter rates for *Inia* and *Sotalia* in waterways of the Pacaya-Samiria Reserve are presented in tables 1-9. These encounter rates are within the range of encounter rates for these dolphins elsewhere in the Amazon and Orinoco Basins (Pilleri 1969, Pilleri *et al.* 1982, Best & Da Silva 1989a, Best & Da Silva 1989c, Schnapp & Howroyd 1990, Utreras 1995, Leatherwood 1996, Vidal *et al.* 1997, Denkinger 1998, Galindo 1998, Henningsen 1998, Aliaga Rossel 2000, da Silva & Martin 2000b). It is difficult to compare absolute encounter rates among researchers and geographic areas, as a variety of methods have been used, and surveyed rivers differ greatly in width, length, and water type. In some cases, survey results have been reported as dolphins per hour (Kasuya & Kajihara 1974), or as numbers of dolphins per river (McGuire 1995, Herman *et al.*1996, Diazgranados *et al.* 1998), without sufficient information to calculate encounter rates per km. Abundance estimates can be greatly affected by survey methods. Strengths and weaknesses of various survey methods that have been used in different studies of river dolphins are presented in McGuire 2002. It is crucial that researchers standardize survey methods as much as possible, as seemingly small differences in encounter rates have large implications for estimating population size and determining conservation status, especially when extrapolated over large areas. Any study that attempts to monitor river dolphin populations should take into account the high degree of yearly, intra-seasonal, and daily variability of river dolphin counts in rivers, lakes, and confluences. Sampling should occur frequently within and between seasons and years. Differences in diurnal occurrence patterns were not detected for either species in Peru (McGuire 2002). If dolphin occurrence patterns varied significantly by time of day, this would have had important ramifications for survey results.

Mortality

Information on mortality of deceased dolphins encountered in the Pacaya-Samiria Reserve between 1996 and 2000 is presented in Table 10 (McGuire 2002). Of the eleven deceased dolphins encountered and examined, probable cause of death could only be determined for one animal (drowning in a turtle net). One dolphin was heavily bruised, but whether this was from humans or other dolphins could not be determined. Harvest of teeth, skull, and possibly of the reproductive organs, appeared to have occurred in only one instance. Although intentional poisoning was likely a cause of death of seven of the dolphins, it could not be substantiated (Reeves *et al.* 1999, McGuire 2002) as collection permits for tissue collection and analysis were not granted. Interviews suggest that poisoning occurred in some areas of the Pacaya-Samiria Reserve. Leatherwood (1996) reported seeing two dolphins that had been caught in gillnets. Zúñiga (1999) lived 11 months in the village of San Martin on the shores of the Tipishca del Samiria, and spent hundreds of hours on the water, yet reports seeing only one dead dolphin, which may have been killed in a net (Elizabeth Zúñiga, personal communication). Dolphins undoubtedly are killed by net entanglement and in drop-traps for fish, but the magnitude of the problem remains unquantified. Accounts of predation on *Inia* by jaguars are common throughout the Reserve, but such predation has not been documented.

Biology

Most of what is known about biology of the *Inia* and of the riverine *Sotalia* comes from the work of Best and Da Silva (Best 1984, Best & Da Silva 1984, 1989*a*, *b*, 1993; Da Silva 1994, Da Silva & Best 1996) in the Brazilian Amazon. Information about reproduction rates, growth rates, size in relation to age class and gestation of non-captive dolphins from regions other than Brazil does not currently exist in the published literature. The remainder of this discussion on biology will be restricted to reproductive ecology. Based on a study of *Inia* in Venezuela, McGuire & Winemiller (1998) found evidence of geographic variation in seasonality of river dolphin reproduction.

Seasonality of Calving and Mating: Mating and calving were observed to occur year-round in the Peruvian Amazon, with *Inia* calving peaking somewhat during falling water, and *Sotalia* calving increasing slightly during high and low water. Henningsen (1998) found the greatest number of *Inia* and *Sotalia* calves in the Peruvian Amazon during the transition (rising and falling) and dry seasons. Leatherwood *et al.* (1991) observed neonate *Inia* in rising water and falling water, and newborn *Sotalia* in falling water (other seasons were not sampled); see McGuire &

Aliaga-Rossel (2007) for a discussion of factors that might affect seasonality of reproduction. Nonadult (neonates, calves, and juveniles) *Inia* accounted for 0.6%-13.6% of all *Inia* observed, and nonadult *Sotalia* accounted for 0.0-4.5% of all *Sotalia* seen. These are similar to the rates Henningsen (1998) found in the Samiria River, in which 10.0% of *Inia* and 3.0% of *Sotalia* were calves. Mating by *Inia* was observed in all seasons, while mating by *Sotalia* was only seen during falling water and rising water. The mean mating group size was 3.6 for *Inia* and 2.0 for *Sotalia.* Mating activity was observed in a variety of micro-habitats in confluence areas, and an association of mating and habitat was not detected. The average mating group size of *Inia* would be consistent with the polygamous mating system proposed by da Silva (1994) and Trujillo *et al.* (1998), and evidence against monogamy of this species, although it was not certain how many animals in a group were actually copulating.

Habitat use by age class: *Inia* neonates were seen in all sampled lakes, and in most of the blackwater tributaries. Neonates of both species were absent from the whitewater Marañón River and from the narrow blackwater (<50 m) tributaries. Nonadult (i.e., neonates, calves, and juveniles) *Inia* were found in all locations and habitats. *Sotalia* nonadults were found in oxbow lakes, and wider white- and black-water rivers, but not in the narrow tributaries. Factors that may make a certain habitat advantageous to nonadult dolphins include calm water, moderate water temperatures, ease of prey capture, refuge from boat traffic and human disturbance, and proximity to fishing nets (this could be positive because of the ease of prey capture or negative because of the possibility of entanglement in fishing gear and harassment by fishermen). Neonates of both species were most likely to be seen in the Tipishca del Samiria, which is a large oxbow lake with no current and moderate seasonal fluctuations in water level and temperature compared to the other lakes. Leatherwood *et al.* (1991) often observed newborn and nonadult *Inia* in "quiet waters of tributaries" of the Pacaya-Samiria, and newborn *Sotalia* in the Amazon and Marañón rivers.

Group size, habitat, and season: In rivers and lakes, *Inia* were seen most often as single animals and *Sotalia* were seen most often as singles or pairs. The largest group of *Inia* was 19, and the largest group of *Sotalia* was 13. Mean *Inia* group size was never greater than two animals, regardless of season. Seasonal differences in mean *Sotalia* group size were of < one animal. Throughout the range of *Inia* and freshwater *Sotalia*, mean *Inia* group size in ranges from 1.2 to 6.1 animals, and mean *Sotalia* group size is between 1.2 and 6.0 (Magnusson *et al.* 1980, Schnapp & Howroyd 1990, Ojeda & Vidal *et al.* 1995, Herman *et al.* 1996, Hurtado 1996, Leatherwood 1996, Vidal *et al.* 1997, Henningsen 1998, Galindo 1998, McGuire & Winemiller 1998a, Parra & Bolaños 1998, Aliaga Rossel 2000, Trujillo & Diazgranados 2000). Few studies have examined seasonal changes in group size, and fewer still accounted for seasonal differences in sampling effort.

Habitat associations, site fidelity and movement patterns: Photo-identification techniques were used to examine site fidelity and movement of river dolphins in the Pacaya-Samiria Reserve. Images and range maps were compared with photo-catalogs of other researchers (Leatherwood 1996, Henningsen 1998, Zúñiga 1999) who had worked in the same area since 1991; therefore results encompass a 10-yr period (McGuire 2002, McGuire & Henningsen 2007). A total of 24 *Inia* were identified and resighted within the study area, and individual sighting histories ranged from 1 day to 7.6 years. Identified dolphins were not observed to move between the three photographed blackwater affluents of the Marañón River (*i.e.*, the Yanayacu River, San Pablo de Tipishca, and the Samiria River System; 30, 40, and 70 km apart respectively), but instead were always observed within the same affluent system (results may be affected by small sample size). In the Samiria System, the maximum *Inia* range (defined as the river distance between the two most-extreme sighting locations of the same individual) was 220 km, with a mean range of 59.5 km (± 61.05 SD). The mean range of those dolphins in the Samiria system that did not restrict themselves to the Tipishca del Samiria was 104.0 km (± 72.11 SD), and the maximum range was 220 km. The greatest rate of travel observed for *Inia* was 120 km in 2 days, which corresponded to 60 km/d, assuming a constant rate of travel. For *Sotalia*, Henningsen (1998) observed a maximum rate of travel of 56 km/12 hr. The lake Tipishca del Samiria appeared to be an important location for *Inia.* Thirty-two percent (n=6) of all dolphins identified in the Samiria River System were never observed outside of this oxbow lake. Fifty-three percent of all identified *Inia* in the Samiria System were seen only in the lake and its vicinity (<5 km from the lake), and 95% of all identified *Inia* in the Samiria System were seen in this lake at least once. Hypotheses as to why this lake may be an important habitat for *Inia* are discussed in detail in McGuire (2002). Zúñiga's (1999) high rate of new identifications throughout the year led her to conclude that the Tipishca del Samiria has a "local population with moderate immigration and emigration of other animals". Taken together with other studies, these results suggest that the lake has both a local and transient population. This result is consistent with the tracking studies of da Silva and Martin (2000) in Brazil, where some *Inia* were seen in all habitats, while others remained in a particular lake system for almost a year.

Threats

South American river dolphins experience habitat degradation due to pollution, river traffic, deforestation, hydro-electric dams (Reeves & Leatherwood 1994*a*), and over fishing of their prey by humans (Best & Da Silva 1989*a*). They are sometimes killed incidentally during human fishing activity, including gill-netting and dynamite fishing (Best & Da Silva 1989*a*). There are no records of non-human predation on river dolphins, although caiman, piranha, jaguars, and bull sharks occur throughout their range. Taboos that prevented the intentional harm of river dolphins once existed among the native people of the region (Best & da Silva 1989*a*, Slater 1994), but such beliefs are disappearing and more recent settlers often regard the dolphins as competitors for fish (Leatherwood 1996, McGuire & Zúñiga 1997, Reeves *et al.* 1999, McGuire 2002).

Direct

Interactions with fishing operations

The major threats to river dolphins in Peru have been reported as entanglement in fishing gear (especially gill nets), and also capture in drop traps designed to catch paiche fish (*Arapaima gigas*) and manatees (Leatherwood 1996). As of 2000, there was no evidence that dolphins were deliberately hunted for use as catfish bait in Peru, or that dolphins were killed to harvest body parts for sale. On occasions in Peru, dolphins are deliberately killed by fishermen attempting to protect their nets or reduce the dolphins' take of fish (Leatherwood 1996, McGuire & Zúñiga 1997, Reeves *et al.*1999). Fishermen, residents, biologists, and community workers living and working in the Pacaya-Samiria Reserve reported that *Inia* are sometimes poisoned with fish that had been injected with a poison called „folidol". According to witnesses, fishermen captured live fish, injected some with the poison, and released the fish into the water, where dolphins consumed them. They emphasized that this was the work of commercial fishermen, not local people; and stated that the commercial fishermen were killing dolphins with the intent of reducing competition for fish and protecting their expensive nylon nets. Dolphins often become entangled in the nets while preying on fish, and break the nets struggling to free themselves, resulting in economic losses to the fishermen. As of 2000, folidol was easily purchased in veterinary supply shops in the marketplace of Iquitos, and is a common trade name of a 2.5 % methyl parathion mixture. It is manufactured as an insecticide and acaricide (mite killer). Methyl parathion is a cholinesterase inhibitor, which interferes with the nervous system. Folidol is toxic to fish and animals that eat poisoned fish, although birds are not as affected. Inhalation and contact with folidol have been known to kill humans (World Wide Web Extension Toxicology Network). The newspaper "El Comercio", 3 November 1997, reported that *Inia* were rapidly disappearing from the lakes and tributaries of the Ucayali River near Pucallpa, as artisanal fishermen were killing the dolphins in an effort to protect their nets. Fishermen reportedly used poison, fed the dolphins fish that have been filled with pins, trapped them with explosives, or more commonly, beat them to death with oars or branches if they were caught in the nets.

Dolphin products

Dolphin teeth and oil were seen in the Iquitos markets in small quantities and at moderate prices; dolphin meat was never seen. There was no evidence that dolphins were not killed for these products, nor did there appear to be much demand for them. Dolphin products were not seen in the market at Nauta or in the villages in and around the Reserve.

Non-human predation

Reports of dolphin-eating jaguars, or more precisely dolphin-blood sucking amphibious jaguars, were given by Reserve residents, rangers, and biologists, although evidence of predation from jaguar, caiman, or piranha on live or dead dolphins was not documented.

Indirect

Oil spills

Although there were reports that dolphins had been killed in oil spills around the Reserve in 1992 and 1994, evidence for this was not documented (Leatherwood 1996). An oil spill of about 1,769,500 liters (467,500 gallons) occurred on 3 October 2001 on the Marañón River, <100-km upriver of the confluence with the Samiria River. The area was surveyed on 6 October, and no dead animals were encountered. The banks of the river and floating vegetation were coated in heavy black oil, and the river water had an oily sheen. Although river dolphins have not been observed to die as a direct result of oil spills, dolphins are probably indirectly affected via destruction of habitat and prey.

Boat traffic

Inia and *Sotalia* appeared to have an immediate, short-term (<3 min) avoidance response to motor boats, which was more pronounced for *Sotalia*. Neither species seemed to respond negatively to canoes, and *Inia* often approached canoes. Future studies should investigate the response of dolphins to boat traffic (perhaps with the use of theodolite to track dolphin and boat movements), and the implications this may have for direct counts of dolphins made from moving survey vessels. Boat strikes of dolphins were never observed. However, two of the 24 photo-identified *Inia* had scars that may have been caused by boat propellers, and a third *Inia* had a broken upper beak that might have resulted from a boat strike. Tourism in the Pacaya-Samiria is increasing (INRENA-AECI 2001) and brings with it an increase in motorized boat traffic. In addition to the potential threats from strikes, boat motors produce noise, which may cause disruption of dolphin behavior and habitat use.

Other threats

Gold mining, hydroelectric dams, and industrial manufacturing did not exist in or near the Pacaya-Samiria Reserve as of 2007. The possibility exists that dolphins ingest mercury via predation on fish that migrate from other regions where mercury is used. Humans living hundreds of kilometers from the nearest gold mining operations have been found to have above-normal levels of mercury in their bodies, attributed to their fish-based diets (Serrill 1994).

Tourism

Tourism may prove to be a double-edged sword for conservation in the Reserve and elsewhere in Peru. Tourism may increase public awareness about particular animals, such as river dolphins, and about the Reserve in general. Tourism has the potential to bring in valuable resources to support research and conservation efforts. On the other hand, tourism can have negative impacts on local people, the dolphins, and the environment. Tourism will need to be carefully regulated and enforced if it is not to contribute to the degradation of the Reserve. As of 2000, raw sewage was directly discharged from tour boats into pristine blackwater lakes, solid waste was often dumped overboard, excursion boats traveled at high speeds (>20 km/h) through manatee, dolphin and aquatic turtle habitat, and electric generators and boat motors (especially outboard motors) create air, noise and water pollution.

Legal status

The conservation status of the freshwater *Sotalia* (*Sotalia fluviatilis fluviatilis)* is designated as "not evaluated" by the IUCN Red List (Reeves *et al.* 2003), while *Inia* is classified as vulnerable.

Peru's National Law Nº 26585 of April 1996 gives legal protection to several cetaceans, including *Inia* and *Sotalia*. Supreme Decree Nº 00296-PE of 1996 allows for the protection and conservation of small cetaceans, and prohibits the consumption of cetacean meat. It also prohibits the harassment, disturbance, harm to, or injury of small cetaceans, and specifies that any small cetacean caught in a net must be released unharmed. This decree encourages state agencies to promote and regulate ecotourism activities in small cetacean habitat. Supreme Decree Nº 0342004-AG of 2004 lists *Inia* as a vulnerable species, and prohibits the hunting, transportation, and commercial exploitation of protected species. Finally, the Regional Government of Loreto, with the Order Nº 018-2008-GRL- CR , issued by the regional government of Loreto State in 2008, calls for the adequate care and maintenance of aquatic mammals kept in captivity for rehabilitation.

Conservation initiatives

As of 2000, river dolphin populations in the study area of the Pacaya-Samiria Reserve appeared to be relatively healthy. Although historic numbers are not known, studies indicate that population numbers were stable 1991-2000 (McGuire 2002). Major threats to river dolphins are related to human fishing activity, and these threats are certain to increase with the increasing human population and related demand for fish. Fishing is the major economic activity in the region, and more than 80% of the fresh fish unloaded in Iquitos came from the Pacaya-Samiria Reserve and its buffer zone (Rogriguez *et al.* 1995). River dolphin research should continue with the aim of contributing to preemptive conservation strategies that should be implemented while populations are still healthy.

As with many top predators, the conservation of river dolphin populations is interdependent with conservation of their habitat. The Pacaya-Samiria National Reserve has been a protected area since 1940, and at its current size of 2,080,000 ha, is the largest reserve in Peru (INRENA-CTARL 2000). The Reserve, although created to protect fish stocks, also has served as an effective river dolphin refuge. The success of the Reserve thus far has been primarily due to its remoteness. Human pressure on the Reserve is growing, along with increased access from the recently opened highway linking Iquitos to the Reserve. Illegal fishing, hunting, logging and homesteading with slash-and-burn agriculture are common, and these activities increase during times of economic hardship. It is questionable how well the Reserve can continue to function with an increase in human population and when faced with limited and unreliable funding. However, several conservation groups (*e.g.,* WWF, The Nature Conservancy, ProNaturaleza) have been working with the Reserve Administration to implement and fund a master plan (INRENA-CTARL 2000), and it is hoped that this will strengthen the ability of the Reserve to protect its natural resources, including river dolphins, their prey, and their habitat.

Ministerial Resolución Nº 588-*96PE of 1996* is a conservation initiative that calls for the creation of an Iquitos-based institute for the captive care and rehabilitation of confiscated, rescued, or accidentally captured *Inia, Sotalia* and Amazonian manatees (*Trichechus inunguis).*

Recomendations

Research

Considering the high degree of intra-seasonal and daily variability of dolphin counts during transects (differences as great as 74 *Inia* and 51 *Sotalia* in the same body of water within a season, and differences as great as 38 *Inia* and 17 *Sotalia* within the same body of water on consecutive days), it is important to emphasize that any research that attempts to monitor river dolphin populations should take this variability into account, and should sample frequently within seasons as well as between. The usefulness of population estimates and particularly population-trend data obtained from short term, infrequent, expedition-type surveys is questionable. It is important that statistical analyses be applied to population estimates and population-trend data. Several unpublished scientific and popular reports have claimed dramatic population declines for river dolphins in some regions of South America in recent years, yet these studies were based on a few samples taken over a period of a few years, and population estimates were not analyzed with respect to variability of survey effort. Had McGuire's (2002) yearly counts of dolphins in any of the lakes been taken out of context and only compared between some years, they too would have shown dramatic declines in some cases (but increases in others). However, when within-year variation is compared to between-year variation, it becomes apparent that none of the differences were statistically significant and that population size was in fact stable. In addition to seasonal, daily, and yearly variation, it is important to consider variation among individual dolphins, as photo-identification suggests the existence of both local and transient individuals.

Education

Environmental education campaigns, especially in rural areas along waterways, are necessary to educate local people about the natural resources and biological diversity of aquatic ecosystems. River dolphins, as charismatic megafauna, serve as a way to stimulate interest in learning about and conserving the waters in which they live and the fish on which they and humans subsist. Conservation of river dolphins and other aquatic species is directly related to the health of aquatic ecosystems and to the human pressures upon these systems.

Conservation

Although laws exist on paper to protect the dolphins and some of their habitat, it is essential to develop efficient mechanisms of monitoring and enforcement in areas where dolphins are present. Many of these laws and supreme decrees are unknown to many people living in the area, and government officials often lack the resources to enforce the law.

The Pacaya-Samiria Reserve, although created to protect fish stocks, also has served as an effective river dolphin refuge. The success of the Reserve thus far has been primarily due to its remoteness. Human pressure on the Reserve is growing, along with increased access from the recently-opened highway linking Iquitos to the Reserve. Illegal fishing, hunting, logging and homesteading with slash-and-burn agriculture are common, and these activities increase during times of economic hardship. Many people, especially first and second-generation immigrants from other regions, view the Reserve as a source of resources to satisfy immediate economic needs. Several conservation groups have worked with the Reserve Administration to implement and fund a master plan (INRENA-CTARL 2000), and it is hoped that this will strengthen the ability of the Reserve to protect its natural resources, including river dolphins, their prey, and their habitat.

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Table 9. *Inia* encounter rates by season in the Marañón River; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	Section surveyed	No. surveys	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood 1996	modified strip transect, direct count with correction factor**	Delfín 7 m	Amazon-Marañón	21	x	0.2/km	0.1 /km [1] 0.2/km [2]	x	no info.	no info
McGuire	modified strip transect, direct count	Delfín 7 m Miron 3.5 m	Marañón	39	0.1/km	0.2/km	0.5/km	0.4/km	0.3/km (± 0.32 SD)	1.07

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water"
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water".
** used a "pro rata" correction factor to account for unidentified dolphins

Table 10. *Sotalia* encounter rates by season in the Marañón River; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	Section surveyed	# surveys	Rising water	High water	Falling water	Low water	Mean encounter rate and SD	CV
Leatherwood (1996)	modified midline, direct count with correction factor **	Delfín 7 m	Amazon-Marañón	21	x	0.2/km	0.2/km [1] 0.3/km [2]	x	no info.	no info.
McGuire	modified strip transect, direct count	Delfín 7 m Miron 3.5 m	Marañón	39	0.3/km	0.5/km	0.4/km	0.5/km	0.4/km (± 0.26 SD)	0.65

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water"
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water".
** used a "pro rata" correction factor to account for unidentified dolphins

Table 11. *Inia* encounter rates by season in the Samiria River; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	# surveys	Section surveyed	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	midline direct count with correction factor **	Delfín 7 m	4	1 and 2	x	x	0.5/km[2]	x	no info.	no info.
Leatherwood (1996)	midline direct count with correction factor **	Delfín 7 m	5	2	x	0.5/km	0.7/km[1]	x	no info.	no info.
Henningsen (1998)	midline direct count	Miron 5.75 m *	7	Section 1-PV7	0.5/km	0.5/km	x	0.7/km	0.5/km no SD	no info.
McGuire	midline direct count	Delfín 7 m Miron 3.5 m	11	1	0.2/km	0.6/km	0.7/km	3.5/km	1.5/km (± 2.88 SD)	1.92
McGuire	midline, direct count	Delfín 7 m Miron 3.5 m	32	2	0.3/km	0.4/km	0.6/km	0.5/km	0.5/km (± 0.27 SD)	0.68

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water" to make it consistent with my classification of season.
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water" to make it consistent with my classification of season.
* the Miron had an additional deck when used by Henningsen that it did not have when I used it. **used a "pro rata" correction factor to account for unidentified dolphins

Table 12. *Sotalia* encounter rates by season in the Samiria River; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	# surveys	Section surveyed	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	midline direct count with correction factor **	Delfín 7 m	4	1 and 2	x	x	0.4/ km[2]	x	no info.	no info.
Leatherwood (1996)	midline direct count with correction factor **	Delfín 7 m	5	2	x	0.7/km	0.5/km[1]	x	no info.	no info.
Henningsen (1998)	midline direct count with correction factor	Miron 5.75 m *	7	Section 1-PV7	0.4-0.3/km	0.3/km	x	0.4/km	0.3/km No SD	no info.
McGuire	midline direct count	Delfín 7 m Miron 3.5 m	11	Section 1	0.8/km	0.7/km	0.1/km	0.2/km	0.3/km (± 0.38 SD)	1.13
McGuire	midline, direct count	Delfín 7 m Miron 3.5 m	32	Section 2	0.3/km	0.2/km	0.5/km	0.4/km	0.4/km (± 0.20 SD)	0.50

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water" to make it consistent with my classification of season.
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water" to make it consistent with my classification of season.
* the Miron had an additional deck when used by Henningsen that it did not have when I used it.
** used a "pro rata" correction factor to account for unidentified dolphins

Table 13. Estimates of mean *Inia* abundance in Tipishca del Samiria; an x indicates that sampling did not occur (modified from Zúñiga 1999).

Study	Method	Vessel, eye height	# surveys	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	line transect, zigzag	Delfín 7 m	13	x	48	50 [1] 36 [2]	x	43 SD not reported	0.15 [3]
Leatherwood (1996)	direct count, loop	skiff about 2 m	3	x	21	36	x	26 (± 8.89 SD)	0.34
Henningsen (1998)	direct count, loop	unspecified	2	x	30	x	30	30 (± 0.00 SD)	0
Zúñiga (1999)	direct count, modified zigzag	skiff about 2 m	78	24	28	24	32	26 (± 15.90 SD)	0.61
McGuire	direct count, zigzag	Delfín 7 m Miron 3.5 m	29	49	46	58	54	51 (± 22.66 SD)	0.44

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water" to make it consistent with my classification of season.
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water" to make it consistent with my classification of season.
3= Leatherwood (1996) used a different formula to estimate CV.

Table 14. Estimates of mean *Sotalia* abundance in Tipishca del Samiria; an x indicates that sampling did not occur (modified from Zúñiga 1999).

Study	Method	Vessel, eye height	# surveys	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	line transect, zigzag	Delfín 7 m	13	x	19	26 [1] 25 [2]	x	20 SD not reported	0.29[3]
Leatherwood (1996)	direct count, loop	2 skiffs about 2 m	3	x	16	23	x	18 (± 4.36 SD)	0.24
Henningsen (1998)	direct count, loop	unspecified	2	x	30	x	30	30 (± 0.00 SD)	0
Zúñiga (1999)	direct count, modified zigzag	1 skiff about 2 m	78	22	22	17	11	20 (± 14.13 SD)	0.71
McGuire (this paper)	direct count, zigzag	Delfín 7 m Miron 3.5 m	29	32	25	22	20	27 (± 17.02 SD)	0.63

1= Leatherwood (1996) classified this as " medium high water, but I reclassified it as "falling water" to make it consistent with my classification of season.
2= Leatherwood (1996) classified this as "medium-medium low", but I reclassified it as "falling water" to make it consistent with my classification of season.
3= Leatherwood (1996) used a different formula to estimate CV.

Table 15. Estimates of mean *Inia* and *Sotalia* abundance in San Pablo de Tipishca; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	# surveys	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	direct count, route unspecified	unspecified	1	x	x	1 *Inia* 6 *Sotalia*	x	1 *Inia* 6 *Sotalia*	Not presented
McGuire (this paper)	direct count, midline, loop	Delfín 7 m; Miron 3.5 m; skiff 2 m	28	14 *Inia* 9 *Sotalia*	17 *Inia* 13 *Sotalia*	7 *Inia* 3 *Sotalia*	1 *Inia* 0 *Sotalia*	11 *Inia* (± 7.9 SD) 7 *Sotalia* (± 6.7 SD)	0.72 *Inia* 0.96 *Sotalia*

* Henningsen surveyed this lake, but does not present specific details. Encounter rates of 0.3 *Inia*/km and 0.1 Sotalia/km were reported for all lakes sampled in the Samiria System.

Table 16. Estimates of mean *Inia* and *Sotalia* abundance in lake Atun Cocha; an x indicates that sampling did not occur.

Study	Method	Vessel, eye height	# surveys	Rising water	High water	Falling water	Low water	Mean abundance and SD	CV
Leatherwood (1996)	direct count, route unspecified	unspecified	10	7 *Inia* 15 *Sotalia*	x	6.8 *Inia* [1] 0.1 *Sotalia*[1]	x	not presented	not presented
McGuire (this paper)	direct count, midline, loop	Delfín 7 m; Miron 3.5 m; skiff	23	11.6 *Inia* 2.5 *Sotalia*	9.7 *Inia* 2 *Sotalia*	7.7 *Inia* s 2.9 *Sotalia*	5.5 *Inia* 0.3 *Sotalia*	9.2 *Inia* (± 7.24 SD) 1.9 *Sotalia* (± 3.06 SD)	0.79 *Inia* 1.61 *Sotalia*

* Henningsen surveyed this lake, but does not present specific details. Encounter rates of 0.3 *Inia*/km and 0.1 Sotalia/km were reported for all lakes sampled in the Samiria System.

1= Averaged from 9 surveys that Leatherwood (1996) classified as " medium high water" and "medium-medium low water", but I reclassified them as "falling water" to make them consistent with my classification of season.

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Table 17. Best available estimates of river dolphins from surveys in the Pacaya-Samiria Reserve, by season and water body, averaged from all surveys 1996-2000. Counts from lakes are direct counts, and counts from rivers are encounter rates per km, multiplied by total km surveyed.

Season	Marañón River	Yanayaquillo River	Lake San Pablo	Lake Atun Cocha	Samiria River (Sect. 1)	Tipishca del Samiria	Samiria River (Sect. 2).	Atun Caño	Yanayacu River	Pucate River	Total
Distance or area surveyed	82.0 km	5.5 km	15.0 km^2	6.0 km^2	16.0 km	14.6 km^2	163.0 km	5.0 km	10.7 km	5.8 km	288.0 km and 35.6 km^2
# *Inia*											
High water	20	2	17	10	10	46	62	1	3	1	172
Falling water	38	3	7	8	12	58	96	1	0	2	224
Low water	35	3	1	6	57	54	88	1	21	2	266
Rising water	11	2	14	12	3	49	55	2	14	4	166
Mean # *Inia*	26	2	11	9	21	52	75	1	10	2	207
High water	39	0	13	2	11	25	39	0	4	1	134
Falling water	34	0	3	3	2	22	75	2	0	1	142
Low water	39	0	0	0	2	20	68	0	3	0	133
Rising water	24	2	9	3	13	32	51	1	5	2	140
Mean # *Sotalia*	34	1	7	2	6	26	58	1	3	1	138

Table 18. Necropsies of dead dolphins in the Pacaya-Samiria Reserve, 1996-2000.

Date	Location	Species	Sex *	Total length (cm) snout to notch of tail	Comments
28-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	230.00	A
28-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	217.05	A
28-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	X	A
29-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	232.50	A
29-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	X	A
29-October-96	San Pablo de Tipishca	*Inia geoffrensis*	U	X	A
21-January-97	San Pablo de Tipishca	*Inia geoffrensis*	M	193.04	B
13-August-97	Tipishca del Samiria	*Inia geoffrensis*	F	82.50	C
5-December-98	Tipishca del Samiria	*Inia geoffrensis*	M	185.00	D
20-February-00	Samiria River-PV2	*Sotalia fluviatilis*	F	176.00	E
12-September-00	Samiria River-PV3	*Inia geoffrensis*	U	X	F

*F= female, M=male, U=undetermined.
X indicates body too decomposed to measure total length.

Comments A: Sex was not determined as the abdominal cavities had been partially eaten by fish and were decomposing. The teeth of all animals (with heads) were in good condition, and none were worn or broken. External examination of the dolphins did not reveal bullet holes, machete scars, puncture wounds (from harpoon or spear), or net scars, although there were several small irregularly shaped holes (about 3-cm diameter) that appeared to have been made by feeding vultures. Local people reported that dolphins had been intentionally poisoned with "folidol" (see interview section, this chapter).

Comments B: Teeth were in good condition, and none were worn or broken. Cause of death was not determined.

Comments C: This animal was discovered by a film crew in the Tipishca del Samiria while the research team and vessel were elsewhere in the lake. Ralf Brier (personal communication) reported that he noticed the carcass floating in the water, and brought it aboard his skiff. An adult dolphin he assumed to be the mother was nearby and became "agitated" (*i.e.*; snorting, leaping) as the calf was brought into the skiff. The skiff then brought the carcass to the research vessel for examination by the researcher and team. Pockets of air were in the lung membranes and peritoneal lining, and the skin had a crackling sound and feel just below the surface when touched. There were dark blood spots and pools in the lungs, and dark purple bruises around head (under the gray outer layer of skin). There were pronounced longitudinal fetal folds, especially along the rear half of the body. The duration of fetal folds in *Inia* is unknown. In Brazil, one *Inia* calf 122-cm long was reported with fetal folds, and one 156-cm calf was seen without fetal folds (Vera da Silva, personal communication.). Leatherwood (1996) reported that fetal folds in river dolphins persist two months, but did not cite the source of this information. In Brazil, body length of *Inia* calves at birth ranged from 66-81 cm (Best and da Silva 1993). At 82.5-cm total body length, this dolphin's teeth had not yet erupted but were visible just below the gums. The smallest calf documented with erupted teeth was 123-cm long; another calf 125.5-cm long did not have teeth; and it is believed that *Inia* teeth erupt during the first year (Vera da Silva personal communication). The stomach was empty, although there was excrement in the anal slit. The excrement lacked fish scales or bones, and suggested a milk diet. Cause of death could not be determined, although strong blows and/or drowning are suggested.

Comments D: This *Inia* was found floating in shallow water, about 3 m from shore at the western end of Tipishca del Samiria. Cause of death could not be determined. The teeth were in good condition, and none were worn or broken. Cause of death could not be determined. A survey was conducted here two days before the discovery of the animal, and the dead dolphin was not detected at that time.

Comments E: Encountered snagged in a fallen tree in the Samiria River, about 100-m downriver of ranger station PV2. The ranger on duty reported that the dead dolphin had been discovered 4 days earlier by a group of students that were visiting the ranger station (G.P. Quarto Sangama, personal communication.). The students had found the dolphin in Atun Caño, dead and tangled in a net used for illegally capturing aquatic turtles. The students brought the dead dolphin back to the ranger station, where they put it back in the water still tangled in the net, and did not necropsy it. Four days later McGuire (2002) retrieved the body and examined it, with assistance from Ranger Sangama. There were large air bubbles in the lung membranes. Stomach contents consisted of the remains of one armored catfish (*Pterygoplichthys spp*) with a 2.5-cm long head. Two of the 106 teeth were broken. At 176 cm, this dolphin is the longest freshwater *Sotalia* on record. In the Brazilian Amazon, da Silva (1994) found maximum total lengths of 152 cm for female *Sotalia*, and 149 cm for males. The worn teeth together with the large size suggest that this was an older individual. I was not permitted to collect teeth.

Comments F: The skull and the front half of the body, except for the skin, were missing. The body was found floating in shallow (<1 m) almost stagnant water, and it seems likely that the skull would have been encountered if it had been near the body. The channel in which it was found was within a few hundred meters of PV3, and along part of the rangers' daily patrol route; however, the rangers said they had not known of the dead animal. It was in a stage of advanced decomposition, and may have been dead at least a week. The skin had several small (<2 cm) puncture marks, which appeared to have been made with the tip of a very sharp knife (I was able to duplicate these marks with my fillet knife). The skin from the front half of the body and head was cleanly cut in straight lines. The reproductive organs were missing, and were either eaten by scavengers or removed by humans. There were rope marks around the tail stock. Cause of death could not be determined. The dolphin may have been encountered dead and dragged to a beach with a rope for harvesting of the skull and reproductive organs, or perhaps was intentionally killed for these products.

1.4. *Inia geoffrensis* and *Sotalia fluviatilis*: A brief review of the ecology and conservation status of river dolphins in the Ecuadorian Amazon

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Abstract

The river dolphins *Inia geoffrensis* (boto) and *Sotalia fluviatilis* (tucuxi), are critical species in the aquatic ecosystems of the Amazon River Basin, not only as top predators, but also as significant elements of the cultures and traditions of many indigenous groups throughout the Basin. However, both species are threatened by the intensification of several human activities with direct and indirect impacts on the populations of river dolphins and their habitats. In countries such as Ecuador, these threats are compounded by the lack of coordination and priorization of conservation initiatives. As a first attempt at identifying critical gaps in our knowledge about river dolphins in Ecuador, this paper presents a review of the main studies that have been carried out with these species in the country.

Keywords: *Inia geoffrensis geoffrensis*, *Sotalia fluviatilis*, ecology, conservation, Amazon, Ecuador

Resumen

Los delfines de río *Inia geoffrensis* (boto) y *Sotalia fluviatilis* (tucuxi), son especies de alta importancia para los ecosistemas acuáticos de la cuenca amazónica, no solo por su gran importancia ecológica, sino también por su papel preponderante en la cultura y tradiciones de muchos grupos indígenas de la cuenca. Sin embargo, la conservación de ambas especies está amenazada por la intensificación de diversas actividades humanas que afectan directa o indirectamente a sus poblaciones o a sus hábitats. En países como el Ecuador, a estas amenazas se suman la falta de coordinación y priorización de los esfuerzos de conservación. Como un primer paso para identificar vacíos básicos en la información sobre los delfines amazónicos en el Ecuador, este artículo presenta una revisión de los resultados de los principales estudios que se han hecho en el país sobre estas especies.

Resumo

Os golfinhos de rio *Inia geoffrensis* (boto) e *Sotalia fluviatilis* (tucuxi) são espécies de grande valor para os ecossistemas aquáticos da bacia amazônica, não apenas pela importância ecológica que têm, como também pelo papel preponderante que apresentam na cultura e tradições de muitos grupos indígenas da bacia. Contudo, a conservação de ambas espécies está ameaçada pela intensificação de diversas atividades humanas que afetam direta ou indiretamente suas populações e seus habitats. Em países como o Equador, a estas ameaças se somam a falta de coordenação ou priorização dos esforços de conservação. Como um primeiro passo para identificar lacunas básicas nas informações sobre golfinhos amazônicos no Equador, este artigo apresenta uma revisão dos resultados dos principais estudos que foram feitos no país sobre estas espécies.

Introduction

Throughout their distributional range, the Amazon River dolphins, boto (*Inia geoffrensis*) and tucuxi (*Sotalia fluviatilis*), are critical species for the functioning and conservation of the aquatic ecosystems of this region, not only because of their essential ecological role as top predators, but also as emblematic species for many indigenous groups from the Amazon River Basin. Despite their importance, both species are experiencing severe threats associated with the expansion and intensification of human activities in the region, and there are many aspects about the biology and ecology of these animals that remain unexplored. Under these circumstances, renewed efforts are needed in order to generate consistent information about the ecological requirements of these species throughout their distributional range, and their response to anthropogenic and natural disturbances, as the basis for the design and implementation of relevant regional conservation strategies at the regional level.

In the case of Ecuador, research and conservation efforts devoted to river dolphins and their habitats have been disperse and discontinuous. Furthermore, the country still lacks any form of strategy that could promote research and management agendas oriented to ensure the long-term conservation of these species. In this context, the following pages present a review of what is known about the populations of Amazon River dolphins in Ecuador. Since emphasis has been put in identifying critical gaps in our understanding of the ecology of botos and tucuxi in this part of their distributional range, for further details the readers are directed to the original bibliographical sources from which information was extracted.

Distribution

Inia geoffrensis geoffrensis. The boto (*Inia geoffrensis*), known in Ecuador as bufeo or pink river dolphin, is widely distributed in the main rivers and some lacustrine systems in Amazonian Ecuador, at altitudes below 300 m (Utreras 1996, Utreras 2001a, Utreras *et al.* 2001a, Tirira 2007). The first official record of this species in Ecuador dates from the mid-nineteen century, when the Italian naturalist Osculati found botos in the Payamino River, near its confluence with the Napo River (Herrman *et al.* 1996). Afterwards, during the twentieth century, botos were reported in all the main Ecuadorian rivers that drain into the Amazon, including the Napo, Pastaza, Tigre, and Santiago rivers (Best & Da Silva 1993, Trujillo & Diazgranados 2002). To date, the only important Ecuadorian river system where botos have not been recorded is the Morona River (Utreras 1996, Utreras 2001a, Utreras *et al.* 2001a, Tirira 2007, Figure 7); however, the species is present in all the other Amazonian watersheds in Ecuador, including the nearby Santiago River watershed, suggesting that this might be due to lack of systematic sampling or reporting.

Together with some records from rivers in Peru, the sightings of botos in the San Miguel, Coca, Payamino and Santiago rivers, constitute the westernmost records of this species throughout its distribution in the Amazon River Basin. The physiognomy of the upper reaches of these Ecuadorian rivers, suggest that the western distributional limits of this species might be determined by the reduction in river depth, as well as the presence of large rocks, waterfalls, and fast flowing waters where these rivers leave the foothills of the Andes.

In relation to its past and current distribution, anecdotal information and informal interviews with local people suggest that botos in Ecuador might be retreating towards the East, being uncommon in areas such as the upper reaches of the Coca, Payamino, and Tiputini rivers. Although it has not been tested so far, it is probable that this retreat might result from water pollution, acoustic pollution, and other forms of habitat degradation that are common in the more populated western reaches of he Basin, near the base of the Andes.

Local names: Shuar and Achuar (Apup); Cofán (Fanjan, Ga´tzuri); Wao-Tededo (Yeyekeo); Siona-Secoya (Wiwi) (Tirira 2004).

Abundance

Our knowledge about the status of boto populations in Ecuador is clearly biased towards the northern Ecuadorian Amazon, particularly along the Cuyabeno, Lagartococha, Tiputini and Yasuní river systems (Utreras 1996, 2001b, Denkinger 2001, Jalil *et al.* in prep.). Compared to large river systems such as the Caquetá, Napo, and Marañón rivers, these Ecuadorian rivers are relatively small (~30 to 40 m wide), and sampling dolphins along them requires special methodological considerations, including counting along strip-transects (Trujillo 1992, Vidal *et al.* 1997, Trujillo & Diazgranados 2002). Using

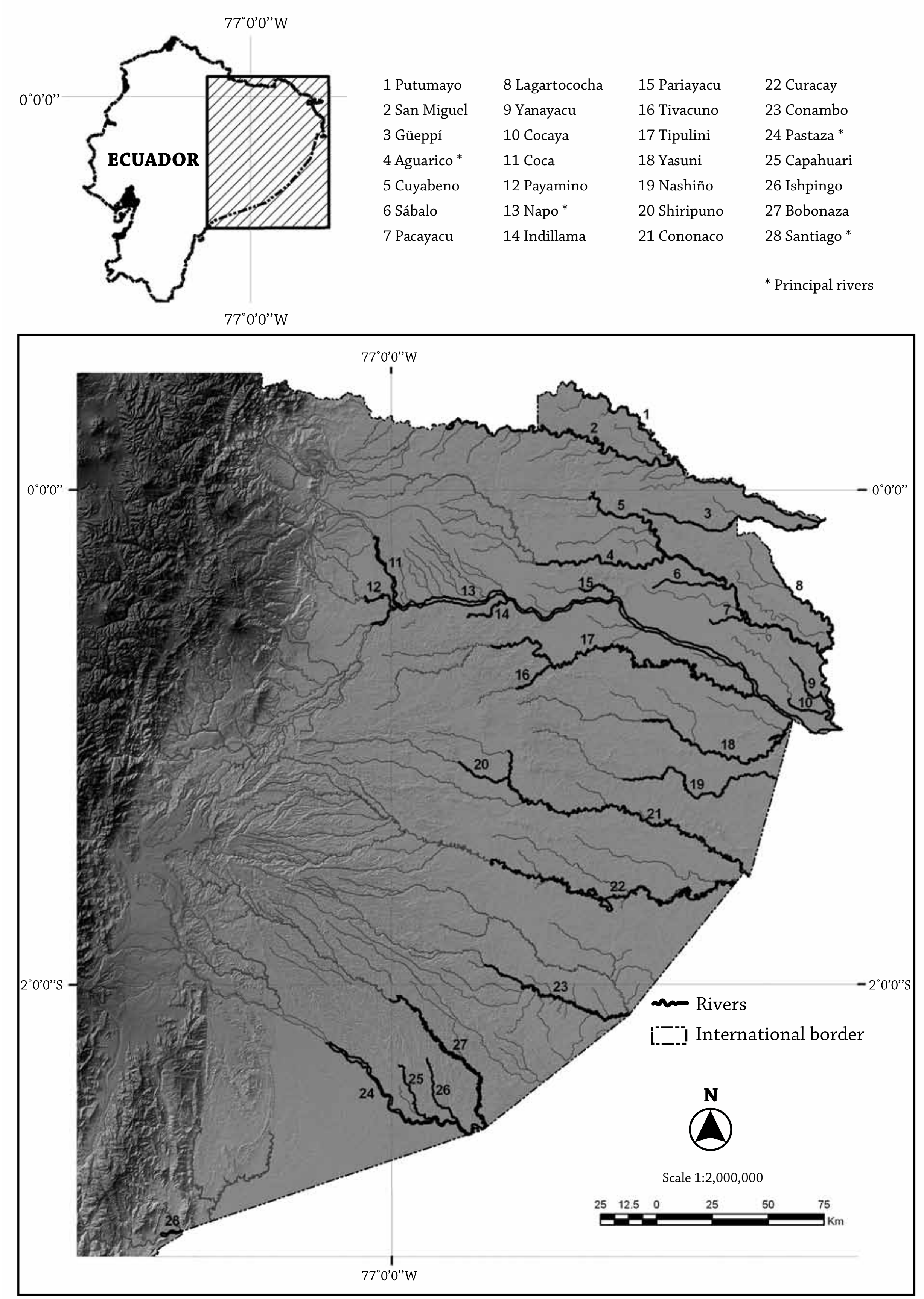

Figure 7. Geographical distribution of boto (*Inia geoffrensis geoffrensis*) in the Ecuadorian Amazon.

these methodologies, previous research in the northern Ecuadorian Amazon has reported relative abundances of botos ranging from 0.3 to 4.7 dolphins/10 km. Variation among these estimates is considerable, and no clear trend has been observed in relative abundances of botos in black water and white water systems (Table 19).

Other factors that apparently influence *I. geoffrensis* abundance is the complexity of the river-lagoon complexes and in particular the presence of productive river-lagoon confluences (Trujillo 2000). Previous studies in Ecuador provide indirect support to this hypothesis, as the dynamic and heterogeneous lagoon-river complex of Lagartococha exhibited boto relative abundances that sometimes were more than ten times higher than those in the uniform channel of the Tiputini River (Utreras 1996, 2001b, Denkinger 2001: Table 19). However, as can be noted here, these studies have not been able to discern between the potential effects of water chemistry and habitat complexity on dolphin abundances, a line of research that deserves further attention.

Regarding seasonal patterns in boto abundance, none of the studies that included seasonal estimates, reported considerable differences between rainy and dry season estimates (Table 19).

Habitat use

Even though the majority of studies in Ecuadorian populations of *I. geoffrensis* have not shown clear seasonal trends in relative abundance of dolphins, there are several lines of evidence suggesting that seasonality might be a very important factor in determining habitat use patterns of this species (Trujillo 2000, Trujillo & Diazgranados 2002). Water level during the dry season, for example, could influence the spatial distribution of fish stocks, conditioning the movement and habitat use patterns of dolphins as they search for food. Support for this hypothesis has been found in the Cuyabeno system (Denkinger 2001), where botos were found to prefer lagoons during the rainy season, and moved away to the river channels during the dry season, as water levels dropped in the lagoons. A similar but much weaker pattern was found in Lagartococha (Utreras 1996), where number of boto sightings during the rainy season was relatively similar between river channels and lagoon-river confluences, whereas, during the dry season, roughly two thirds of the sightings corresponded to the confluence between the rivers and the lagoons. In both systems, the river channels exhibited less seasonal variation in water levels than lagoon bodies, where water levels dropped by almost 4m during the dry season (Utreras 1996).

Many rivers of the northern Ecuadorian Amazon (i.e. Cuyabeno, Lagartococha, Tiputini, and Yasuní) exhibit strong fluctuations in water level, which cannot be easily predicted solely in terms of local rainfall patterns, or seasonality. These fluctuations result in the presence of large tracts of temporally flooded forests, which represent critical habitat for botos. Despite the potential importance of this relationship, to date little is known about the extent and persistence of floods along these forests, and about their impact on fish and boto distribution and habitat use.

Mortality

The only information about boto mortality that is available comes from incidental records

Table 19. Estimates of boto (*Inia geoffrensis*) relative abundances in rivers or lagoon systems in the northern Ecuadorian Amazon.

River	Season	Mean number of sightings	Transect length (km)	Effort (n)	Density Dolphins/10km	Year	Source
Lagartococha	Low waters	7.7 ± 0.3	20	53 (transect runs)	3.8	1994-1995	Utreras 1996
	High waters	8.8 ± 0.5	20	65 (transect runs)	4.4	1994	Utreras 1996
Lagartococha	Low waters				2.7	1996-1997	Denkinger 2001
	High waters				2.1	1996-1997	Denkinger 2001
Lagartococha	Low waters				3.2	2007-2008	Jalil *et al.* in prep.
	High waters				3.0	2007	Jalil *et al.* in prep.
Cuyabeno	Low waters				4.7	1996-1997	Denkinger 2001
	High waters				0.4	1996-1997	Denkinger 2001
Tiputini	Low waters	3.5 ± 1.0	209	Eight (monthly estimates along transect)	0.3	2001	Utreras 2001
Yasuní	Low Waters	21 ± 9.7	70	Four (monthly estimates along transect)	3.0	2001	Utreras 2001
Yasuní	Low waters				0.8	2007-2008	Jalil *et al.* in prep.
	High waters				0.9	2007	Jalil *et al.* in prep.

that have been made during 17 years of work in several locations throughout the northern Ecuadorian Amazon. From this period we have ten records of river dolphin mortality, involving a total of 22 individuals (12 in a single event). Among these records, the main cause of mortality was hunting with rifles by military personnel in army posts along the Lagartococha, Aguarico, and Cuyabeno rivers (44% of the killings). Following in importance was the use of dynamite for fishing, which accounted for 22% of the killings, and killing by fishermen with guns or machetes (11% of the killings).

Biology

Dispersal: Based on a two year study in Lagartococha, Utreras (1996) reported that juvenile dolphins (between 100 and 180cm in length), and adult individuals (> 180cm) accompanied by newborns tended to stay and use the same area throughout the year. On the contrary, large adults (> 250cm) were usually observed in a single location for no more than three days, after which they moved away. Similarly, Denkinger (2001) reported that *I. geoffrensis* in the Cuyabeno system exhibited frequent short-term dispersal movements of less than 20km, and occasional long displacements of more that 50 km, suggesting that this population moved freely between the Cuyabeno and Lagartococha lagoon systems. Based on observations of individuals identified with photographs, it was shown that some botos can travel distances of more that 150 km.

Social behavior: The vast majority of records of botos in Lagartococha and Cuyabeno rivers correspond to single individuals (~30% of the sightings), or small groups of no more than two (~24%) or three individuals (~18%); groups of up to 10 individuals were rarely observed (Utreras, 1986; Denkinger, 2001). Similar results have been found in the Tiputini and Yasuní rivers, where single individuals accounted for 37 to 41% of the sightings and 40 to 46% of the records corresponded to pairs of botos (Denkinger 2001, Utreras 2001b, Jalil *et al.* in prep.).

Births: The only direct report of a birth event of *I. geoffrensis* in Amazonian Ecuador was done by Utreras (1996), who described the birth of a boto in Delfincocha Lagoon in June 1994, during the peak of the rainy season, when water levels in the lagoon were very high. After birth, the female boto and her cub were consistently observed in the area for at least six months, when the fieldwork of this study ended. The event is described in detail in Utreras (1996).

Acoustic: May-Collado & Wartzok (2007) presented the only study that has analyzed the acoustics of high frequency whistling among Ecuadorian populations of boto. This study confirmed that *I. geoffrensis* produced whistles as part of their communication, feeding, and traveling behavior, a fact that was previously doubted as former recordings of *I. geoffrensis* were usually assigned to sympatric individuals of *S. fluviatilis*.

Threats

The main threats to botos and to aquatic ecosystems in Amazonian Ecuador are associated with the expansion of oil industry, especially in its northern region. On one hand, the spills of crude and polluted water from oil wells are frequent and almost inevitably end-up in streams and rivers before mitigation or remediation measures can be taken. On the other hand, the intensification of oil industry also results in large socio-economic changes, increased colonization along new roads, and intensification of boat traffic along rivers. Altogether, these changes increase pressure on boto populations, not only in the form of acoustic, organic, and chemical pollution of water bodies, but also by increasing the potential for human-boto conflicts in the fishing grounds that develop along new colonization fronts (Utreras *et al.* 2001a).

As noted in earlier sections, the impacts of human-boto conflict are evident in the direct records of boto mortality in fishing nets, or in hunting events, many of them intended to extract body parts that are used as aphrodisiacs, or as ingredients in traditional medicine. However, our understanding of the indirect effects of increasing human populations on boto populations is less clear. On a recent study, Jalil *et al.* (in prep.) made extensive surveys of botos along a human disturbance gradient in the Yasuní River, starting in a growing Kichwa community in the border of the Yasuní National Park. In this study, the average relative abundance of botos was almost two times higher in the more disturbed area of the river, in the surroundings of the Kichwa community, than in the relatively undisturbed area, more than 30 km upstream. In this study, the higher abundances of boto in the more disturbed area might be due to the fact that this area is also very near the confluence of two lagoon systems (Tambococha and Jatuncocha) and the large the Napo River; as noted earlier, previous studies have suggested that confluence areas might be preferred habitat for botos. From this perspective, this study suggests that, under certain circumstances, the negative impacts of human settlements might be counterbalanced by the presence of good quality habitat, or abundant food resources in productive areas. Clearly, additional studies are needed to assess in more controlled situations the impacts of human activities on boto populations.

In the case of the northern Ecuadorian Amazon and, more specifically, the Napo River watershed, a new threat is imminent as the Ecuadorian and Brazilian governments develop the plans for the implementation of the Manta-Manaus transportation corridor. This project, intended to create a direct commerce route between the Ecuadorian seaport of Manta, in the Pacific Ocean coast, and the Brazilian city of Manaos, includes plans to dredge the Napo River, making it accessible for large cargo vessels. Both, the dredging of the river and intensification of boat traffic, with the incorporation of large barges, will surely affect boto populations, not only long the Ecuadorian course of the Napo, but also as this river flows into Peru.

Legal status

According to the Red Book of Ecuadorian Mammals (Tirira 2001), *I. geoffrensis* is an Endangered Species under C2a(i) criteria (Utreras *et al.* 2001a), implying that their local population size is estimated to be less than 2500, and showing a decreasing population trend (UICN 2001). Under these conditions, Ecuadorian regulations prohibit the capture, hunting, trade, and transportation of botos (dead, alive, or in parts). However, the institutional weakness in the Ministry of the Environment, as well as the lack of knowledge of environmental laws among local communities, means that effective control is almost absent. Much needs to be done in terms of reducing the threats that Ecuadorian boto populations are facing, including the generation of better information on the extent of these threats and their impacts, and education campaigns intended to involve local communities in the conservation of the species.

Conservation initiatives

Although the management of Ecuadorian protected areas is still incipient and needs to be strengthened, the presence of the Cuyabeno Wildlife Production Reserve and the Yasuní National Park offer important alternatives for the conservation of botos, as both protected areas include large representations of critical habitat for this species. Precisely in these areas, local and foreign scientists started generating basic information on the ecology and conservation status of Ecuadorian populations of boto (Utreras 1996, Denkinger 2001; Jalil *et al.* in prep.), generating local interest in the species through education campaigns for local people and tourists. Despite these initiatives, Ecuador still lacks a coherent national plan or strategy for the conservation of botos. The development of such strategy is imperative, and will be a critical step in terms of developing the education, research, and conservation initiatives that should ensure the long-term persistence of *I. geoffrensis* in this region.

Sotalia fluviatilis. *Local names*: Cofán (bo´to); Wao-Tededo (uhuada); Siona-Secoya (oko wi) (Tirira 2004). Throughout the Ecuadorian Amazon, the tucuxi (locally know as bufeo or delfín cenizo) is an elusive species, characterized by a discontinuous distribution and sporadic records (Utreras 1996, Utreras 2001a, Utreras *et al.* 2001b, Zapata-Ríos & Utreras 2004). Only present at altitudes under 300 m, the tucuxi has been recorded in the Napo, Coca, Pastaza, and Bobonaza rivers (Borobia *et al.* 1991, Da Silva & Best 1996), and also in the Cuyabeno River, near its confluence with the Aguarico River (Herman *et al.* 1996). A recent review of the distribution of this species (Zapata-Ríos & Utreras 2004), included records from the Putumayo and Guepí rivers, near the Ecuador-Colombia border, as well as from the Panayacu, Tiputini, and Yasuní watersheds. In the southern Ecuadorian Amazon, this review added records from the Pastaza River and from several tributaries of the Morona River, including the Mangosiza, Cushuimi, Cangaime, Makuma and Wichimi rivers (Figure 8).

Very little information exists about the abundance or population size of this species in Ecuador. Jalil *et al.* (in prep.) reported relative abundance estimates of tucuxi ranging between 0.13 and 0.16 indivduals/10 km, along the Yasuní River. Regarding their social behavior, Zapata-Ríos & Utreras (2004), reported that the majority of the records of tucuxi corresponds to couples (53.5% of the sightings), or groups of three individuals (17.8%). Solitary animals, as well as groups of four or five individuals, each accounted for 7.1% of the sightings, whereas larger groups with 7 or 10 individuals were seldom observed (3.5% of the sightings respectively).

The threats that *S. fluviatilis* are facing are basically the same described in earlier sections for *I. geoffrensis*. However, because of their smaller populations, it is likely that this species will be more susceptible to the habitat changes that are occurring throughout the region (Utreras *et al.* 2001b). In terms of its legal status, the tucuxi is also considered an Endangered Species under C2a(i) criteria (Tirira 2001, Utreras *et al.* 2001b).

Conclusion

Current knowledge about the populations of

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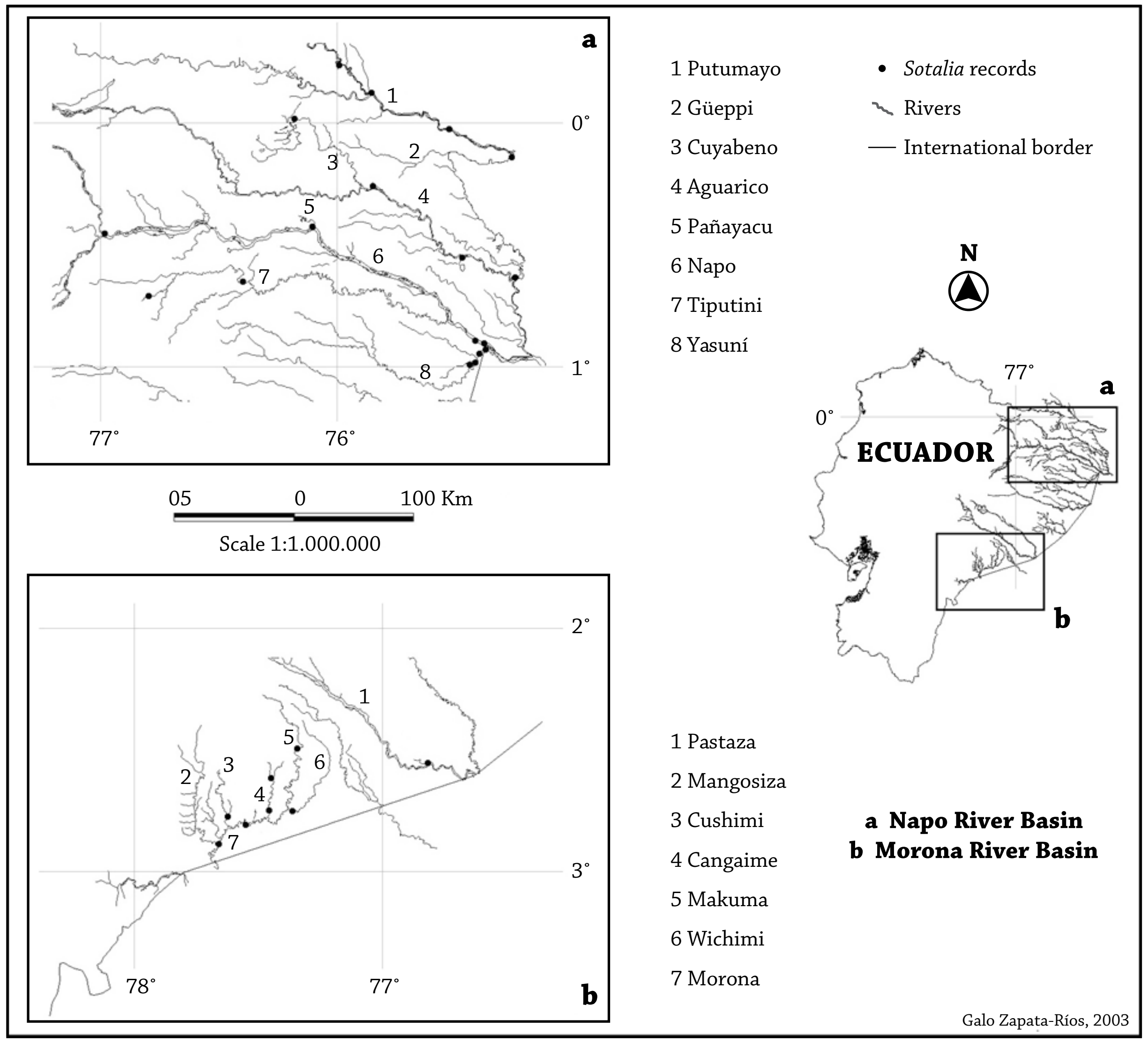

Figure 8. Geographical distribution of tucuxi (*Sotalia fluviatilis*) in the Ecuadorian Amazon (from Zapata-Ríos & Utreras 2004).

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botos and tucuxii in Ecuador is scarce. Beyond specific reports about the abundance and patterns of habitat use of these species in the Northern Ecuadorian Amazon, little is known about their ecology, population status, and their distribution in the southern watersheds of eastern Ecuador. Although the causes for this lack of information are diverse, one of the most important is the shortage of qualified researchers interested in these species, as well as the absence of research resources and programs oriented towards Amazonian aquatic ecosystems in Ecuador.

In the near future, considerable advances could be made towards improving the knowledge and conservation of Ecuadorian river dolphins, by drafting a research and conservation agenda, with emphasis in the acquisition of research funds, and the construction of local capacity, and training of young professionals with interest in these species or their habitats. Once new professionals are trained, specific studies should be promoted, oriented towards filling the main research gaps that have been identified in this paper and elsewhere. Extensive regional cooperation will be needed in order to fulfill these objectives.

Acknowledgements

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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 rio 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 rio Beni, cerca a la localidad de Cachuela Esperanza, las primeros estribaciones montañosas del Andes en el suroeste de la cuenca amazonica 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 geoffresis* e só ate 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 geográfica 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 precambrico no sudeste da mesma. O baixo numero 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 hidroelétricas 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 & Gihr 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 "bufeo". The indigenous people Guarayos used the name "Inia" for bufeos (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 & Gihr 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 southamerica 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 & Gihr (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 & Gihr (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.*

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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 & Gihr, 1977).

Pilleri & Gihr (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 cm^3. The color pattern of *I. boliviensis* is variable, varying from dark grey, white to pink, whereas claves are grey (Pilleri & Gihr 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.

	Inia geoffrensis	***Inia boliviensis***	**Source**
Sexual dimorphism	_>_	_>_	Da Silva 1994
	_>_	_>_	Ruiz-García *et al.* 2006
Total length (mm)†	_2740	-	Layne 1958
	-	_2160	Pilleri & Gihr 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 *et al.* 2006
	_2030 ± 249.3 *	_1937.7 ± 91.5 *	Ruiz-García *et al.* 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 *et al.* 2006
	_219.2 ± 61.5	_ 209.7 ± 43	Ruiz-García *et al.* 2006
Length from the tip of the jaw to mouth basis (LTJMO) (mm) †	_ (305.7 ± 29.5 *	_330.9 ± 37.5 *	Ruiz-García *et al.* 2006
	_ 280.8 ± 63.9 *	_ 290 ± 44.7 *	Ruiz-García *et al.* 2006
Length from the tip of the jaw to spiracle (LTJS) (mm) †	_ 397.9 ± 41.4 *	_389.1 ± 35.6 *	Ruiz-García *et al.* 2006
	_ 351.5 ± 92.6	_ 351.3 ± 54.7	Ruiz-García *et al.* 2006

	Inia geoffrensis	*Inia boliviensis*	Source
Length from the tip of the jaw to genital aperture (mm) (LTJGA) †	_ 921.5 ± 194.2 *	_ 890 ± 92 *	Ruiz-García *et al.* 2006
Width of the dorsal fin (mm) (WPF) †	_ 200.7 ± 30.4 *	_180.9 ± 20.2 *	Ruiz-García *et al.* 2006
	_186.5 ± 30.4 *	_ 166.1 ± 18.3 *	Ruiz-García *et al.* 2006
Length of dorsal fin (LDF) (mm) †	_ 82.1 ± 11.3	_ 66.4 ± 9.7	Ruiz-García *et al.* 2006
	_ 83.1 ± 23.8 *	_ 58.5 ± 8.8 *	Ruiz-García *et al.* 2006
Width of fluke (WF) (mm) †	_ 170 ± 17 *	_153.6 ± 25 *	Ruiz-García *et al.* 2006
	_ 164 ± 30.4	_145.3 ± 13.9	Ruiz-García *et al.* 2006
Flukes tip to tip (FIT) †	_ 453.6 ± 66.7	_446.4 ± 33.8	Ruiz-García *et al.* 2006
	_ 483.1 ± 107.6 *	_ 408.8 ± 44.8 *	Ruiz-García *et al.* 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 ± 2.1 (72 – 141) _154.2 ± 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

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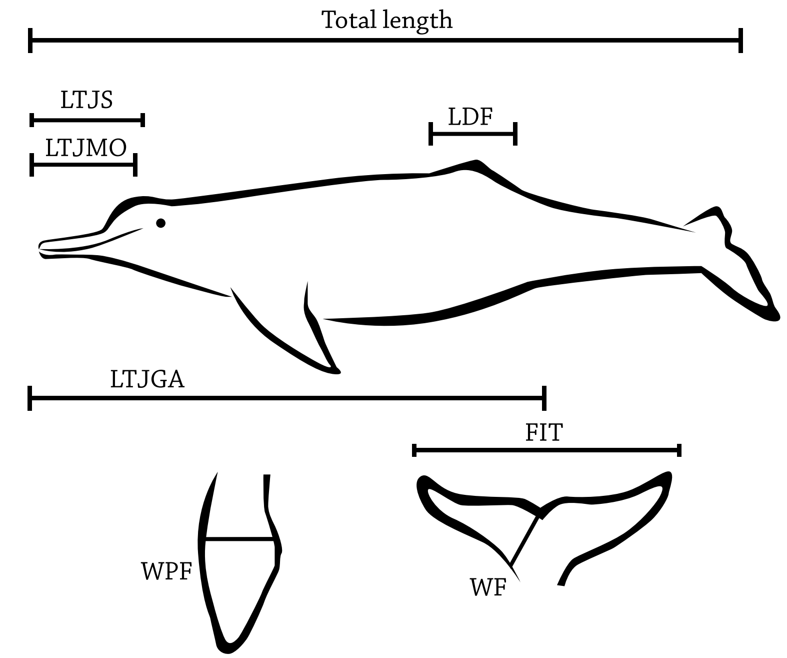

Figure 9. Abbreviations of measures of *Inia* spp. used in Table 20 (Ruiz-García *et al.* 2006).

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 & Gihr 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 Serrasalmidae, 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 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 m^3/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

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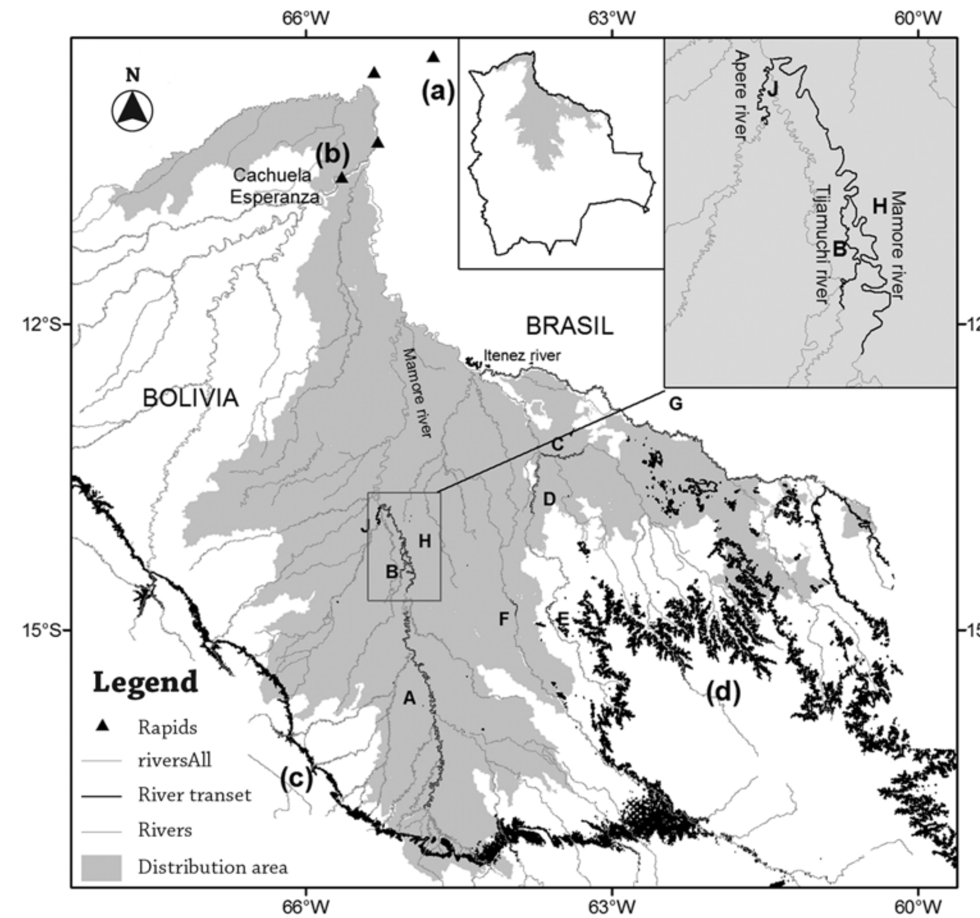

Figure 10. Estimated Extent of occurrence and river surveys of *Inia boliviensis* in the Bolivian Amazon. Only main rivers are shown. Physical barriers for the species are indicated as follows: (a) rapids in the Madera river downstream of its distribution range; (b) rapids in the Beni river which impede dispersion to the Beni and Madre de Dios watersheds; (c) Elevation in piedemonte 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 Martin 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.

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 & Gihr 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

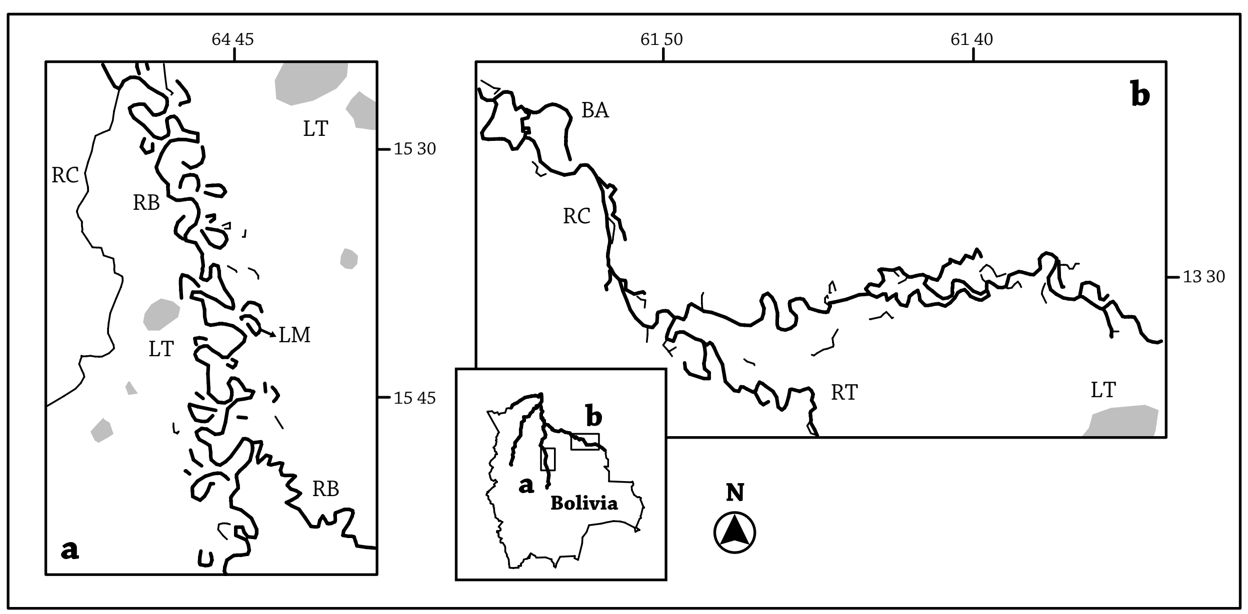

Figure 11. Main habitat types in the Hydro-ecoregions (a) "Lowland Floodplains" (Mamore River) and (b) "Precambrian Shield" (Iténez River), used by *Inia boliviensis*; RC = Clear water river; RB = White water river channel; LT = Tectonic lake; LM = Floodplain lake; BA= Old river arms.

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was based on not confirmed local anecdotic information. Pillieri & Gihr (1977) established 380m as the upper distribution limit for the species; however, their reference location (Puerto Villarroel) 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)

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 & Gihr 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 lenthic 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 & Gihr (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 & Gihr (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 rivers 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).

Pilleri & Gihr (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 Martin 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)
Pilleri & Gihr 1977	Ichilo	White	130	0.25
Pilleri & Gihr 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 *et al.* 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 *et al.* unpublished data	Ichilo-Mamoré	White	550	1,30
Tavera *et al.* 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).

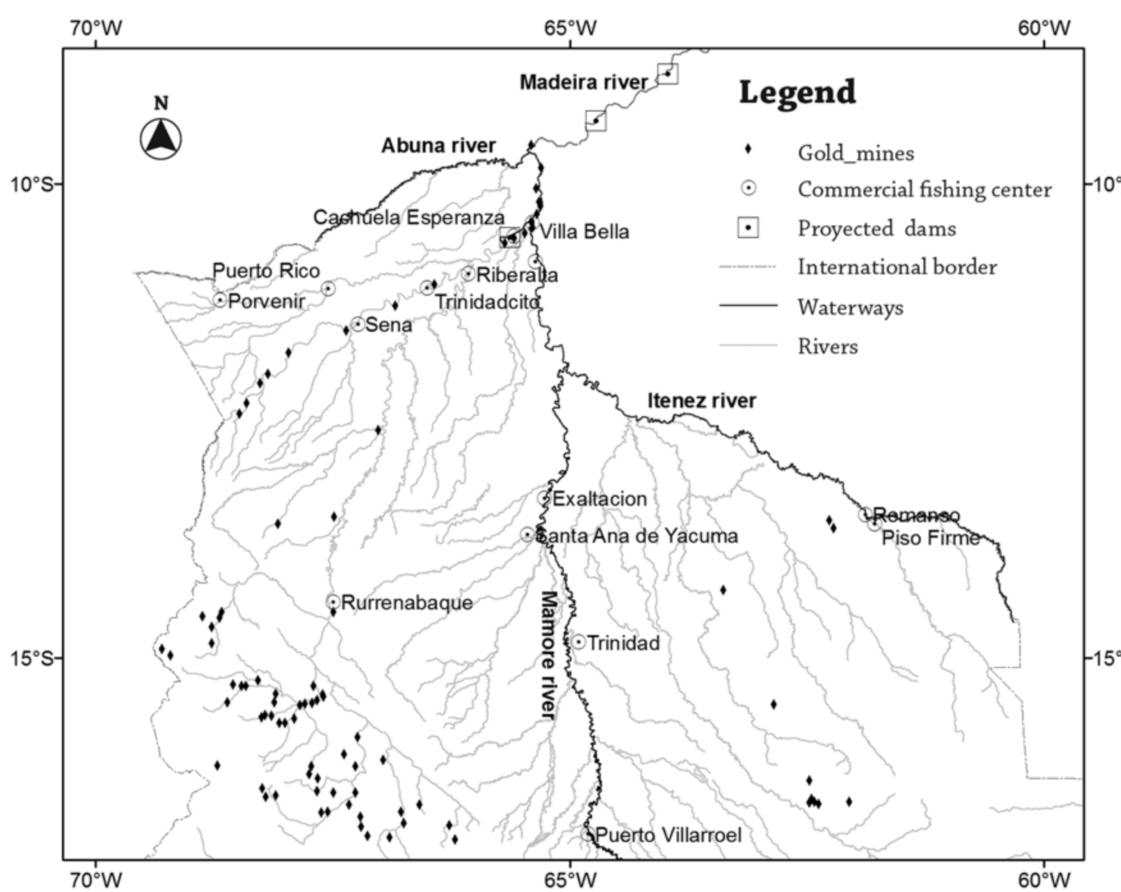

Figure 12. Map of threats that put on risk the future of *Inia boliviensis* in Bolivia: gold mining, dam construction, planned waterways and main commercial fisheries.

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 detrivorous 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 Martin 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. Anecdotic 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 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 localalized 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 brasilensis* (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 world-wide 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 km^2 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, Triportheus* 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 km^2 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.

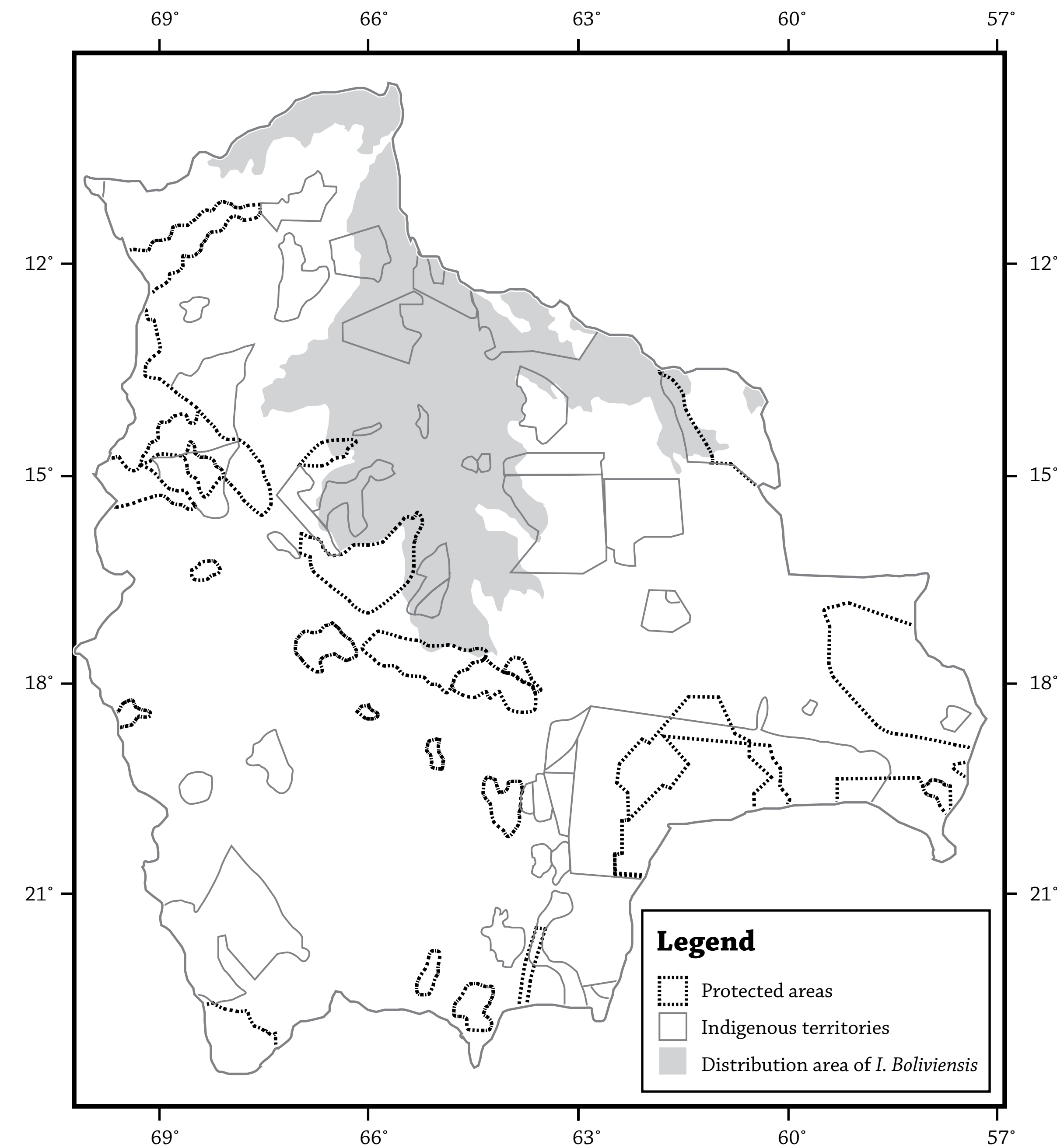

Figure 13. Overlap of the Extent of Occurrence of *I. boliviensis* with protected areas and indigenous territories in the Bolivian Amazon.

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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.

1.6. Status, threats, conservation initiatives and possible solutions for *Inia geoffrensis* and *Sotalia fluviatilis* in Brazil

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Abstract

The boto, or Amazon river dolphin, genus *Inia* occurs as two or more geographically-discrete populations, together covering most of the Amazon and Orinoco watersheds. The current convention of recognizing one species *I. geoffrensis* has been challenged, not least on the basis that the Bolivian population differs in some fundamental cranial characteristics from counterparts in the main Amazon River Basin. Certainly, the conservation status of the separate populations needs to be considered independently. Knowledge of the biology and ecology of the boto is uncertain, though improving through current research. Despite widespread incidental catches in fisheries, directed catches for use as bait and habitat deterioration due to industrial and agricultural development, the boto remains apparently

abundant, though numbers are declining fast in some areas. It is essential that mechanisms are put in place to allow the detection and quantification of status changes in this dolphin. Less information exists for *Sotalia fluviatilis* although the species, sympatric with the boto in most of its distribution, is subject to same pressure and threats and should be treated under the same conservation criteria as the boto. Without the ability to pinpoint and reverse damaging human impacts, there will be no means of preventing the boto from following the same disastrous path as its Asian counterparts.

Resumen

El delfín del río, conocido popularmente como bufeo o boto (genero *Inia*), consiste en dos o más poblaciones geográficamente distintas que cubren la mayor parte de las cuencas del Amazonas y el Orinoco. La convención actual de reconocer una sola especie, I. geoffrensis, ha sido criticada considerando, por ejemplo, diferencias fundamentales en la anatomía craneal entre poblaciones de bufeo de Bolivia y la bacía principal del Amazonas. Por lo tanto, la situación de la conservación de estas poblaciones también debe ser considerada de forma independiente. Conocimientos sobre la biología y la ecología del bufeo es limitado por hay muchos avances en investigaciones actuales.

Las amenazas principales son la captura accidental por la industria pesquera, captura intencional (especialmente para empate para ciertas prácticas pesqueras) y la deterioración de habitat causada por la expansión de la agricultura e industrias. Sin embargo, y a pesar de la caída de las poblaciones en algunas áreas más impactadas, el bufeo continua abundante en general. Es crucial implementar mecanismos para detectar y cuantificar cambios en la situación de conservación del bufeo en diferentes regiones. Hay menos información sobre el bufeo negro o tucuxi, *Sotalia fluviatilis*, que comparte casi la misma distribución con el bufeo y enfrenta las mismas amenazas; por lo tanto, la situación de conservación de esta especie debía ser considerada igual al del bufeo hasta que haya informaciones más detalladas. Solamente a través de proyectos de monitoreo y intervención sobre los impactos negativos se puede prevenir que los bufeos amazónicos sigan el mismo camino desastroso que el bufeo asiático.

Resumo

O boto, ou boto vermelho, gênero *Inia,* apresenta duas ou mais populações geograficamente discretas, distribuídas na maior parte das bacias dos rios Amazonas e Orinoco. A convenção taxonômica atual, que reconhece apenas uma espécie, *I. geoffrensis*, tem sido questionada, e não apenas porque populações bolivianas diferem em características cranianas fundamentais, quando comparadas com outros congêneres na bacia amazônica. Certamente, o estado de conservação dessas populações disjuntas precisa ser considerado separadamente. O conhecimento atual da biologia e ecologia do boto é incipiente, embora exista um importante aumento nas pesquisas atuais. Apesar da ampla ocorrência de capturas acidentais em redes de pesca, das capturas diretas para uso do boto como isca e da degradação do habitat devido ao desenvolvimento industrial e da agricultura, o boto continua aparentemente abundante, embora em algumas áreas os números estejam diminuindo rapidamente. É crucial que sejam estabelecidos mecanismos que permitam detectar e quantificar as alterações do número desses golfinhos. Bem menos informações existem para *Sotalia fluviatilis,* apesar desta espécie, simpátrica com o boto na maior parte de sua distribuição, estar submetida a mesma pressão e ameaças e deve ser tratada com os mesmos critérios de conservação que o boto. A incapacidade de se apontar e de se reverter os impactos humanos sobre esses animais, e a inexistência de mecanismos de prevenção farão que o boto siga o mesmo caminho desastroso que levou a extinção os golfinhos da Ásia.

Introduction

In the Brazilian Amazon there are two different species of cetaceans from two different families: the largest of the river dolphins, *Inia geoffrensis* (the boto), and the only freshwater member of the marine family Delphinidae, *Sotalia fluviatilis* (tucuxi). The boto and the tucuxi have a very broad distribution occurring almost in all rivers and lakes they can possibly reach where the main barriers are rapids, falls and shallow water. Despite all threats, both species are still abundant and widely spread in most of its original distributional area. Much of the difficulty in protecting these two species of freshwater dolphins is due to their great mobility and the direct proximity and competition with humans for food, space and water quality.

Although sparsely inhabited, the six main states of the Brazilian Amazon region where the botos occurs holds a population of 13.4 million humans, with an average density of 24.3 inhabitants/ km^2 (IBGE 2007) concentrated in a few large urban areas of the region and along the margins of the main rivers of the Amazon River Basin. Most human activities in the Amazon, such as transportation, electricity, survival and development programs are connected to the rivers and under the influence of its seasonality, making conservation efforts for all aquatic organisms more difficult.

Species and local names

Inia geoffrensis is the only recognized species in the Amazon River Basin. It is known in the Brazilian Amazon as *boto-vermelho* (red boto) or simply boto, and is also popularly called in the rest of Brazil as *boto -cor-de-rosa* or *boto-rosa* (pink dolphin), due to the strong pinkish color exhibited by some adult individuals. Fisherman perceptions on the color pattern of this dolphin at different stages of life or body condition can differ along boto distribution, thus different names are used locally according to the fisherman's description. Fetus, calves and young animals are always gray, while adults are pinkish or light gray and present large areas of gray color in the dorsal area of the body (Best & da Silva 1989a, 1989b). Adult males are in large part, pinker than females. This pinkish tonality is the result of the progressive loss of the dark coloration, with age and growth, and due to the abrasion caused during intraspecific interaction between males and is not related with the health of the individuals. Usually in males, the strong pink color is associated to the maturity status inferring that the bright pink color is a visual display in adult male botos (Martin & Da Silva 2006).

Sotalia fluviatilis is the only exclusive Delphinidae freshwater dweller in the Amazon River Basin and one of the smallest dolphins of this family. In Brazil it is mainly known as boto-tucuxi or tucuxi, although in some places can also receive names according to its colour or fisherman perception as boto "pretinho","roxinho" or "cinza". Differently from the boto, the tucuxi do not change body color or color pattern with age or sex, but a variation from dark to light grey can be observed in all age classes (Da Silva & Best 1996).

Status of population

Distribution

The boto and the tucuxi have an extraordinarily wide distribution, occurring in the Amazon River Basin almost everywhere they can physically reach without venturing into marine waters, and are sympatric in the largest part of its distribution. They occur in all types of water (black, white and clear) and in most habitats of the region throughout the year. The very large seasonal river level fluctuations are a major influence on the distribution and occurrence of the dolphin during the year. The water level varies as a consequence of the rainfall, both annually and regionally. During the high-waters, the floodplains or ‚varzea' of white rivers and the, igapó' (floodplains of black- and clear water rivers) are flooded. Due to its body flexibility the boto can explore both habitats, swimming among the submerged vegetation in the flooded forest or ‚igapó' in search of fish or can enter the floodplains in the very rich ‚varzea', while the tucuxi do not venture in waters with dense vegetation, preferring open waters. During the dry season, the varzea and the igapó are completely dry and the dolphins are concentrated in the main channel of the rivers and in permanent lakes (Da Silva 1994, Martin & Da Silva 2004a).

Inia geoffrensis is widely distributed within, and endemic to, the Amazon and Orinoco Rivers Basins. It occurs in six countries of South America: Bolívia, Brazil, Colombia, Ecuador, Peru, Venezuela and throughout the Branco and Tacutu rivers along the border between Guyana and Brazil (Best & Da Silva 1989a, 1989b, 1993) in a total area of about 7 million km^2 (Nordin & Meade 1986). The geographical distribution of the genus was hitherto known in a broad sense, but not in detail. Records for the boto are mainly based on opportunistic observations reported from generalized areas. In the Amazon River drainage system the boto is found from the delta near Belém, as far upstream as the Ucayali and Marañon rivers in Peru, throughout the main river, the main tributaries and smaller rivers (Best & Da Silva 1989a, 1989b, 1993, Hershkovitz 1963, 1966, Leatherwood *et al.* 2000). The principal limits of its distribution are impassable rapids, very small and shallow rivers and possibly cold waters from the smaller tributaries near the Andes, although there are several records of the boto passing extensive rapids, mainly during high waters (Best & Da Silva 1989a).

Geographical barriers

The boto population of the Amazon system is separated from animals of the Beni/Mamoré system by a series of rapids in the upper Madeira River between Porto Velho and Guajará-Mirim (Pilleri & Gihr 1977, Casinos & Ocaña 1980, Grabert 1983, Best & Da Silva 1989a,b, 1993, Da Silva 2009). These 200km of rapids are not, however, a barrier to large migratory catfish during high water (Goulding 1979, 1981) and botos occur between these rapids and above and below the Abuña falls (Da Silva, pers. Obs.), and so the separation may not be absolute. The populations from the Orinoco and the Amazon river systems are considered to be isolated from each other by the falls on the upper Rio Negro, by the rapids on the Orinoco River between Samariapo and Puerto Ayacucho, and by the

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Casiquiare Canal itself (Pilleri & Gihr 1977, Grabert 1983, Best & Da Silva 1983). The boto was previously reported as absent in the upper parts of the Orinoco River (Trebbau & van Bree 1974, Pilleri & Gihr 1977, 1981) but was confirmed to occur above, below and between the rapids mentioned above (Pilleri & Pilleri 1982, Best & Da Silva 1983, 1993, Defler 1983, Meade & Koehnken 1991). Botos also pass rapids on the Tocantins and Branco rivers but not those below Altamira in the Xingú River and those on the Tapajós River near São Luís do Tapajós (Lamb 1954, Best & Da Silva 1989b, 1993, Da Silva & Martin 2000). There are no published records of *Inia* for several rivers in the Amazon River Basin, although from Belém at the mouth of the Amazon River to Tabatinga at the border between Peru and Colombia this dolphin has been observed along the Amazon River in the mouth of all tributaries. If there is no physical barrier between these rivers and the main rivers where the dolphin reside, the lack of reports is likely to be more related to the absence of observers than that of dolphins.

Sotalia fluviatilis is endemic to the Amazon River drainage system. Records exist from Belém through the main river and tributaries of the Amazon in Brazil to the Ucayali and Putumayo rivers in Peru, Colombia and Ecuador (Borobia *et al.* 1991, Best & Da Silva 1984, Da Silva & Best 1994, Flores & Da Silva 2009, Grimwood 1969, Leatherwod *et al,* 2000, Rios & Utreras 2004, Vidal *et al.* 1993). In Brazil, the principal limits of its distribution are small and shallow rivers and the presence of rapids (Da Silva 1983 1986, Da Silva & Best 1994). *Sotalia* does not occur in the Araguaia River, and in the Tocantins River it occurs only below the Tucuruí dam, near its mouth. The boundaries between the marine and freshwater *Sotalia* at the Amazon estuary is not well defined (Cunha *et al.* 2005, Caballero *et al.* 2007) however, due to the influence of the Tocantins and Guamá rivers discharge into the Pará River, the fluvial species can be found several kilometers below Belém. The tucuxi does not pass the rapids at São Gabriel da Cachoeira on the upper Rio Negro, and thus does not occur in the upper Orinoco (Best & Da Silva 1983, Da Silva & Best 1994, Meade & Koehnken 1991).

Species / stock identity

Very little information about stock identity in botos and tucuxis exists. Most researchers have considered the animals in their study area as part of a larger stock or population, but without any evidence as to its geographical limit.

Inia geoffrensis. The possibility of three large populations of *Inia*, one in each of the three main river systems where the genus occurs, has been suggested by several authors (e.g. van Bree & Robineau 1973, Casinos & Ocaña 1979, Hamilton *et al.* 2001). This discrimination was suggested because of the potential geographical barriers between the Amazon and Orinoco river systems and between the Amazon and the upper Madeira/ Beni/ Mamoré river systems. There has been considerable discussion as to whether these populations should be regarded as different species, subspecies or simply races (e.g. Hershkovitz 1966, Trebbau & van Bree 1974, Pilleri & Gihr 1977, Best & Da Silva 1989a,b, Hamilton *et al.* 2001, Banguera *et al.* 2002).

The current recognition is of a single species *Inia geoffrensis* and three subspecies *I. g. humboldtiana* (distributed throughout the Orinoco drainage River Basin), *I. g. geoffrensis* (Amazon drainage River Basin, excepting the upper Madeira River drainage) and *I. g. boliviensis* (upper Madeira and Beni Rivers drainage, above the Teotônio Rapids) (van Bree & Robineau 1973, Pilleri & Gihr 1977). Best & da Silva (1989a) concurred, believing that the defined sub-populations were sufficient for management purposes, since they encompassed discrete geographical areas and as such should permit separate treatment of conservation problems as they pertain to each region.

On the basis of cranium characteristics da Silva (1994), using canonical discriminant analysis, proposed the classification of *Inia* into three taxa and two separate species This study found substantial differences between animals in the Beni river system of Bolivia [proposed as the monotypic *Inia boliviensis* (D'Orbigny, 1834)] and all other populations [proposed as *I. geoffrensis* (de Blainville 1817)]. A second discriminant separated two proposed sub-species; *I. g. geoffrensis* in the Amazon River system (van Bree & Robineau 1973) and *I. g. humboldtiana* for the population of the Orinoco River system (Pilleri & Gihr 1977).

Sotalia fluviatilis. The taxonomy of the species *S.fluviatilis* was recently revised, with the re-establishment of *S. guianensis* based on molecular genetics and cranium morphometry and morphology (Monteiro-Filho 2002, Cunha *et al.* 2005, Caballero *et al.* 2007, Fettuccia 2006). The controversy about the boundaries of each species in the estuary of the Amazon and the possible existence of hybrid individuals in a transitional area still exists. Molecular results of *Sotalia* from the delta of the Amazon River revealed that these dolphins are genetically much closer to *Sotalia* from Santa Catarina State than from the riverine *Sotalia* geographically closer (Cunha *et al.* 2005).

The tucuxi *Sotalia fluviatilis* is endemic to the Amazon River Basin. Although known in most rivers and lakes of the region, it is little studied, and no information exists on stock identity or population structure. Cunha and collaborators are currently working in a broad project "Phylogeography of tucuxi (*Sotalia fluviatilis*) in the Brazilian Amazon" using mitocondrial and nuclear markers (Microsatellite), aiming to verify the population structure of this species. A study of mark-recapture in the central Amazon suggests that *S. fluviatilis* present a fission-fusion society, revealing long-term site fidelity (Da Silva & Martin, unpublished data).

Abundance

Inia geoffrensis. Several long distance surveys of both species of riverine dolphins in the Amazon have been carried out along its distributional area. However, because of the differences in survey methodology, river morphology and hydrology, no meaningful comparison between the results of different surveys can be made, and none provide a basis for robust estimates of population size (Da Silva & Martin 2000).

A survey covering a distance of 500 km between Manaus and Tefé provided the first detailed long distance survey including boto and tucuxi (Magnusson *et al,* 1980). This survey estimated a density of 0.19±0.06 botos per km of river. Almost two decades later, Vidal *et al.* (1997) performed a survey covering 120km of the Amazon River bordering Colombia, Peru and Brazil producing an estimated density of 4.8 botos per km^2 in main tributaries. Between March 1999 and April 2001 six multi-day surveys were carried out covering a total track line distance of 1402 km in strip transect and 810 km in line transect mode in the Central Amazon, Brazil (Martin & Da Silva 2004a, 2004b). As found in common with all other researchers, botos were disproportionately clustered in eddies and where small channels met the main river and few were seen during the zig-zag line-transects in mid-river (Martin & Da Silva 2004a, 2004b). The exact same scenario was found by Vidal *et al.* (1997) some 700 km upstream. In effect, therefore, the width of a major river seems to have little influence on the number of botos it holds; since the dolphins are restricted to a narrow strip on each margin (Martin & Da Silva 2004a, 2004b). This has obvious implications for the design of future large-scale surveys. Summary results obtained by these authors of the strip and line transects are given in Tables 23 & 24 respectively. The estimated density of botos given by Vidal *et al.* (1997) and Martin & da Silva (2004b) is among the highest measured to date for any cetacean.

Table 23. Density estimates of botos *Inia geoffrensis* in Brazil.

Country / Area	Date/Water Level	Estimate Density	Source
Solimões River, 490 km	August 1979; Receding	N= 107; 0.19±0.06 / km (SD)	Magnusson *et al.* 1980
Amazon River, bordering Colombia, Peru and Brazil ~120km.	5 to 26 June 1993 (High water)	346 (CV= 0.12) *Inia* in the study area; D = 4.8/ km^2 in tributaries, D=2.7 / km^2 around islands, D= 2.0 / km^2 along main banks.	Vidal *et al.* 1997

Table 24. Summary results of strip transect surveys of *Inia geoffrensis* carried out along the margins of the main rivers in six multi-days surveys in central Amazon (from Martin & da Silva 2004a).

Survey Period	Total distance covered	Area within strip (km^2)	No. of botos seen	Mean no. of botos per km of margin	Mean no. of botos per km	Water Level (m)
Mar 1999	202.9	32.5	83	0.41	2.55	12.6
Jun 1999	161.3	24.4	140	0.87	5.75	15.4
Oct 1999	172.3	33.7	131	0.76	3.89	3.9
Mar 2000	374.1	56.1	99	0.26	1.76	8.6
Jul 2000	227.3	33.9	164	0.72	4.84	13.8
Mar-Apr 2001	263.4	39.5	199	0.76	5.04	12.0

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Table 25. A summary result of line transects surveys for *Inia geoffrensis* carried out in the middle reaches of the Japurá and Solimões rivers (from Martin & da Silva 2004b).

		Density (numbers / km²)								
					Confidence Limit					
Survey Period	**Survey Effort (km of track)**	**Mean**	**% CV**	**df**	**Lower**	**Upper**	**No. of groups within 405 m of the track**	**Group Size**	**No. within 315 m of the track**	**Water Level**
Jun-99	91.2	0.23	54.9	44.8	0.08	0.66	11	1.3±0.14	14	15.4
Oct-99	118	1.75	23.9	115.5	1.1	2.79	45	1.6±0.11	67	3.9
Mar-00	89.1	0.35	54.2	64.2	0.13	0.95	11	1±0	11	8.6
Jul-00	133.2	0.55	43.2	61.3	0.24	1.25	17	1.4±0.12	23	13.77
Mar - Apr 01	150.6	0.16	47.6	95	0.07	0.39	8	1±0	8	12

Sotalia fluviatilis. The abundance and status of *S. fluviatilis* populations is unknown or, at best, based on qualitative assessments of small geographical areas (da Silva and Best, 1994, 1996). In about 500 km of the Solimões River, between Manaus and Tefé, Brazil, the average density of animals observed (±SD) was 1.1 ± 0.4 tucuxi/km of river (Magnusson *et al*. 1981). Four similar boat surveys from Manaus to Leticia (about 1,525 km each) gave a mean total (±SD) of 768 ±104.7/ trip or 1.02 individuals/ km² (da Silva and Best, 1994). In an area of about 250km² in the upper Amazon River bordering Colombia, Peru and Brazil during high water (June 1993), Vidal *et al*. (1997) estimated a total of 409 (CV=0.13) *Sotalia*. The highest density was found in lakes (8.6 tucuxis/ km²), followed by areas along main banks (2.8) and around islands (2.0). Results of line-transect surveys (200m from the nearest riverbank in an area of 170.1km²) gave a mean sighting rate of 0.439 (CV=0.27) tucuxi per km $^{-1}$, a density of 0.895 dolphin/km² and an abundance of 152 *Sotalia* (CV= 0.33). Results of strip transect survey (in lakes, smaller tributaries and canals, in water closer than 200 m from the edge in an area of 89.6 km²) revealed the overall mean sighting rate of 0.41 tucuxi per km $^{-1}$ and an abundance of 257 tucuxi (CV= 0.07). Martin & da Silva (2004b) conducted six multi-day surveys covering a total track line distance of 1402 km in strip transect and 810 km in line transect mode in the Central Amazon, Brazil between March 1999 and April 2001 and found a density of 3.2 tucuxis per km² in the main tributaries.

Mortality

Inia geoffrensis. During the 15 years of Projeto Botos' presence in the Mamirauá Lake System, very few botos were encountered dead. The total was only 26 dead botos and three tucuxis. Of the botos found, 13 died of net-entrapment, five due to harpoon or other injuries and 8 of unknown causes. In an area containing an average in the high tens of dolphins, and where carcasses are likely to come to people's attention, these numbers represent an apparent low mortality. Fishery-related dolphin mortality, in and around Mamirauá Reserve area however, is higher. A study using carcasses collected from 1993-2002 revealed a total of 117 botos and 41 tucuxis, from which 76% and 78% respectively were caught in nets and 24% and 22% by harpoon (Calvimontes & Marmontel 2004). Data from Projeto Boto abundance estimates, obtained from minimum counting surveys related to the volume of piracatinga fisheries received by one fish plant of Tefé city, estimated the killing of 1600 botos per fishery season (Da Silva & Martin 2007).

Sotalia fluviatilis. Nothing is known about natural mortality of the tucuxi in the Amazon River Basin. In contrast with the sympatric boto, the tucuxi is considered to be harmless and pleasant by local people, including fishermen. Usually when captured alive in fishing gear the tucuxi is released unharmed (Da Silva & Best 1994).

There are no records of past or recent commercial fisheries for the tucuxi in Brazil. Most of the known causes of mortality of this dolphin involve accidental entrapment in fisheries gear. The increasing fisheries pressure in the Amazon in recent decades has greatly heightened the potential for dolphin/fisheries interactions. Neither the number of tucuxis killed in fishery interactions, nor the impact of such mortality on this dolphin population, is known for any upriver freshwater region. However, the few published records of incidental takes, and the authors' experience in the central Brazilian Amazon, suggest that entrapment is not very common. In the Amazon River estuary, however, the magnitude of catches is substantial, showing strong seasonality and suggesting that the interaction between the fisheries and the tucuxi is indirect, where the dolphins and the fisheries are targeting the same prey (Beltrán-Pedreros 1998). This author found that there is no intentional capture and that dolphins are not used as indicators of the presence of fish. In general, the presence of the dolphins is not welcome during fishing activities since an incident can result in the end of the trip, with subsequent loss of earnings.

Biology

The reproductive anatomy of *Inia* was described for the first time by Harrison & Brownell (1971) and Harrison *et al*. (1972). Brownell (1984) reviewed the reproductive characteristics of platanistoid dolphins and Best & Da Silva (1984) presented a preliminary analysis of reproductive parameters of the two species of Amazon River dolphins, *I. geoffrensis* and *S. fluviatilis*. Ovary maturity of *Inia geoffrensis* is Type I in which both ovaries mature and ovulate at the same time (Brownell 1984, Harrison & Brownell 1971, Best & da Silva 1984), while in *S. fluviatilis* Type II ovulation occurs only on the left ovary (Best & Da Silva 1984). A study of the placenta anatomy of both species of dolphins revealed that the interhemal membrane of the placenta was of epitheliochorial type (Da Silva *et al.* 2007).

Age and body length at sexual maturity

Inia geoffrensis. In a sample of 32 female boto, ovarian scars were present in both ovaries of all females larger than 174 cm body length. Based on the presence of scars in the ovary, the smallest mature female recorded was 174.5 cm long, 68.5 kg in weight. A 15 year old female, 184 cm long and weighing 68.5 kg was found to be lactating and pregnant at the same time. The fetus was located in the left side of the uterus and the left ovary had 5 Ca + 1 Cl while the right ovary had only one Ca. The largest immature female was 5 years old, 160 cm long and weighed 50 kg. Both ovaries were completely smooth without any scaring (Da Silva 1994).

Sotalia fluviatilis. Information is limited regarding the reproductive system and the morphologic characteristics of *S.fluviatilis.* Examination of the weight of the testicles, the diameter of the seminiferous tubules, and histological analyses of thirteen individuals suggest that young males 143 cm in length are sexually mature. Above of this length, they can be sexually mature but show great testicular variation, reflecting strong reproductive seasonality. Females reach sexual maturity between 132 and 137 cm and ovulation always occurs in the left ovary (Da Silva 1994, 2004).

Length at birth, gestation time and fetal growth ***Inia geoffrensis.*** In the Brazilian Amazon sample, the smallest neonate of boto recorded was 81 cm long and the largest near-term fetus was 66 cm long (Best & Da Silva 1984). Five reports of neonates (Huffman 1970, McCuster 1973; Caldwell & Caldwell 1972 ,Harrison & Brownell 1971, Gewalt 1978), ranging from 76 to 83.6 cm (X_5 = 79.4 ± 3.5 cm) suggest that the length at birth is around 80 cm (Da Silva 1994).

Based on the models of Kasuya (1977) and Perrin *et al.* (1977), gestation time has been estimated at about 10.7 to 11.2 months and the fetal growth rate at 8.35 cm/month (Best & Da Silva 1984).

Information on captive live births of two *Inia* calves was obtained by Huffmann (1970), McCusker (1973) and Caldwell and Caldwell (1972) from specimens collected in the 1960s and 1970s from different areas of the Amazon river system (near Iquitos, Peru; Leticia, Colombia and Manaus, Brazil), and taken to American and European Aquariums for public display (Best & Da Silva 1989a, Caldwell *et al.* 1989 Collet 1984). The composition of *Inia*'s milk was first presented by Gewalt (1978). Milk analysis of one female from Central Amazon presented 6.9% of fat content, 9.6% of protein, and 176 ng/ml of total mercury, considered very close to the minimum level of methylmercury toxicity (200ng mercury/ml blood) in humans (Rosas& Lehtil 1996).

All available information on birth size and gestation time for *S. fluviatilis* was presented by Best & Da Silva (1989a) and Da Silva & Best (1996). According to these authors birth size was estimated to be from 71-83 cm after a gestation of 10.2 months, during the receding and low water. No milk analysis exists for this species.

Seasonality of births

For botos, calving season is apparently quite long, and both mating and parturition are not well synchronized in the population. An 81 cm neonate and a 66 cm fetus were recorded in the

same month, May, in areas relatively close to each other (Best & Da Silva 1984).

If the reproductive cycle of this species is indeed synchronized with seasonal fluctuation in flood levels, then we might expect calving to peak 4-6 months out of phase between the Amazon and Orinoco watershed on the one hand, and the more southern river on the other. At present there is insufficient information available to allow this hypothesis to be tested. The majority of lactating females with a large calf of about two years old captured alive during the months of October/ November in the central Amazon were also pregnant (Projeto Boto unpublished data).

Genetics

Little is known of the genetics of *Inia geoffrensis* and no studies have yet been published on the genetic structure of this species, the genetic variation within and between populations or social structure. A study to genetically differentiate *Inia* individuals from four Colombian rivers using three DNA analysis methods (RFLP, RADP and AFLP) was carried out by Banguera *et al.* 1996. These authors concluded that there was very little genetic variation among the individuals analyzed suggesting the possibility of a high degree of inbreeding in the Putumayo River Basin population, a higher proximity between individuals from the Orinoco and Guaviare rivers, and a strong separation from those of Putumayo River.

Another study using mitochondrial D-loop DNA to compare samples from three geographically separated populations of *Inia* (from rivers of the Orinoquian Basin, tributaries of the Amazon River in Colombia and rivers of the Beni/Mamoré systems) was conducted by Banguera *et al.* in 2002. Phylogenetic grouping analysis performed on all characterized haplotypes showed two distinct clades; one for the Colombian Amazon and Orinoco river systems, the other for the Beni/Mamoré river systems, supporting the proposal to subdivide the genus *Inia* into two distinct allopatric species (Banguera 2000).

A study genetically comparing two groups of botos separated by 55km, in the Negro River, about 115km from Manaus, revealed an absence of population structure, where the largest variation was observed within groups rather than between groups. The degree of relationship within groups was low, although few individuals presented a high degree of relationship, suggesting an intense genetic flux inside the Negro River Basin but restricted when compared with the other rivers of the Amazon River Basin. (Gravena 2006).

Inia's chromosomes are cytogenetically similar to other odontocetes (with the exception of *P.macrocephalus*) since it has a diploid chromosome number of 44 (Kulu 1971). Balanced translocation in *I. geoffrensis* without apparent phenotypic abnormality has been observed (Duffield 1977).

Sotalia fluviatilis. No information of social structure in any particular population or genetic variation within and between populations is available.

Threats

Several studies recognize potential anthropogenic threats to tucuxis and to botos along its distribution, but very little has been done to quantify these threats in terms of the absolute or relative levels of impact on these species. This is simply because there is insufficient knowledge to allow an objective assessment of such impacts. The threats to river dolphins in South America, listed in Best & da Silva (1989 a,b); Perrin & Brownell (1989) and da Silva & Martin (2000), still exist, however, the main threat today, is the direct killing of the boto for bait. This activity became evident in Brazil with the new millennium. Although no direct catch exists for the tucuxi, this riverine species is subject to the same threats faced by the sympatric boto. In the central Amazon, more than 30 individuals caught alive in nets presented some sort of severe healed wound of anthropogenic origin (Projeto Boto unpublished Data).

No records exist of natural predation on either species, and are implausible except perhaps on sick or wounded animals. Wounds caused by piranhas (Serrasalmidae) are not uncommon on these dolphins (da Silva pers. obs.) but it is improbable that piranhas will attack and kill a healthy boto or tucuxi.

Direct

According to the Action Plan for the Cetacean World 2002-2010, (IUCN 2003) direct exploitation is usually driven by the demand for products, whether this means food to be consumed (subsistence) or meat, blubber, oil and other commodities to be sold commercially in national and/or international markets. In Brazil, the genital organs and the eyes of river dolphins were sold as love charms (Best & da Silva, 1989a) and the teeth and some bones were used by artcraft makers to produce bracelets and necklaces, and the oil is used for different purposes. This occurs despite the existence of federal laws protecting these species (Ibama 2001).

Inia geoffrensis. In Brazil, during colonial times, *Inia geoffrensis* was captured by the Portuguese for oil to be used in lamps for illumination (Best & da Silva 1989a). The large scale capture of the species for its dried eyes and genitalia to be used as love charms in Brazil in the past was never confirmed and apparently did not constitute a significant take. Several visits to more than 30 different shops selling amulets, love charms, and witchcraft items in Manaus in 1998 did not reveal any evidence of commercial use of dolphin body parts in the central Amazon. Informal visits to this type of shop and markets in different cities of the Amazon region in the last three years (2005-2008) didn't reveal any significant change. A recent study using molecular forensics analyzing the dried eyes of presumed botos from different markets of the Amazon region revealed that the boto amulets sold in these markets are not from *I. geoffrensis*, but that a large proportion of the analyzed material belonged to the marine *Sotalia* (*S. guianensis*) incidentally caught in the Amazon estuary fisheries. The remaining products were from domestic animals such as pigs (*Sus scrofa*) and sheep (*Ovis aries*); not a single fetish product analysed came from *I. geoffrensis* (*Gravena et al.* 2008). Similar results were found from the Mercado Ver-O-Peso in Belém using dry genitalia, where all samples analyzed were from the marine *Sotalia*.

In the past, botos were protected by the legends and traditional beliefs of the inhabitants of the Amazon (Slater 1994, Cravalho 1999, Smith 1985). These traditions however, appear to have eroded in some areas. In the last decade, a new direct exploitation of the boto for use as bait to catch the catfish *Callophysus macropterus* (piracatinga or mota) started and created a new fisheries market of selling boto carcasses to piracatinga fishermen. According to local fishermen, one carcass of about 150kg can catch about 300 kg of catfish. The killing of more than 1600 botos was estimated based on the catch of 50% of the total piracatinga

bought (72 tons) by one of the nine freezing plants of the city of Tefé (total estimated for all 9 freezing plants of 650 tons + 350 from the surrounding cities = 1,000 tons) in this area of Amazon State alone in 2005 (Da Silva & Martin 2007). On top of that, commercial and subsistence fisherman became less tolerant with botos, killing them as a consequence of the exponential increase of fishing nets and because botos can steal and damage fish from the nets, disturb the fisherman or fishing gear, or just because they represent an irresistible target (Best & da Silva 1989a; Da Silva & Best 1996).

Sotalia fluviatilis. Different from the boto, the direct capture of this species for specialty market doesn't exist in the Brazilian Amazon with the exception of the Amazon river estuary (probably *S. guianensis*). In the central Amazon, while still alive in the net, the tucuxi is usually released unharmed by the fisherman. Dead animals however, when available, are also used as bait to catch piracatinga. Because of this species' behavior of avoiding beaches and shallow areas plus its small size and fast speed, the tucuxi is not an easy target.

The dolphin dry organs and teeth available at the Ver-O-Peso market in Belém (Pará State) near the Amazon river estuary are mainly from marine tucuxi (Salvatore e equipe) caught accidentally in the fisheries at the mouth of the Amazon and represent a small proportion of the available carcasses. No direct capture of dolphins for organ trade has been confirmed.

Indirect

Bycatches (Incidental mortality) in fisheries

Inia geoffrensis & Sotalia fluviatilis

Very little is known about non-natural mortality in these species. Most reported boto and tucuxi mortality is due to fishery interaction, but no estimates of the absolute or relative magnitude of incidental catches in the fisheries in the Brazilian Amazon exist. From the 13 different types of fishing gear that exist in the Brazilian Amazon, only three may be considered dangerous to river dolphins: seine, fixed gill nets, and drifting gill net (Da silva & Best 1996). Lampara seines are used on beaches. Fixed gill nets are often set in areas where dolphins swim and the mesh size can be greater than 10 cm. These types of nets are widely used in the local fisheries, varying in length, height and mesh size, according to the type of fish targeted. The drifting gill net, set at the surface and usually with a large mesh, is used mainly to catch large catfish in the main river channels. This gear is the principal cause of incidental mortality of tucuxi. Although the drifting gill nets are used mostly on the bottom to capture catfish, during the low water period, river depths are minimal and the top of these nets are often at a depth where the tucuxis commonly swim.

The amount of net in the water, number of fishing boats operating or the quantity of fish disembarked in the main ports of the region may provide an index of the probability of incidental takes of botos and tucuxis. In 1984 a total of over 33,000 metric tons of fish were disembarked in the State of Amazonas; representing a four-fold increase over 26 years of fisheries activities in the Amazon (Best & da Silva 1989 a).

In 2005, (Da Silva & Martin 2000) 16 years later, the statistics of fish landings in Manaus, Tefé and Belém were better controlled and the available data more realistic. In Manaus market only, the landings were of 30-35,000 metric tons of fish per year. Lampara and strait haul seine, purse seine and fixed gill nets are the most important nets used in these fisheries (Batista 1998). In Tefé alone, the annual production recorded in the market was about 1,500 t. Fixed gillnets and purse seine are responsible for c. 39-40% by weight (J. P. Viana pers. comm). In Belém, at the mouth of the Amazon the annual landing of fish in 1996 was c. 10,500 t; some 85% of these fish came from drifting and fixed gill nets (R. Barthen pers. comm.).

Accidental takes

Accidental takes are associated with development projects such as oil prospecting, transportation, construction of navigational waterways using dynamite, irrigation dams where botos become stranded when the water is drawn down by the pumps, dams for hydroelectric plants, mining on river beds etc. There are no estimates of the number of dolphins involved in these activities in the Brazilian Amazon.

Human & boats

Despite the increasing human pressure in the Amazon region, the increase in size of the fishing fleet and number of speedboats, and the potential for boat collisions, there are no reports or evidence that this is becoming a problem to river dolphins in Brazil. However, there is no systematic collection of data related to this subject. Cetaceans are acoustic animals using sound to navigate and to perform other essential behaviors (Tyack & Miller 2002). In the Brazilian Amazon, the main way of transporting people and their products are by boat, using the rivers as highways to move from one place to the next. The number of boats that navigate in the Amazon main channel everyday is not known, but small dugouts canoes to large tourist vessels to petroleum and cargo freighters can be seen navigating from the mouth of the Amazon River up to Iquitos in Peru. These boats and vessels, not only produce enormous amount of noise, but also pollute the water with human waste, dripping oil and other types of fuel in the water. These effects of noise and pollution certainly affect the dolphins and their prey, but there is no quantification of these effects and evaluation on the reaction on the dolphins.

There is no obvious sign of negative reaction of botos to the human permanent presence in water. However, botos show a distinct preference for bends and curves of the rivers (small bays), where the current is slow, to rest and socialize, the same sort of place used by humans to place their floating houses and tie up their boats. Telemetry results revealed that botos are sensitive to the noise and constant activities of humans, thus avoiding places with floating houses during the day, preferentially using these areas at night (Martin *et al*. 2004). This sort of effect did not occur in the same type of areas without human houses or boats. The initial effect of this long term occupation is very small for the dolphins and certainly is not threatening their lives, but can potentially interfere with daily movements and behavior of the species, changing the patterns of use of the areas and reducing the available habitat.

Competition & culls

In Brazil, some fishermen kill botos in retaliation not only because of the competition over resources, but mainly because of the damage to their fishing gear and to the fish entangled in the nets, as well as because botos disturb the fisheries. This problem is increasing not only because botos are learning to use the nets in the same way as the fisherman (corralling the fish against a wall), but due to the escalating number of nets being used in the region and deployed at the same time in some fishing grounds. A few strategies are traditionally employed by fishermen to drive the botos away: beating the surface of water with the paddles to keep the dolphins away from the nets, setting

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a second net behind the first one in operation to stop the dolphins going inside the "sac", use of a sling with palm seeds or bottle tops as bullets, shooting the animals with guns, or throwing small home-made bombs in the water. However, and more recently, two more techniques have started to be employed in Central Amazon to remove the botos from the fishing area: one or more botos are caught and tied up with a rope to a tree near the edge of the river or lake, far from the nets; the call of the captive boto attracts the other ones away from the nets. The animal can be left tied to be used over a few days, but is killed at the end of the fishing activity and the carcass can be used as bait or discarded. The other technique is poisoning the botos, throwing fish stuffed with poison to the animals near the nets. There is no information on this sort of behaviour from fishermen towards the tucuxi, but the poison used can also affect this dolphin and other aquatic organisms.

Habitat loss and degradation

Dams

The potential consequences of dams for the survival of the botos were discussed by Best & Da Silva (1989a). Dams have a major impact on fish fauna, thus affecting the food resources available to dolphins. They also break up dolphin populations into smaller isolated groups, thereby profoundly influencing the genetic structure and movements of the species, and rendering each group more vulnerable to extinction through disease or environmental stress.

There is an ambitious plan to supply energy to southern Brazil from the Amazon (e.g. Goodland 1980, Cagnin 1985, Fearnside 1995). Four large dams (> 10 megawatt [MW]) are already functioning, in addition to 6 more small reservoirs. A total of seventy more are planned in Brazilian Amazônia by the ELETRONORTE system, and others are planned by state governments and private firms (Fearnside 1995). According to the Ibama site (www.ibama.org.br), under the actual government development program PAC (Programa de Aceleração do Crescimento) today, there exist 45 projects of hydroelectric power plants awaiting the expedition of the environmental permits to start operating in the Amazon region. A further concern is that due to lack of water flushing, dams can concentrate pollutants, which then enter the aquatic food chain.

Contaminants

A few micropollutants (e.g.methylmercury, polychlorinated biphenyls and chlorinated pesticides) flow through food chains and they may go through a concentration increase as they reach high trophic levels, resulting in biomagnification (Connell 1989, Gray 2002).

Mercury

Toxicologically, mercury can be considered one of the most dangerous trace elements. It can be naturally found in the environment, in different forms such as: elemental mercury (Hg^0); inorganic mercury (Hg^{2+}); monomethylmercury (CH_3Hg^+); and dimethylmercury (CH_3HgCH_3). Mining, fossil fuel combustion, solid incineration, fungicide and fertilizing application, as well as solid discharge in sanitary embankment (batteries and thermometers) constitute some of the anthropogenic activities that are responsible for a considerable part of mercury released into the environment (ATSDR 1999). A total environmental emission of mercury (Hg) in the Brazilian Amazon was estimated to be around 2000 tons between 1979 and 1996

(Malm *et al.* 1997). Approximately 65-85% of this Hg entered the atmosphere as vapor during the burning process of gold amalgam, and widely dispersed. The remaining Hg entered the aquatic environment directly (Pfeiffer *et al.* 1993). Anthropogenic sources of heavy metals (e.g. gold mining activities) in the Amazon add to high natural levels that have built up from background deposits over millions of years (Pfeiffer & de Lacerda 1988, Roulet *et al.* 1996, Fearnside 1999). Methylation is occurring in reservoirs, as indicated by high mercury levels in fish at Tucuruí dam (Porvari 1995). In a sample of 101 predatory fish taken from the reservoir, 92% had Hg levels higher than the 0.5mg Hg/kg fresh weight safety limit (Leino & Lodenius 1995). As an apex predator, botos are likely to accumulate the highest levels of mercury, though the direct effects of this burden on health and reproduction (if any) have not been investigated.

Mercury concentrations in tissues of four specimens of freshwater dolphins, two *I. geoffrensis* from the Japurá River (one adult female and one calf), one juvenile from the Madeira River, and one tucuxi (*Sotalia fluviatilis*) from the Negro River were examined. Samples from the liver, kidney and muscle of all individuals and the brain from the adult female boto, were analyzed (Lailson-Brito *et al.* 2008). Mercury concentration (in mg/kg ww) in the brain was 0.07; varied from 35.89 in liver of the adult female to 0.09 mg/kg (ww) in the kidney of the calf. The tucuxi presented an extremely high hepatic mercury concentration (215.97 mg/kg ww).

Organochlorine compounds, PCB´s and DDTs

Polychlorinated biphenyls (PCBs) are mainly used as dielectric fluid as well as in heat exchange systems (WHO,1993). It produces a number of effects in organisms, some of which include hepatomegaly, thymic atrophy, immunosuppression, neurotoxicity and dermal toxicity (WHO 1993, Hoivik & Safe 1998).

Organochlorine pesticides, such as DDT (dichlorodiphenyltrichloroethane), besides being cancer promoters, may disrupt endocrine and central nervous system.

PCB measurement from four Amazonian dolphins (*Inia geoffrensis*), 3 from Mamirauá area (Solimoes/ Japurá) and one from Madeira River were performed. _PCB levels varied between 151 and 1314 ng/g lip wt in the individuals from Mamirauá area (Solimões/ Japurá) while the one from Madeira River, the _PCB concentration measured was 3216 ng/g lip wt (Torres *et al.* 2007).

DDT determination in blubber samples from the same four Amazonian dolphins (*Inia geoffrensis*) above was performed. From the 3 botos from Mamirauá Reserve area, _DDT concentrations in the adipose tissue samples varied from 190 to 3176 ng/g lipid weight (lip wt.) while in the dolphin from Madeira River, the _DDT concentration verified was 2430 ng/g lip wt (Torres *et al.* 2007, Lailson-Brito *et al.* 2008). The acceptable daily intake of DDT is 0.025-mg/kg bw/day.

Oil

Oil exploration along the main channels of the Amazon and oil spills are still some of the most dangerous threats to dolphins and for the species of fish used by these cetaceans in their diet. Information on these events has not been recorded, as it should be in the Amazon region. The Brazilian Petroleum Company (PETROBRAS) doesn't make this type of information available. Records of routine leakage from boats, petroleum cargo and the cleaning and washing of the petroleum cargo

tanks are difficult to monitor, although it can cause as much as damage as crude oil spills. In one decade (1995-2005) six oil spills were recorded in the central Amazon resulting in a total of more than 20.5 m^3 of oil into the waters of the Amazon. The main causes of these accidents were the lack of maintenance and inspection of the equipment used during operations of transferring and transporting the oil and their derivatives by ship (IPAAM-2000). Considering the long distances over which oil must be transported in the Amazon, more accidents are inevitable and its consequences to aquatic mammals need to be evaluated.

Diseases

The existing literature of diseases on river dolphins in the wild is very scarce. The large proportion of parasites described to the boto is species specific, with one exception, of the trematode *Pholeter gastrophilus*, which is also known from marine dolphins. Respiratory problems in wild and captive animals are also caused by trematodes. Skin lesions and ulcers are very common. One of the most common pathogenic diseases is *golf-ball disease*, caused by *Streptococcus iniae* (Da Silva *et al.* 2008). Twisted, broken and deformed mandibles, dental caries and teeth anomalies are very common in the boto (Bohórquez-Mantilla & Da Silva 2008, Da Silva *et al.* 2008) although the causes are unknown.

Preliminary results of a health survey of a boto population in the central Amazon revealed that the animals surveyed (N= 51) tested negative for *Campilobacter* bacteria, commonly found in captive Amazonian manatees (Projeto Boto unpublished data). However, serological analysis using MAT (Galton *et al.* 1965) indicated two serovars in wild botos, some authors, suggesting that leptospirosis can became of a clinic importance to the species if the conditioning factors are favorable (Marvulo *et al.* 2003).

Climate change

The prognosis of the effects of climate change for the Amazon is very dramatic, suggesting a desertification of extensive areas of the rainforest, severe changes in the rain systems (Marengo 2006) and, as a consequence (among several), reducing habitat areas and available prey for aquatic organisms in general. Effects of climate changes however, are very complex and difficult to allow a direct connection with health and wellbeing of cetaceans and their prey. The workshop sponsored by the IWC in 1996 recognized this problem, emphasizes the precautionary principle, and urges actions to reduce emission of ozone-depleting chemicals and greenhouse gases.

Live-captures for captive display and/ or research

Live capture for public display of cetaceans does not occur in Brazil and is an illegal activity (Ibama 2001). Live-captures for research, under special permit issued by Ibama/ ICMBio, occurs at the Mamirauá Sustainable Development Reserve (RDSM), where once per year a number of individuals of boto and tucuxi of different age and sex are captured, examined and sampled (sex determination, measurements, weight, collection of blood, skin, pathologies, branding, photos, and ultrasound images), and are released at the place of capture and monitored daily thereafter (Da Silva & Martin 2000). Up to November 2008, the Projeto Boto has marked and monitored a total of 471 dolphins.

Dolphin & tourism

Amazon river dolphins in Brazil are widespread and easily observed at the surface, spend several weeks around the same area and can be very pink when an adult is showing a very inquisitive behavior approaching boats and floating houses. These factors make them an ideal species for tourism purposes. For a long time in the Amazon the boto was considered a magic creature and the local people didn't like to approach or interact with dolphins. However, in the last few decades, with the new wave of colonization of the region, the new settlers didn't embrace or adopt the taboos and traditional prohibitions, so negative encounters and interactions became more intense. Today there are two well known places that are using the botos as a very profitable tourist attraction; in Novo Airão, a town at 115 km far from Manaus, and at the Ariaú River, 60 km from Manaus and 55 distant from Novo Airão, where a program of hand-feeding and swimming with dolphins are being held. Genetic molecular studies of these individuals revealed that the animals of the two groups were not closely related and the groups were exclusively male (Gravena 2006). In both sites, there is no establishment of rules and operation procedures on how the tourists can interact with the animals. By law, in Brazil, hand-feeding programs and swimming with dolphins is not legal, but the local authorities do not reinforce the existing Law. There is no regulation to this sort of activity to limit the impact on the animals.

Possible solutions to conservation problems

Existing legislation

A summary of national laws and international agreements affecting river dolphins in South America was presented by Atkins (1989). Best & da Silva (1989a) indicated a series of international agreements and conventions in which *I. geoffrensis* could be included to increase the protection and conservation of the species, although to date, the species was not included in any of them. The Brazilian Action Plan for Aquatic Mammals of Brazil (Ibama 2001) provides an extensive list of International and National (Federal, State and Municipal) laws, *decrees* and *ordinances* related to Aquatic Mammals in Brazilian waters. A specific Federal Law that forbids the harassment, hunting, fishing or capture of small cetaceans, pinnipeds and sirenians in national waters (Lei Nº 7643, de 18 de dezembro de 1987) exists, but the enforcement of this law is not effective. Topics of research and management to be given priority are listed in the report of the Workshop on Biology and Conservation of the Platanistoid dolphins (Wuhan, China, 1986) (Perrin & Brownell 1989), in the reports of the IWC meeting in Adelayde (Australia 2005), and, specific to *Inia geoffrensis* and *Sotalia fluviatilis* in the Brazilian Action Plan.

Direct exploitation

In the last five years, several letters and open statements in official Ibama meetings and scientific congresses, as well as interviews to radio and national and international media, expressed the worries of the increased killing of botos in the Amazon. In May 2007, during the IWC meeting another alert was presented (Martin & da Silva 2008) for urgent action from the international scientific community. During the 17th Biennial Conference of Marine Mammals in Cape Town, two presentations brought to the attention of the public the killing of botos in Brazil and the scale of these events (da Silva & Martin 2007, Serrano *et al*. 2007). Recently the Ibama/ICMbio (March 2008) organized a meeting to understand the process and to evaluate the dimension of this killing of botos and to find alternative solutions. The main recommendation was to make the use of the box or cage ("gaiola") used to catch and

hold the piracatinga illegal in Brazil, but it was not implemented.

Incidental mortality in fisheries / Indirect effects

In Brazil, with the establishment of the "Salário defeso" - a salary that the government pays to the fisherman during the months that fishing activities are closed to protect the reproductive migration of the fish – it became easier to identify the number of active fisherman per year, the number and capacity of fishing boats and other important information related to the fisheries, since all fisherman and boats need to be registered at the fisherman association called "Colonia de Pescadores". However, the volume of fish caught and any incidental catch is not reported. In order to get more reliable information on incidental catches of dolphins it is necessary to work closely with fisherman associations, presenting interesting talks and promoting activities to them and their families, showing the importance of the dolphins in the aquatic food chain and the importance to conserve them.

Accidental takes

There are no estimates of the number of freshwater dolphins involved in accidental takes in Brazil. Today there are few studies of population size and habitat use of botos in hydroelectric dam reservoirs, but the results are not available yet. Despite the huge program of oil extraction and oil pipelines in the Amazon, no assessment for potential impact on the dolphins or its prey was conducted. No direct evaluation of mining activities exists and the same is true for any other man-produced activity that affects the dolphins directly.

Table 26. Threats for river dolphins in Brazil.

Threats	Location	Description
Direct		
Killing for bait	Records are mainly from below Manaus up to Tabatinga, at the border of Brazil, Colombia and Peru.	Botos are being killed and the carcasses used as bait to catch piracatinga, and in small scale, other catfish.
Deliberate killing	Tefé and Fonte Boa area (1) with reports from several other places along their distribution (2 & 3).	(1)Giving poisoned fish to the botos near the nets (2)Shooting with gun (3)Harpooning
Habitat destruction	Madeira and Tocantins rivers	Hydroeletric dams construction isolating botos groups and stopping fish movements, thus reducing food items.
Indirect		
Incidental catches in fisheries	All over the Amazon region	Entangle and waiting nets

Threats	Location	Description
Indirect		
Pollution (Micropollutants)	Madeira and Tapajós rivers, and several undetermined rivers	Heavy metals (mercury), Organochlorates, DDT, PCB's from agricultural activities
Contamination by hydrocarbonates	Between Coari and Manaus	Leaking of boats and engines; washing oil tanks, oil spills,
Mining activities	Madeira, Tapajós, Negro and other rivers	Mining for gold, gravel and sand, contaminating the environment with heavy metal (mercury); destruction of the river bed and increasing the suspended sediment.
Increasing boat traffic	Between Coari and Manaus	As a consequence of petrochemical activities; exploitation and transport of oil and gas.

Legal status

Inia geoffrensis. Before 1991 *Inia geoffrensis* was classified as "Insufficiently Known" (equivalent to Data Deficient category today) by the IUCN. During the River Dolphin meeting in China in 1986 it was proposed to increase the conservation level for the species to "Vulnerable" (Perrin and Brownell 1989), mainly due to the threats imposed by several mega-development projects planned in the Amazon region by the Brazilian government. In 2008 the species was reclassified as "Data Deficient" due to the lack of information in the large part of its distribution (IUCN 2008).

Although still widespread in the rivers of the region, none of the threats listed in 1986 (Best & da Silva 1989a) were removed; instead, several became more severe and new ones appeared. As a consequence, the National Environmental Agency (Ibama), kept *Inia geoffrensis* as "Vulnerable" (Ibama 2001).

Sotalia fluviatilis. This species was for a long time classified as "Insufficiently Known". Today it is in the conservation category "Data Deficient" (IUCN 2008), based on the absence of population information along most of its distribution. In Brazil, Ibama also classified the species in the same category (Ibama 2001). For conservation purposes, Cunha *et al*. (2005) suggested the inclusion of *S. fluviatilis*, the first non-platanistoid dolphin to live exclusively in freshwater in a category of riverine dolphins.

CITES

Inia geoffrensis and *Sotalia fluviatilis* are listed on Appendix II of the Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES), meaning that trade is allowed, but regulated through export licensing.

We propose an up listing to Appendix I (no commercial trade allowed) to avoid the illegal exportation of dolphin carcasses to be used as bait or meat in other countries of the Amazon region.

Conservation initiatives

Increase the life history knowledge of the species in order to increase measures of protection of the species and their critical habitat.

To find a way to increase the financial support of biological research of these species. This is important when considering the size of their distributional area, the difficulties in traveling in the Amazon region and the basic needs of the two species of Amazon dolphins.

To stimulate young biologists to study these fascinating animals, providing support for the establishment of new scientific groups in different areas of the region.

Provide incentive for the publication of the accumulative data collected from these species along their distributional area in peer review journals.

Produce attractive publications with easy access and comprehension of the different aspects of the dolphin's biology and behavior. These would be distributed among fisherman and their families, school communities and fisherman associations, aiming to increase awareness of the local people on these two species of dolphins.

Recomendations

Research

- Increase the life history studies (reproduction, maternal investment, survivalship and mortality).
- Definition of stocks/ population along the distributional area of the species.
- Establishment of the home range of the species.
- Population and conservation genetic studies.
- Determination of the social structure

Education

- Work with the local government Educational Departments to include in their programs of biology and conservation, information on the Amazon river dolphins
- Produce stimulating material such as booklets and folders to be distributed among the students in the public schools.
- Training the teachers on the subject, so they can use the information with their students.

Conservation

- Promote the awareness of the existing legislation protecting these dolphins among the local fisherman and stimulate the enforcement of the existing laws.
- Guarantee the integrity of the habitat important for the survival of the species.

Chapter 2
Summary of threats for river dolphins in South America: Past, present and future

Summary of threats for river dolphins in South America: Past, present and future

Fernando Trujillo, Enrique Crespo, Paul van Damme, Saulo Usma, Diana Morales-Betancourt, Alison Wood & Marcela Portocarrero

In the early eighties a great concern about the future of river dolphins led the Cetacean Specialist Group of the IUCN Species Survival Commission to concentrate their efforts on strategy to deal with those concerns. In 1986, the Workshop on Biology and Conservation of the Platanistoid Dolphins was the first step to asses issues related with threats and recommendations for the survival of river dolphins in the entire world (Perrin *et al*. 1989). This meeting encouraged some researchers in South America to start long term river projects related to river dolphins, especially in Brazil and Colombia. For almost ten years some important contributions about the distribution, biology and identification of threats were made. During these years some documents were published. These documents were and are currently the lead information to all researchers involved in research, conservation and educational projects. These documents are the 1994-1998 Action Plan for the Conservation of Cetaceans (Reeves & Leatherwood 1994), International Whaling Commission Scientific Committee Report 2000, and the 2002-2010 Conservation Action Plan the World's Cetaceans (Reeves *et al*. 2003).

At the 1986 Workshop, the Amazon River Dolphin or Boto (*Inia geoffrensis*) was considered less common than the Tucuxi (*Sotalia fluviatilis*), the other freshwater South

American dolphin species, and therefore *Inia geoffrensis* was the only one included in the Report of the Workshop. Both species were included in reports and action plans thereafter, in which many direct and indirect threats to the species were determined and recommendations on these issues were made. Both threats and recommendations have changed over time according to reality and the new information on dolphins and their areas of distribution. Issues like the lack of information regarding ecology, behavior, abundance and density estimations, non-standardized data, incidental and direct mortality due to fisheries and the review of taxonomic classification for the genus *Inia*, are some of the current topics written down in Action Plans and Conservation Strategies, and in accordance to this the same recommendations are formulated. Today almost 20 year later, those efforts and recommendations are yielding results and the commitment of researchers and conservationist organizations are getting stronger each day.

Summarized in this chapter are the main threats to river dolphins in South America and the end of the document a chart is included showing the different Action Plans and Conservation Strategies and the threats to each species and recommendations regarding each issue.

Conflict with fisheries

This is one of the highest concerns and has been reported in every document related to conservation of both species. The problem is based on the overfishing taking place in almost all rivers of the basins of Amazon and Orinoco. The overexploitation of the aquatic resources

Figure 14. Dead river dolphin.

are leading fishermen to despair and to use fishing techniques that can be harmful to other aquatic species, as is the case of river dolphins and occasionally river otters. The decrease in the amount of appropriate sized fish, the increase in working hours on the river and the identification of potential competition in the activity of fishing are endangering dolphins. Many threats are related to this scenario:

1. The use of long nets across the river and in the mouth of streams and some lakes increases the chance of dolphins getting entangled and drowning.

2. The dolphins, specifically *Inia,* are regarded as a strong competitor for resources. In some areas dolphins steal or damage fish in nets, injuring the fishermen. People usually resort to killing or hurting the animal in many ways. They get shot, poisoned, hit or in the best case they are frightened with sounds or lemon drops are applied to their eyes.

Deliberate killing of river dolphins

During the last 10 years, the mota fish *Calophysus macropterus* (Pisces, Pimelodidae) have appeared in the national market of Colombia, replacing the depleted capaz fish *(Pimelodus grosskopfii)* that inhabited the Magdalena river in Colombia. To catch the mota fish, dolphins and black caimans are being killed in the Brazilian Amazon to be used as bait to attract the scavenger fish (Trujillo *et al.* 2005, Gómez-Salazar *et al.* 2008, Flores *et al.* 2008). The capture of dolphins especially *Inia geoffrensis* are increasing resulting in serious threats for their population (Da Silva & Martin 2008).

Fishery and dolphin kills is occurring mainly in the Brazilian Amazon and the commercialization of mota is occurring in Colombia, conforming a commercialization network starting by dolphin hunters, fishermen, gathering centers along the Amazon river (Brazil) big ships that transport the mota to Leticia, main gathering centers, main markets and consumers (Colombia). Dolphin kills are being monitored by the INPA Brazilian research group in the Mamiraua Reserve (Da Silva & Martin 2008).

At present, Mota fishermen and traders confirm that mota fish make up almost 80% of their production. A small percentage of catches take place in Venezuela and Peru, the fish being traded in that country and Colombia.

Since 2005, attempts have been made to implement initiatives among fishermen and traders to stop this killing and to introduce alternative baits, but there have been no results yet. The main facts of this new threat for river dolphins are:

1. Almost 200.000 tons of the Mota fish (*Calophysus macropterus*) is traded from Brazil to Colombia every year, and most of them are captured using dolphins and black caimans as bait.

2. Prices of the fish increase dramatically along the trade chain, with very little value in the region, and high prices in big cities.

3. In the big cities most of the consumers do not know how the mota fish is caught.

4. An estimate of 1500 dolphins are being killed each year only in the area of Mamiraua (Brazil) (Da Silva & Martin 2008).

5. Not statistic data of fisheries is available in the Brazilian Amazon to evaluate the amount of Mota fish caught.

6. Because the media display the problem especially in Manaus and Bogotá, D.C., dolphin hunters are killing dolphins in other areas as the river Purus (Brazil) and then sale the carcasses in the black markets.

7. The main market has been in Colombia, but during the last four years this fish is being sold as well as in Sao Paulo, Bahia and Minas Gerais under a different name (Pirosca).

8. Now the situation is more difficult regarding the spread of the market and also the areas where dolphins are being killed (Figure 15).

As regards to the geographic scale of this fishery, the deliberate killing of river dolphins may be the most serious threat for these species at present. This situation requires the attention of the Governments and specific regulations for this fishery.

Direct catching

From the 50's to the 70's several dolphins (*Inia* and *Sotalia)* were caught for the purpose of display in aquariums. During the 90´s some aquariums in the United States approached the Government of Venezuela to buy some *Inia geoffrensis*, but international lobbying stopped these operations. This bears witness to the poor legal control in each country, to the violation of the World Association Zoos and Aquariums Ethic Code, where it is clearly stated that members must "endeavor to ensure that the source of animals is confined to those born in human care and this will be best achieved by direct zoo to zoo conduct", and to the fact that conventions and international agreements aren't really being observed. Most recently the catch and sale of river dolphins has been reported in Peru.

Use of dolphin's products

Use of dolphin products was first reported in 1986 concerning both species (Perrin *et al.* 1989). Related documents have reported on that issue since. Local communities use eyes, teeth, genitalia and skin. Oil is extracted from the skin in order to use it against respiratory diseases. Other body parts are used as love charms and in traditional medicine (Best & Da Silva 1989, Trujillo *et al.* 2006). This threat was probably important during the 70s and 80s and in many cases corresponded to incidental catches of dolphins in nets.

Dam construction

It constitutes an important threat for the species. Dams isolate dolphin populations and reduce the amount of consumible fish, interfering with their migration. The vast number of projects in the Amazon and a few in the Venezuelan Orinoco and the poor or almost lacking inclusion of dolphins and other freshwater species in plans prior to the construction, show that there is not governmental willingness to prevent environmental catastrophes such as the extinction of charismatic aquatic species in their countries and in the neighboring ones. Brazil is probably the only country that has constructed large dams such as the Belo Monte, Balbina, Tucuri with an area of more than 6.000 km^2 (Goulding, Barthem & Ferreira 2003, Fearside 2006), and with active plans to build more than 45 new dams, including the Jirau and San Antonio ones in the River Madeira, affecting river dolphins and other aquatic species that have migrations.

Hydro-way construction

This is a potential threat for the whole area and it is motivated by economic interests

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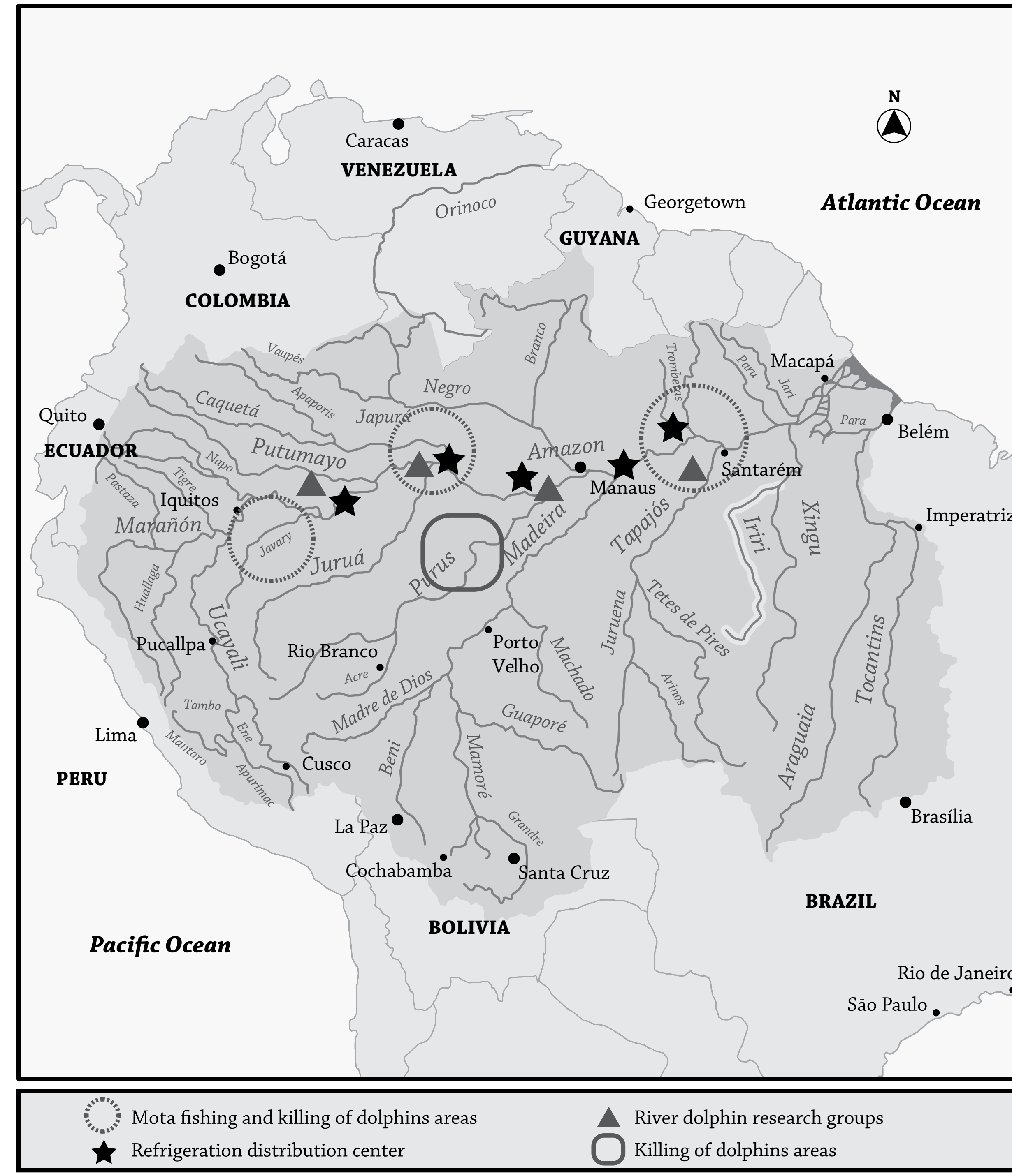

Figure 15a. Map showing the Mota fishing and killing of dolphin areas, river dolphin research groups and refrigeration distribution centers.

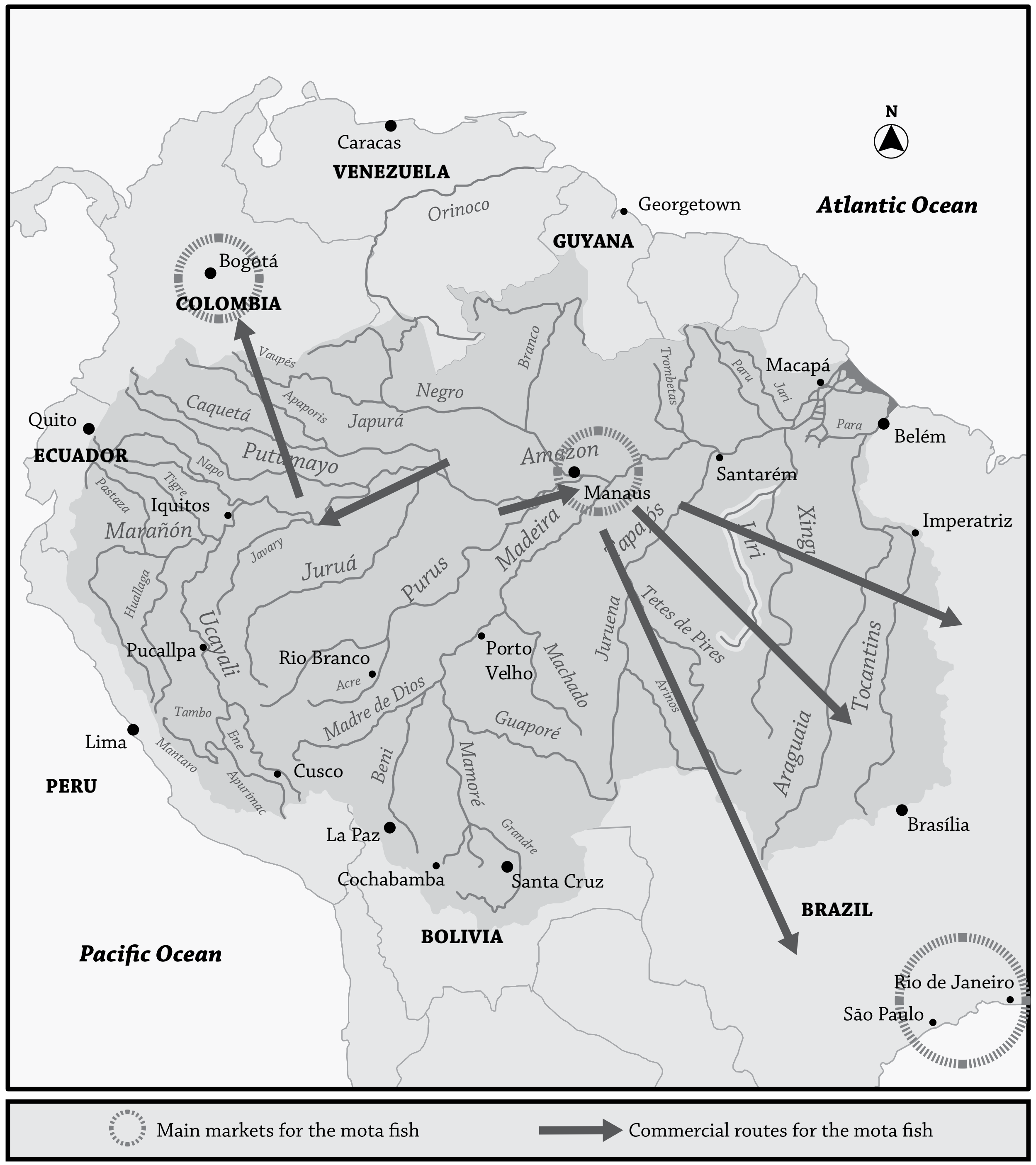

Figure 15b. Map showing the Main markets where the Mota fish is distributed and the commercial routs for the species.

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and expansion of markets. This is the case of Brazil and the soybeans production looking for mechanisms of exportation from central and southern states to international markets (Goulding, Barthem & Ferreira 2003). Colombia and Venezuela have proposed along the last 30 years the interest of a water way along the River Meta to connect the Andes in the Atlantic Ocean. This project involves the construction of ports along the river and the transformation of the flooded pulses that will affect reproductive migrations of fish and reduction of sand banks affecting reproduction of turtles, birds and caimans. Alternative proposals such as a railway had emerged as a less negative environmental solution for the transportation of goods along the region.

Landscape transformation and deforestation

Different levels of habitat transformation are affecting the ecological integrity of the Amazon and Orinoco River Basins. Deforestation process is dramatic in Brazil and Peru due to logging and commercial agriculture. In Brazil the main threat for the forest has been deforestation by cattle ranching, and more recently biofuel crops, specifically soyabeans, that provides economic and politic stimulation for new highways and infrastructure projects, which accelerate deforestation patterns Andersen *et al*. 2002). Between 2000 and 2006 Brazil lost nearly 15.000 km^2 of forest in the Amazon, and the process appears not to be abating.

The main ecologic impact of deforestation in aquatic ecosystems is associated to the reduction of alocton food for fish, especially in small tributaries where an important number of species rely on the provision of seeds and fruits from the flooded forest.

Water pollution

The increasing rate of human population is increasing water pollution levels resulting from agriculture, industry and other anthropogenic activities. This threat has been reported in 2000 regarding both species and also on 2003 for *Inia* (IWC 2000, Reeves *et al*. 2003). Population increase was documented as a threat especially in Amazonian areas belonging to Colombia and Brazil. In Ecuador, this is also a threat and it is mainly due to the industrial expansion of oil companies in the Amazonian area. Human population growth has a similar pattern in all countries in the Amazon River Basin, with large deforested areas along the river shore.

Mercury from gold extraction

The use of this heavy metal is having an impact not only in the areas where gold is being extracted, but in areas far away from the extraction site. Mercury is a bio-accumulative element. After being released in the water, in the form of methyl-mercury, it attaches to the sediment, algae and macrophytes that are all part of the food chain. It means that the element will eventually reach dolphins, otters and human beings. This threat has been *evaluated* extensively in the Amazon, especially in Brazil (Martinelli *et al.* 1988; Lacerda & Salomons 1992, Nriagu 1993) Regarding aquatic species, most research has been conducted on fish (Bidone *et al.* 1997, Peixoto-Boischio *et al.* 2000, Trujillo, Gómez & Alonso 2008), showing high concentrations of mercury (Table 27) .

Oil exploitation and production

Oil exploration and exploitation are taking place in most of the countries where river dolphins are located. Perforations and use of

Table 27. Values of Mercury found on fish in different geographic areas.

Geographic Area	Hg (ug.g-¹)	Reference
Erie Lake, Canada	0,20 – 0,79	Mitra (1986)
Niigata, Japon	2,60 – 6,60	Inskip & Piotrowski (1995)
Tapajós, Amazon (Brazil)	0,15 – 0,73	Padberg *et al.* (1991)
Madeira, Amazon	0,21 – 2,70	Pfeiffer *et al.* (1991)
Lakes in Finlandia	0,21 – 1,80	Mannio *et al.* (1984)
Lakes Sweden	0,68 – 0,86	Bjorklund *et al.* (1984)
Carajás, Amazon (Brazil)	0,30 – 2,30	Lacerda *et al.* (1994)
Upper Amazon, Colombia	0,05 – 0,77	Trujillo, Gómez & Alonso (2008)
Orinoco River Basin, Colombia - Venezuela	0,03-3,44	Trujillo *et al.* 2010

big machinery increase the risk of spills. This has been observed recently in the Ecuadorian Amazon in the area of the Cuyabeno River. It is alarming that in countries as Ecuador, those camps of exploration and exploitation are located inside natural parks and reserves. Other kinds of oil spills were due to the Colombian guerrillas in the Colombian Orinoco during the 80s. Their guerilla warfare operations lead to water contamination and affect the habitat and fish resources.

Boat traffic

As a result of the unregulated ecotourism, the boat traffic is generating underwater noise pollution that affects dolphin populations as well as possibly causing collisions that can hurt dolphins. This activity has been reported since 1994 to 2008 in almost all Action Plans. Additionally, continuos presence of boats can interfere with reproduction and feeding behavior.

Bad tourism practices

Tourism and specifically dolphin watching may be a good economic alternative for riverine communities in the Amazon and Orinoco basins. However, good practices and ethic codes should be promoted to avoid that this activity became a threat. During the last five years, some people are implementing feeding program of dolphins in two locations in Brazil without rules and creating serious problems

that can end in injuries for dolphins and people (Pinto de Sá Alves et al. 2009, Trujillo 2009, Romagnoli et al. 2010).

Feeding and swim-with-botos activities are promoted to tourists visiting the Brazilian Amazon and both activities have increased over the past decade. Tourists are now able to feed wild botos at many locations in the Brazilian Amazon and this lucrative activity is spreading to new locations all the time. In many cases, wild botos have already become habituated to human contact.

The most established location is at Novo Airão, a small town on the southern banks of the Negro River 115 km northwest of the city of Manaus. Locals have regularly fed botos since 1998, from a small floating restaurant. Despite being located only approximately 10 meters from one of the city's main streets, the restaurant is located inside the limits of the Anavilhanas National Park area (Pinto de Sá Alves et al. 2009).

The feeding of wild dolphins creates significant risks, both for the dolphins and for the tourists and these dangers are evident at Novo Airão. There are no strict regulations, inadequate infrastructure supporting this interaction and no specialized employee training or surveillance of the activity to minimize risks. Several cases of potentially harmful human behaviour have also been observed such as attempting to restrain or ride the dolphins, striking the dolphins and feeding inappropriate objects. Over time, competition amongst the provisioned botos for access to the fish has resulted in

Table 28. Identified threats for river dolphins since 1986 in Action Plans and river dolphins meetings.

Inia geoffrensis

Threats	1986	IUCN 1994-1998	IWC 2000	IUCN 2002-2010
Insufficient Data				
Fisheries conflict				
Direct catching (aquariums)				
Use of body parts				
Dam Construction	Brazil		Brazil	
Landscape transformation				
Deforestation				
Water pollution				

Mercury from gold extraction				
Oil exploitation and production				
Hydro-way (potential)				
Population increase				
Law				

Sotalia fluviatilis

Threats	1986	IUCN 1994-1998	IWC 2000	IUCN 2002-2010
Insufficient Data				
Use or body parts				
Direct catching(aquariums)				
Fisheries conflict				
Dam construction				
Landscape transformation				
Water pollution				
Mercury from gold extraction				
Boat Traffic				
Oil exploitation and production				
Hydro-way (potential)				
Law				

increased aggression, both between dolphins and toward the tourists. Botos pushing and shoving, leaping and biting both one another and tourists are now commonplace (Pinto de Sá Alves *et al*. 2009). This kind of escalation of dolphin's behavior from habituation to increased confidence, assertiveness, 'pushiness' and potential eventual aggression was observed at Tangalooma, Australia. The risk of such behavior is widely understood in the case of provisioned wildlife.

Law situation

Some countries had passed laws to protect dolphins. Other countries need to enforce more intensively the ones that already exist (1986). On the other hand, there is poor control as to the compliance with current legislation (2008 CE).

Identified threats in the different Action Plans that have considered river dolphins

The following table (Table 28) summarizes the identified threats for river dolphins in action plans and specific meetings around river dolphins. The first one was in China in 1986; the second and third corresponded to IUCN/ Cetacean Specialist Group Action Plans for the conservations of cetaceans (1994-1998 and 2002-2010) and finally, the Report of the Scientific Committee at the 52th Meeting of the International Whaling Commission in Australia in 2000.

Status of river dolphins in South America

During the last ten years the IUCN has promoted that each country undertake an specific analysis of the fauna and flora, taking into consideration that levels of threat can be different in each geographic region. Some countries have published their own red books of threatened species and others have published action plans. In both cases the classification criteria has always been that of IUCN.

Table 29. Conservation Status of River Dolphins in South America.

Country	*Inia geoffrensis*	*Inia boliviensis*	*Sotalia fluviatilis*	*Sotalia* sp	Source
Venezuela				VU A2d	Rodríguez & Rojas 2008
Colombia	VU A2acd+3de		VU A1acd+2ce		Rodríguez-Mahecha *et al*. 2006
Ecuador	EN C2a(i)		EN C2a(i)		Tirira, 2001
Peru	VU		NE		
Bolivia		VU			Ministerio de Medio Ambiente y Agua 2009
Brazil	VU		DD		IBAMA 1997

Based on the results obtained during the evaluations of abundance of river dolphins in South America, the analysis of threat for the categorization of the IUCN is suggested. In addition to considering the status of the species in each country, an evaluation by hydrographic river basin and sub basin should commence, which would be the unit most appropriate for ecological analysis. The Convention on Migratory Species (CMS) and WWF report that these species are migratory and move between countries, especially in the Amazon basin, so again, a watershed assessment would be most appropriate to determine the level of threat.

Chapter 3
Freshwater protected areas and their importance in river dolphin conservation

The Action Plan for South American River Dolphins 2010 - 2020

Freshwater protected areas and their importance in river dolphin conservation

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A protected area (PA) has been recently redefined by the World Conservation Union (IUCN) as "a clearly defined geographical space, recognized, dedicated and managed to achieve the long-term conservation of nature, associated ecosystem services and cultural values" (IUCN 2008).

According to the IUCN World Commission on Protected Areas' (WCPA) Strategic Plan 2005-2012, PAs deliver a variety of purposes for society. This Plan stresses that protected areas are "vital for life on earth; they conserve vital biodiversity and offer the world a model of how people can live in harmony with nature. There are treasured landscapes reflecting the inherited cultures of many generations, and they hold spiritual values for many societies. Protected areas also represent the diversity of the earth's history and the current natural processes, and provide many ecosystem and wider environmental services and natural resources, such as clean air, copious supplies of water and nutrients. Protected areas are an expression of community goals to maintain the value of biodiversity and to ensure these values can be passed on to future generations. Indeed protected areas provide an opportunity to promote today's values for the generations to come".

PAs have provided an effective strategy for the conservation of representative terrestrial and marine ecosystems around the world. The protection of these ecosystems is crucial for the process of saving endangered species within these areas. PAs are considered a primary tool for conserving terrestrial and marine biodiversity (Pittock *et al.* 2008). In the case of freshwater ecosystems, in spite of being some of the most productive ecosystems on earth, establishment of PAs to protect them is woefully behind that of terrestrial and marine ecosystems. Rivers, lakes, streams, *varzeas* (white water flooded forests) and *igapos* (black water flooded forests), among other types of freshwater ecosystems, are seriously threatened. The extensive pressure on them and their resources (including water, fish, turtles, caimans, snakes, manatees and river dolphins) is leading to their degradation as well as to the collapse of socio-economic activities such as fishing, harming not only the environment, but the livelihoods of the communities reliant on these resources.

In 2003 during the 5th World Parks Congress held in Durban, South Africa, experts in protected areas and other stakeholders were brought together to observe steps PAs were making to sustainable social and economic development. During this meeting it was established that it is necessary to implement and integrate the management of hydrographic basins and freshwater protected areas as a key tool for the conservation of aquatic ecosystems. This recommendation is in line with the established priority of the Ramsar Convention on Wetlands to identify and maintain representative continental aquatic systems.

The creation of new freshwater protected areas (FWPAs) is thus considered an important and effective conservation strategy but it is lately emerging as a priority. FWPAs are a key tool for providing a sound basis for ecosystem and endangered species management, helping to maintain ecological processes, conserving species diversity and genetic variability, and maintaining the productive capacities of ecosystems. FWPAs can also play a key role in conserving the historical and cultural characteristics of local people and their traditional lifestyles and can provide opportunities for the development of more sustainable local human communities. Currently over 90% of all freshwater species are recognized as being at risk or threatened by the impact of human activities, and 71% of fish extinctions to date are attributed to human activities (Abell *et al.* 2007).

Freshwater aquatic ecosystems and their associated biodiversity are now in crisis. New and alternative strategies for conservation are being urgently sought to ensure that threats are mitigated and prevented and at the same time, natural resources and the well-being of local communities are protected and conserved.

Although it is true that some aquatic ecosystems are incidentally protected because they are included within the boundaries of terrestrial PAs (Saunders *et al.* 2002), in general in South America the representation of freshwater protected areas is low compared to that of other countries. For example, according to the "List of Wetlands of International Importance", released by the Ramsar Convention (Dec. 2008), the total number of Ramsar sites for South America is 86. Of these, only 10 are located in the Amazon River Basin. The paucity of FWPAs is contributing to the increase in risks and threats faced by freshwater species. According to Aylion *et al.* 2005, over three-quarters of the IUCN Red-listed freshwater bird, mammal, and amphibian species in South America (280) have 50% or less of their range covered by PAs. About one-third of the species (130) receive no protection at all while 70 species have more than 50% of their range covered by PAs. Only 20 species have 100% of their range covered by PAs. Today, many freshwater species and their habitats are in serious danger of simply disappearing.

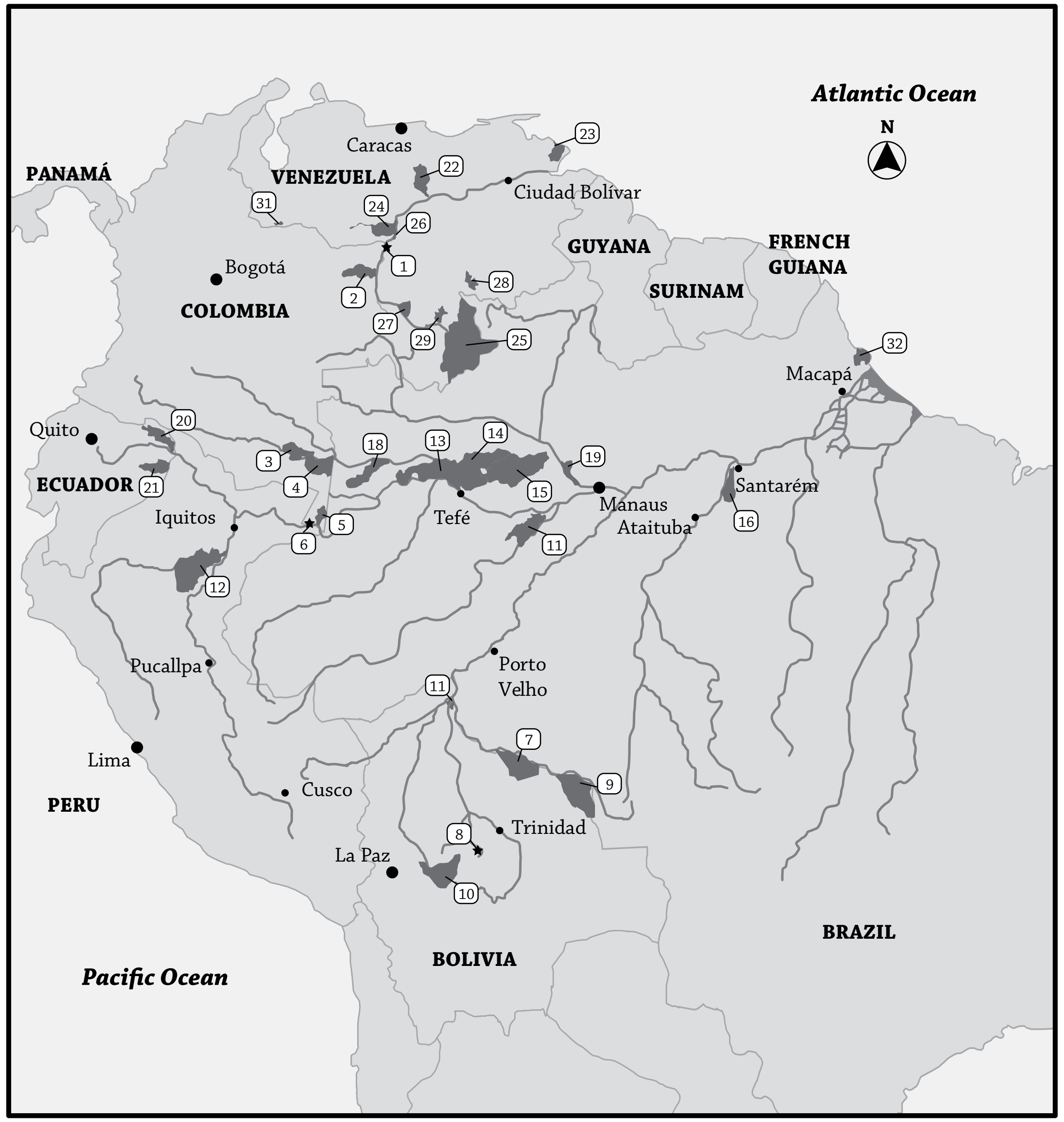
The failure to establish a greater number of FWPAs in South America is due in part to lack of ecosystem-based management by governments and environmental authorities, as well as to insufficient consideration given to freshwater resources by the people exploiting them. Both governments and users have the responsibility to look after the protection and care of the environment. Currently, NGOs, universities and Amazonian institutes are largely behind the urgent efforts to identify freshwater habitats of biological importance and seek ways to protect them.

Protected areas for river dolphin conservation

The river dolphins *Inia geoffrensis, I. boliviensis* and *Sotalia fluviatilis,* are amongst the species considered at serious risk in the major freshwater habitats of South America, the basins of the Orinoco River and the Amazon River. These species are highly mobile and travel through and use many habitats and ecosystems to meet their basic needs. As fully aquatic mammals, dolphins depend exclusively on the quality and condition of these ecosystems to survive. Every impact on the ecosystem will be felt by the species and reflected in their behavior, distribution and in the status of their populations.

Currently, there are no protected areas created exclusively for river dolphins in South America. A few PAs have been established specifically to protect other freshwater species, particularly fish, and freshwater habitats, but unfortunately, reserve designation does not guarantee the protection of these resources (Saunders *et al.* 2002) and they do not have provisions specifically to protect dolphins. With the importance of river dolphins for ecotourism in Amazonian countries increasingly recognized, these species should now be considered as important elements of the conservation strategies for these PAs. However, there is no coordination between existing PAs and no overall assessment of their coverage or of the gaps that exist.

To help address the need for a network of PAs in South America which fully consider the protection of river dolphins and their habitats, WDCS, the Whale and Dolphin Conservation Society, in coordination with researchers in the region, has set up the South American River Dolphin Protected Area Network (SARDPAN). SARDPAN is meant to be as much a network of river dolphin protected areas as a network of protected area researchers, government departments and NGOs who contribute to river dolphin conservation. Currently, WDCS is working with researchers in six South American countries to assemble a directory of existing as well as proposed protected areas which include river dolphin habitat (Figure 16). While recognizing that there are many gaps, the goal is that by looking at the big picture, these gaps can be addressed in a concerted,



1	Confluence River Meta and Orinoco	7	Iténez	17	Piagaçu-Purus	26	Tortuga Arrau
2	El Tuparro	8	Mamoré	18	Juami-Japura	27	Yapacana
3	Cahuinari	9	Noel Kempff	19	Anavilhanas	28	Jaua Sarisariñama
4	Pure River	10	Isiboro - Secure	20	Cuyabeno	29	Duida Marahuaca
5	Amacayacu	11	Bruno Racua	21	Yasuní	30	Río Viejo San Camilo
6	Tarapoto / El Correo / Caballo Cocha	12	Pacaya - Samiria	22	Aguaro-Guariquito	31	Piratuba Lake
		13	Mamirauá	23	Orinoco Delta		
		14	Amana	24	Santos Luzardo		
		15	Jau	25	Parima-Tapirapeco		
		16	Tapajos				

Figure 16. Map of protected areas included within SARDPAN initiative.

non-redundant way, and further proposals can be made.

It is also important to identify how protection in each individual area can be improved to meet the goals of good habitat protection and threat reduction for the dolphins and other species. Protected areas are only one tool for conservation. Theoretically, they could indeed function as comprehensive tools that effectively manage and reduce threats, facilitating enforcement of regulations, and conducting good educational activities and monitoring of species and health of ecosystems. But in practice, the Protected Area tool is usually part of a suite of conservation actions necessary to ensure good conservation.

SARDPAN not only counts with the support and expertise of WDCS, it also counts with the support of WWF and the Fundacion Omacha, whom are working on the improvement of this network through the conduction of abundance estimation surveys all around the continent, especially in areas surrounding Protected Areas, building capacities and integrating researchers into the use of methodologies for the study of the species.

Capacity of stakeholders to manage protected areas (PAs)

All PAs and MPAs require the active participation of stakeholders in order to succeed. This may even be truer with FWPAs than with oceanic areas due to the entirely inland location with riverine habitats sometimes literally surrounded by communities. The process of involving stakeholders should begin in the earliest stages of envisioning and proposing a protected area. However, if the area has already been chosen or selected, then the task of involving local people must begin without delay. Experience with protected areas has shown that the most successful and enduring protection is only possible when there is local interest and dedication to the idea of protection and where local people can see the benefits to conserving wildlife through ecotourism, enhanced fishing, and clean water. It is essential that communities are able to participate in all aspects of environmental education, research and conservation work associated with a PA.

There is a growing demand for alternative sources of income to compensate for the non-use and conservation of resources – the current President of Brazil speaks in these terms. Certainly, if biodiversity is to be conserved and protected, both traditional fishermen and local high school graduates need some source of income that does not involve overexploitation of wildlife and habitats. It is essential that local people – particularly the younger generation – grow up with an understanding of environmental problems and learn to value local wildlife, ecosystems and other resources as part of the capital for their own future.

FWPAs can provide an excellent framework to work with local communities to ensure that local resources are managed effectively to benefit people and wildlife in the long term. This could be an effective way of addressing the increasing and widespread problem in the Amazon created by the fact that many communities now overexploit natural resources for sale to generate monetary income rather than for subsistence. Those who once lived entirely from hunting, fishing and farming now exploit resources without management and planning.

Environmental education programmes in proposed and established protected areas are essential. All who work on FWPAs must strive to create a culture of conservation by working with local communities on education, research, monitoring and management programmes. Local guardians of wildlife and habitats can be very effective at ensuring that rules and regulations are implemented on the ground.

Two examples of local environmental education are the Natutama ("under water world") Interpretation Centre in Puerto Nariño, an area in the Colombian Amazon inhabited by native Ticuna, Yagua and Cocama people. The centre has proved a great success as a focus for education and conservation in the region. Natutama is now being recognized as a model for other ventures, especially in proposed protected areas throughout South America.

The second example is the Yaku Kawsay Interpretation Centre in the Kichwa community of Nueva Providencia, inside the Yasuni National Park in Ecuador.

Finally, in addition to the effort to improve and extend existing FWPAs, it should now also be possible to plan for the creation of new river dolphin FWPAs in South America through purchasing land and rivers or applying to governments for long-term concessions for areas to be managed for conservation purposes. As high-profile charismatic species, river dolphins may not only inspire better conservation practices but also serve as crucial bellwether species for the health of the Amazon and Orinoco River Basins. Keeping river dolphin populations strong and healthy could well prove to be instrumental for the conservation of these freshwater ecosystems.

During October 2009 took place the Workshop on Establishing Protected Areas for Asian freshwater Cetaceans. This workshop was held in Samarina, East Kalimantan, Borneo, Indonesia and was organized by the East Kalimantan Provincial Government, Mulawarman University, and Yayasan Konservasi RASI, a local non-governmental organization, and brought together local and international experts on freshwater cetaceans.
As a conclusion of this reunion, it was proposed that Freshwater Dolphin Day be held as an annual event on every 24th October.

This initiative presented by the Asian representatives has being taken and aproved by the Southamerican ones and with it, stronger ties between the two continents have been established contribiuting to the conservation of the riverine species and to the establishement of new and improved Freshwater Protected Areas.

Chapter 4
Abundance estimation program of South American river dolphins 2006 - 2009: A summary

Abundance estimation program of South American river dolphins 2006 - 2009: A summary

Fernando Trujillo, Catalina Gómez-Salazar, Marcela Portocarrero, María Claudia Diazgranados & Saulo Usma

During more than two decades, statistically robust and standardized population estimates were proposed by several researchers to assess the status of South American river dolphin populations (Perrin & Brownell 1989, Reeves & Leatherwood 1994, Reeves 2000, IWC 2000, Gómez-Salazar *et al.* in prep) as little information is available at regional scale and it comes from sporadically surveys conducted within small areas using different methodologies and therefore all river dolphins are now listed as data deficient (DD) by the IUCN, as it was mentioned in above chapters.

As a consequence of this, the Fundación Omacha, WWF and several partners developed a regional initiative to provide reliable information to evaluate the conservation status of river dolphins in both the Amazon and Orinoco River Basins in South America, monitoring population trends, densities and sizes. A standardized methodology was implemented in six different countries. More than 4.300 linear kilometers were surveyed and near 80 researchers were trained as part of this long-term ongoing program.

This initiative aims also to create a regional experts network between Andean and Amazonian countries, as part of the Freshwater Protected Areas Network (FWPAs) and the South American River Dolphin Protected Area

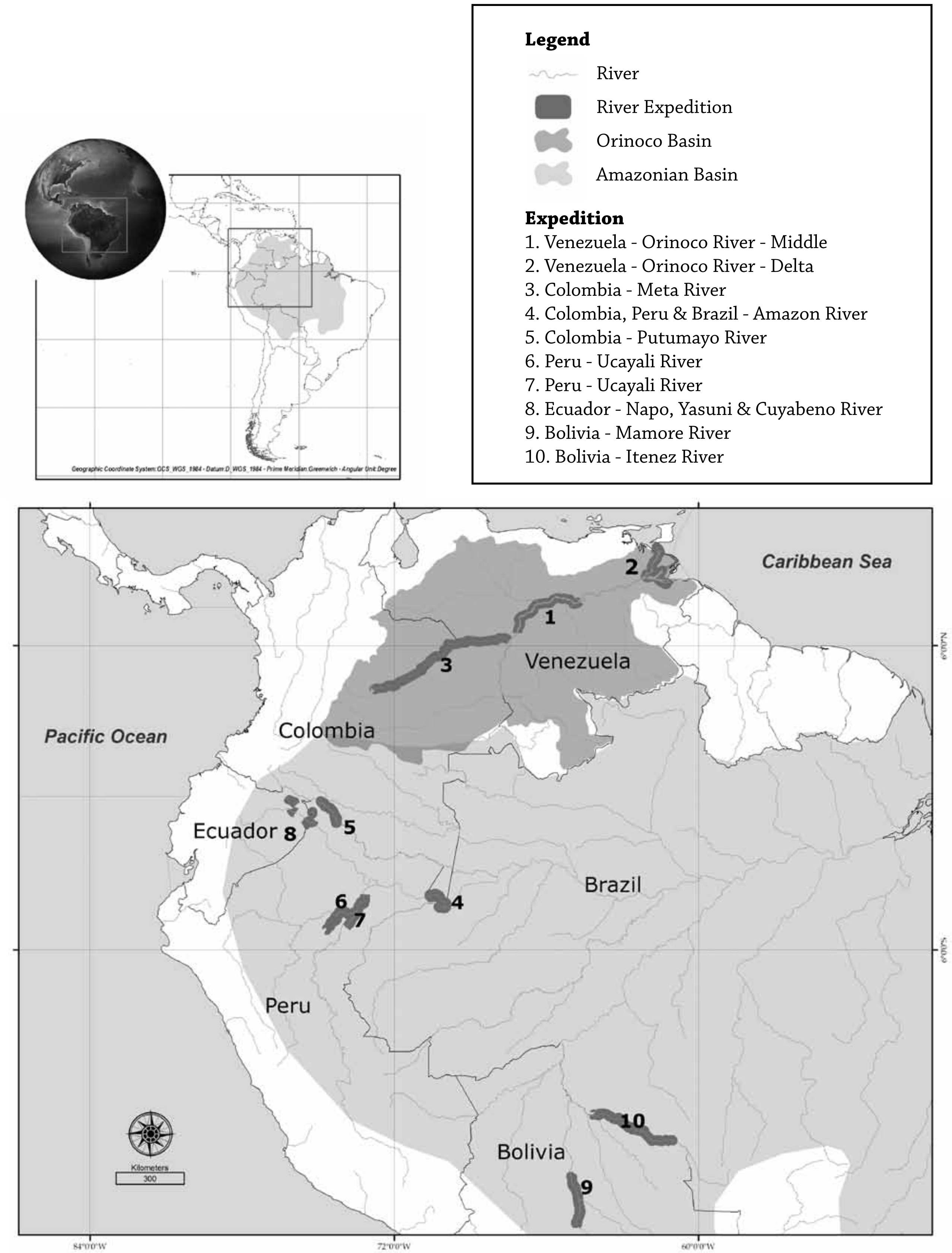


Figure 17. Population and density estimates of River Dolphins in the Amazon and Orinoco basins.

Network (SARDPAN), which fully considers the ecological integrity of freshwaters for the conservation of key species in those habitats.

Ten expeditions were made between 2006 and 2009 in the following rivers: Meta (Colombia); Orinoco (Venezuela), Orinoco Delta (Venezuela); Putumayo (Ecuador, Colombia, Peru), Cuyabeno, Yasuni, Napo, and Lagarto (Ecuador); Samiria and Marañón (Peru); Ucayali (Peru), Amazon and Javari (Colombia, Peru, Brazil); Ichilo, Mamore, and Itenez (Bolivia) (Figure 17).

In each area visual off-shore line transects and 150m strip-width transect surveys were conducted. *Off-shore line transects* were mainly conducted while crossing main rivers from one shore to the other, while *150m strip-width transects* were oriented parallel to the banks along the river margins of each river, maintaining an average distance of 100m from the shore (Figure 18). Sightings protocols were the same for both transect types and included:

1) Two platforms (bow and stern) installed in each ship with at least two observers per

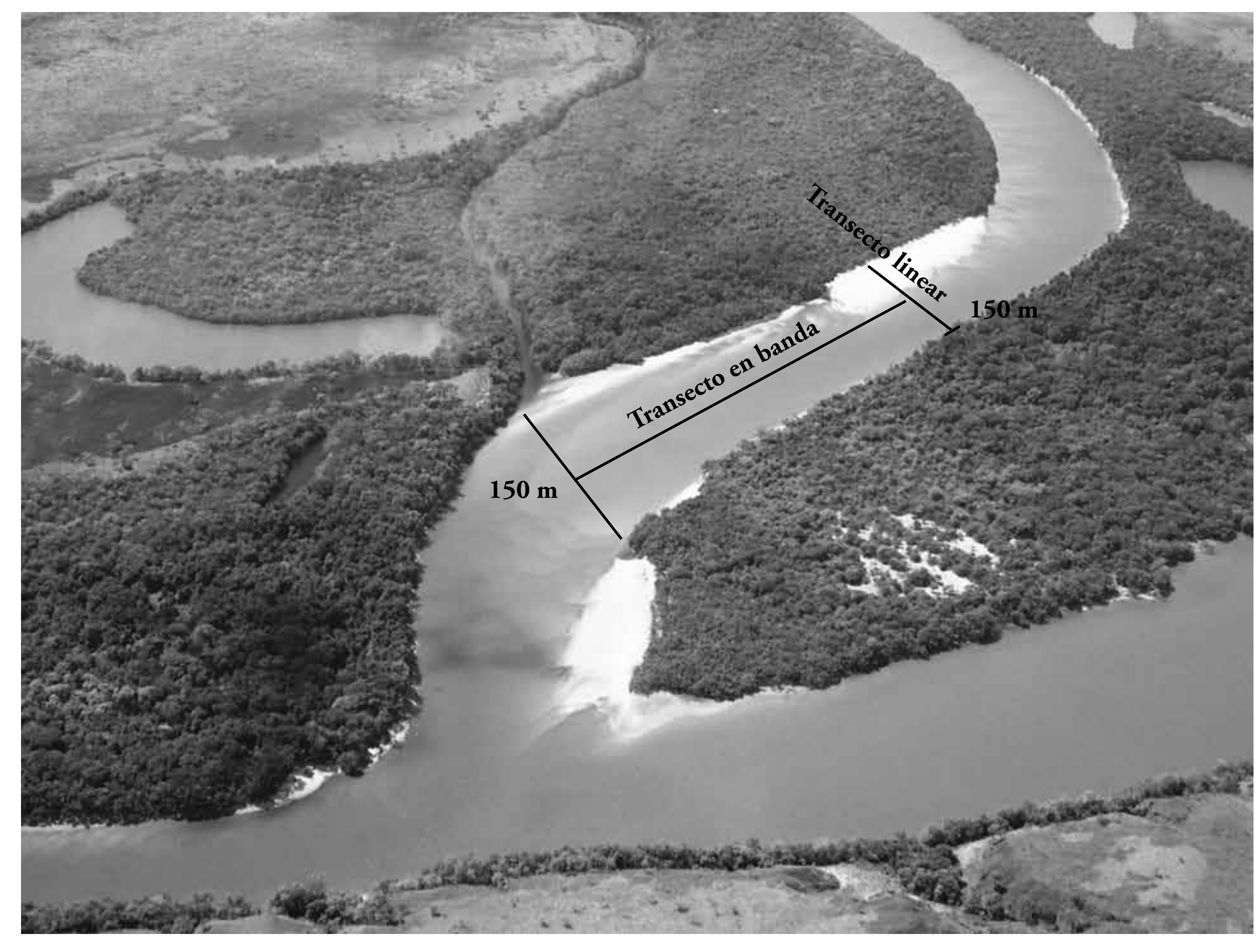


Figure 18. Survey design combining strip and linear transect.

platform (Figure 19). Both platforms were in permanent communication to increase certitude in dolphin detection and counting.

2) observation height was at least 4.5m above the river surface, allowing a wider field of vision, enhancing dolphin detection and at the same time reducing possible interferences with their behavior;

3) time, position, species and number of dolphins were registered for each sighting by both the forward and rear platforms;

4) the distance from the platform to the dolphin was estimated by eye with trained observers.

Environmental data were also recorded in each transect including date, time, position, speed (5 – 19 km/h), direction of travel and thus number of kilometers surveyed per transect (length of transect). Each survey was also classified according to the annual flood cycle: low waters, high waters and transitional periods (Sioli 1984, Goulding 1989, Junk *et al.* 1989).

Data was recorded every ten minutes during the strip transects including the distance from the bank, or from side to side (in the case of channels).

In the bow, one person was in charge of recording information in a Progress Log every ten minutes, another was responsible for permanent observation of the river and measuring angles at the moment of sighting and a third was responsible for the Bow Record where entries were made at the moment of each sighting. In the stern, one observer registered all observations in the Stern Record. Another was responsible for observations and measuring angles whenever dolphins were sighted.

It was important to bear in mind that both linear and strip transects were distributed as uniformly as possible. That is to say those

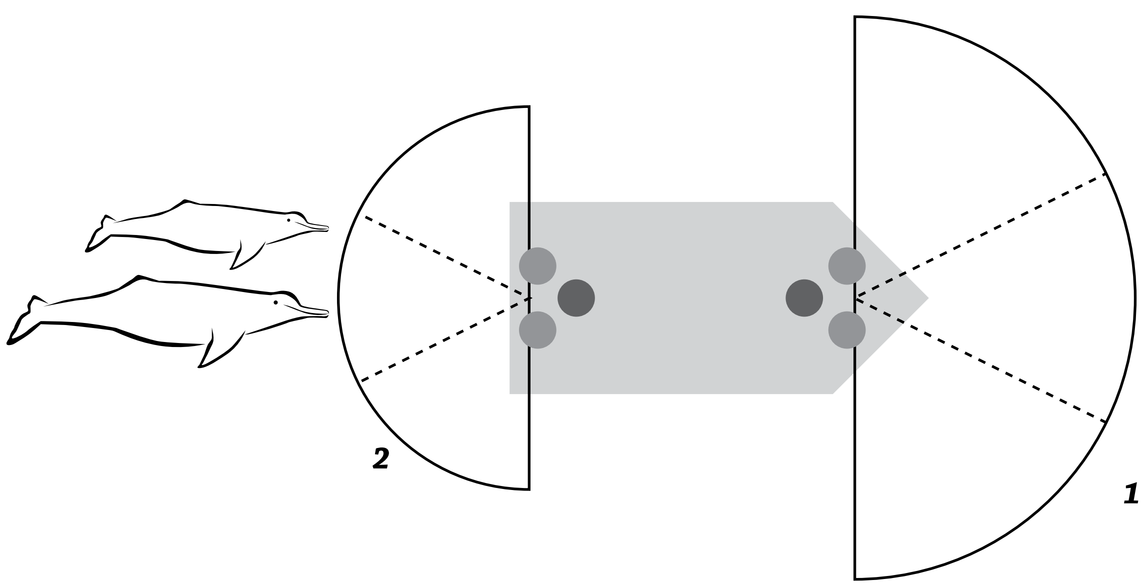


Figure 19. Observation platforms: Bow and stern.

areas were chosen where there were both high and low densities of dolphins, in order not to either overestimate or underestimate dolphin numbers throughout the study area, and avoid creating large variances in encounter rates.

Subsequently, the information was organized in tables that were exported to a program called *Distance* to make the abundance estimates. The area of the rivers and other aquatic habitats in the study area were calculated through satellite imaging.

The fundamental idea behind applying a consistent methodology for dolphin abundance estimation and standardized information gathering is the ability to design an integrated conservation and monitoring strategy for South American dolphins, which is at present non-existent.

Results

Ten expeditions were carry out between 2006 and 2009 covering 4309 linear km and counting 4123 dolphins: 1492 *Inia geoffrensis*, 1323 *Inia boliviensis* and 1308 *Sotalia fluviatilis* (Table 30).

Table 30. Types of habitat used by dolphins.

Type of habitat	Characteristics
Main River	Rivers of Andean origin and from the Guyanese shield. Their waters are typically white, dark or a yellowish-brown colour with little transparency, due to the large quantity of suspended sediment (Sioli 1975). More than 400m width creating a watershed or sub-watershed. Examples: Rivers Orinoco and Meta.
Confluence	Intersection areas of two river flows (main river and a tributary channel) that stays connected in all water seasons. They generally showed a mixture of waters (white water with dark or clear) (Trujillo 2000). Examples: Meta-Orinoco, Meta-Casanare and Orinoco-Cinaruco.
Tributary	Small and medium rivers not more than 400m wide. Generally show dark or clear water. The majority are of forest origin (Trujillo 2000). Examples: Manacacias, Guayabal and Arauca.
Channel	River course with a maximum width of 300m, generally associated with island systems in the principal rivers, where both banks can be seen on each side. Strait of little navigability at some times of year.
Island	Land bodies present within the river course with evidence of vegetation, which appear or disappear depending on water dynamics.

In general, results showed that river dolphin densities varied according with the geographical area, with low densities in Ecuador (Cuyabeno, Aguarico, Yasuni) and the rivers Putumayo, Meta and Orinoco; and high densities in the rivers Samiria (Peru), Itenez and Mamoré (Bolivia) (Gómez-Salazar *et al.* 2009, Gómez-Salazar *et al. in press*).

Low dolphin population densities could be explained by low prey availability (fish). In these areas there are no organized fisheries, and efforts were not successful in past decades as shown by the low number of catches. In the specific cases of Meta and Putumayo rivers, it is reported that historical (over 50 years) aggregations of dolphins were common in the upper reaches of the river, but as fisheries resources were depleted, the dolphin populations moved to the middle and low areas of the rivers.

In contrast to the Meta and Putumayo rivers, in the Samiria (Peru) and Itenez-Mamore (Bolivia) rivers environmental conditions appear to be optimal and able support healthy aquatic ecosystems with very high densities and abundance of fish, dolphins, turtles, alligators and birds. The disturbance levels are low, and in the first case, the figure of the protected area plays a fundamental role in the conservation processes.

The expeditions along the rivers sampled, brought together information based on direct observations and supporting literature (scientific papers, technical documents) to identify some of the major threats to the dolphins and their ecosystems (Table 32).

The future

The Amazon and Orinoco basins are a very complex net work of rivers where the occurrence of river dolphins is very heterogenic. Preliminary results showed important differences in densities and levels of threats for these species. For this reason it is important to continue the evaluation of abundance in other geographic areas, especially on those with plans for development projects such as dams, water ways, mining and overfishing. Researchers from different countries suggest that some of the most important areas to cover are:

- The River Pastaza (Ecuador-Peru)
- The River Purus (Peru-Brazil)
- The River Guaviare (Colombia)
- The River Madeira (Bolivia-Brazil)
- The River Santiago (Ecuador)
- The River Essequibo (Guyana)

This initiative has contributed to consolidate a network of river dolphin researchers in South America, increasing scientific skills, communication opportunities, evaluation of isolated geographic areas and also the conservation of aquatic ecosystem as one of the priorities for the agenda of most of the countries where river dolphins occurs.

Table 31. Density values (ind/km²) from Gómez-Salazar *et al.* (2009).

	Density Values (ind/km²)	
Rivers	***Inia***	***Sotalia***
Orinoco	1,1	0,8
Meta	0,5	NA
Napo/Tributaries	1,3	0,2
Samiria	3,1	2,1
Amazon/Javari	2,1	2,4
Putumayo	1,1	0,01
Itenes/Mamoré	3,2	NA

Table 32. Main threats identified for surveyed river in South America.

Country	Rivers	Main threats
Ecuador	Yasuni, Aguarico, Cuyabeno, Napo, Lagarto-cocha	Oil spills, tourism, over fishing
Venezuela	River Orinoco	Mercury pollution, over fishing, deforestation
Colombia	River Meta	Over fishing, hidroway (in process harbor building)
	River Amazon	Over fishing, deforestation, boat traffic
Peru	Javari	Deliberate killing of river dolphins, over fishing
	Samiria	
	Ucayali	Deforestation, over fishing
	Marañón	Over fishing, deforestation, boat traffic
Bolivia	Itenez	Dams (Madeira River), conflicts with fishermen
	Mamore	Increasing tourism

Chapter 5
The Action Plan for River Dolphins in South America

The Action Plan for River Dolphins in South America

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To build the action plan, an international workshop was carried out at the city of Santa Cruz de La Sierra, Bolivia between the 21 and 23th of April 2008. Approximately 42 researchers and representatives from Governments of nine countries actively participated in the workshop. Initially, Dr. Enrique Crespo, Chairman of the Cetacean Specialist Group of the IUCN for Latinamerica presented an overview of the status of river dolphins. Following this, each country (Venezuela, Colombia, Ecuador, Peru, Bolivia and Brazil) made presentations of the status and conservations of theses species. Additionally, four presentations were made by experts on phylogeography and taxonomic status of river dolphins, Geographic Information System analysis of distribution, threats and research initiatives, Abundance estimation and, fisheries and conflicts in the Amazon River Basin.

After the background about river dolphins and their habitats, working groups were established to identify objectives and goals for five strategic lines (Figure 20):

- Scientific Research and Conservation
- Legislation and Policy
- Communications
- Administration and Institutional strengthe-ning
- Education and community participation

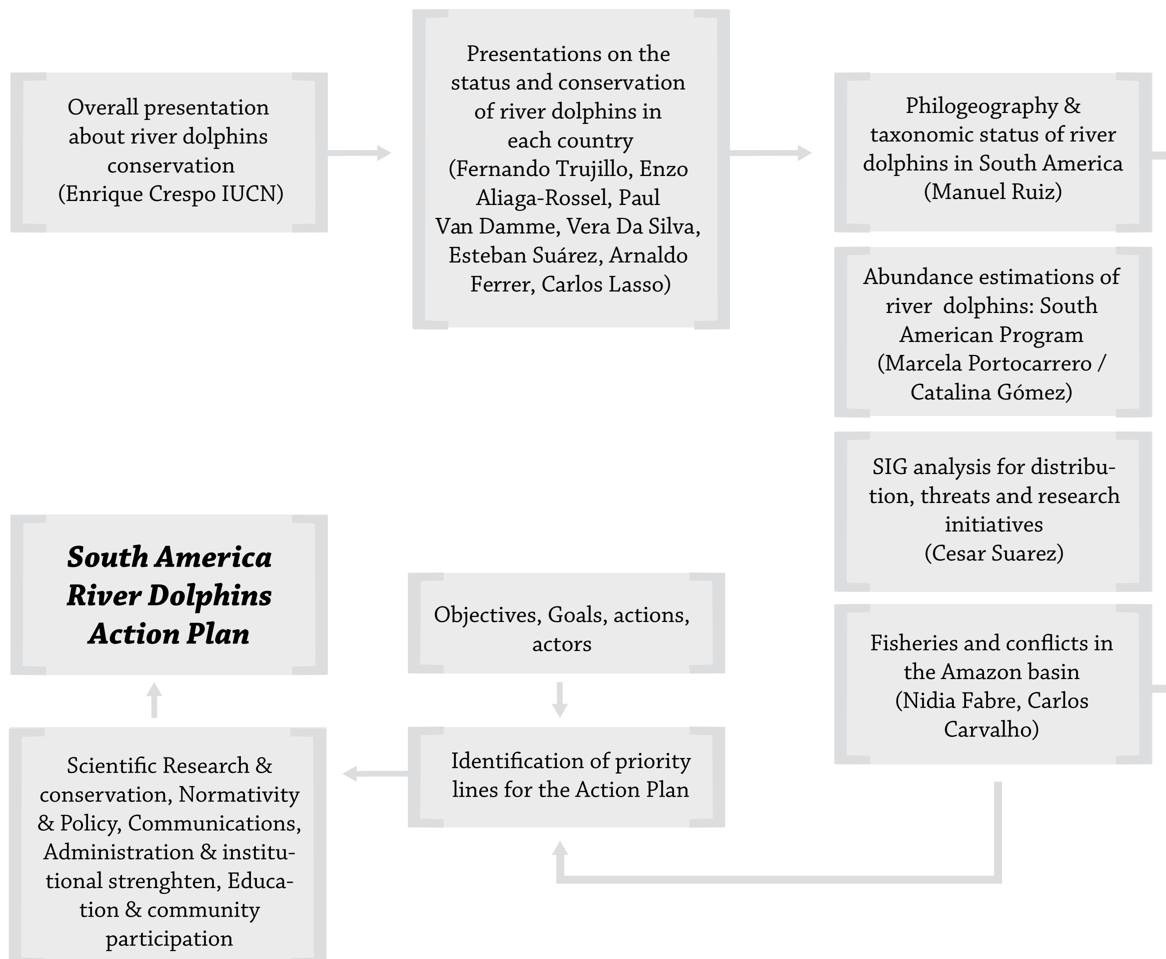

Figure 20. Formulation of the Action Plan for River Dolphins in South America.

Level of priority to conduct the actions proposed in every Strategic Line

Priority	
Very high priority	
High priority	
Medium priority	
Low Priority	

Table 33. Strategic line 1. Scientific research and monitoring.

To create and consolidate scientific knowledge to conserve and manage the populations of river dolphins and their ecosystems in South America.

Goals	Strategic goals	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia	Level of priority
To plan and conduct research contributing to the conservation of river dolphins	**Fisheries and river dolphins**	Identification of geographic areas where interactions occur	Very high	Very high	Very high	Very high	Very high	Very high	5
		Identification and analysis of different types of human-dolphin interactions	Very high	Very high	Very high	Very high	Very high	Very high	5
		Development of a conceptual model of human-dolphin interaction	High	High	High	High	High	High	1
	Taxonomy and genetics	Definition of molecular taxonomy of *Inia* (Upper Orinoco, Tocantins)	Low						3
		Definition of molecular taxonomy of *Inia* (Madeira)					Medium	Medium	3
		Evaluation of molecular taxonomy of *Sotalia* (Amazon Delta, River Orinoco)	Low						1
		Population genetics of river dolphins at fine geographic scale (Ecuador, upper Caquetá-Japurá, Tapajós, Iténez)			Medium	Medium	Medium	Medium	3

Goals	Strategic goals	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia	Level of priority
To plan and conduct research contributing to the conservation of river dolphins	Population dynamics	Relative abundance estimations							6
		Estimation of population parameters of river dolphins							4
		Study of river dolphin population structure							4
	Evaluation of trophic ecology and limnology	Evaluation of fish community structure, fish population dynamics and(or and specific **fish** stocks in key areas							3
		Feeding ecology of dolphins using isotopes							1
		Development of trophic models in key areas							1
	Ecosystem alterations and habitat loss	Assessment of boat traffic effects on river dolphins							3
		Evaluation of changes in fluvial dynamics and its effect on river dolphins and fish							2
		Biomagnification and bioacumulation of pollulants							3
		Water quality evaluation (continous sampling)							1
		Habitat loss evaluation focused on deforestation, mining and agroforestry							2
		Evaluation of the impact of habitat loss on river biodiversity							2

Goals	Strategic goals	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia	Level of priority
To plan and conduct research contributing to the conservation of river dolphins	Ecosystem alterations and habitat loss	Effects of global climatic changes on Amazonian aquatic ecosystems and on traditional local communities							3
		Efficiency of river dolphins as bio-indicators							2
		Impact of cultural and social changes on the perception about freshwater biodiversity use and conservation							3
To implement at least one conservation program in each country according their respective research priorities	Local knowledge	Evaluate the influence and effect of the implementation of sustainable economic alternatives on social, economic and environmental dynamics							2
		To studysustainable economic alternatives with local communities (craft carving, tourism)							2
	Responsible tourism	To set up, implement and encourage responsible dolphin watching programs							3
		Evaluation of social and economic benefits of responsible tourism							2
		Colection of a data base on experiencies with responsable tourism							1

Goals	Strategic goals	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia	Level of priority
To implement at least one conservation program in each country according their respective research priorities	**Geopgraphic Information System**	Identification of priority areas for research and conservation							3
	Environmental modeling	Population viability analysis (PVA)							1
		Tropho-dynamic models							1
	Fisheries management	Fishery management plans in key areas for river dolphins							4
		Regulation/ban mota fishery							4
		Development of alternative baits for the mota fishery							2
		Development of alternative fishing techniques with low or no interaction with dolphins							1
		Development of an aquaculture program for the mota fish in geographic areas with conflicts							3
	Impact of human activities on aquatic ecosystems	Co-management of lakes and river ecosystems							1
		Evaluation of river dolphin populations in habitats with different degrees of alteration (mining, dams, water ways)							2
		Ecosystem restauration in priority areas for conservation							1
		Inclusion of river dolphins in enviromental impact studies							4

Table 34. Strategic line 2. Legislation and policy.

To establish and to consolidate a regional policy for the conservation of the species and their ecosystems, harmonizing legal instruments and frameworks from each country.

Goals	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve protective legislation in each country taking into account the regional legal frameworks	**Articulation of regional policies and enforcement of international agreements about aquatic ecosystems, endangered species and freshwater resources.**	Workshops and technical-political national and bilateral meetings						
		Binational agendas. The application of the Convention on Biological Diversity (CBD), OTCA, CMS to solve specific poblems such as the mota fishery and the mercury effect						
		Evaluation of demands and possibilities to articulate legal instruments for border areas						
		Articulation of national policies and agreements in border areas						
		Sistematization and comparison of legal instruments specially fisheries legislation						
	Formulation of national plans for the conservation of river dolphin or the inclusion of the species within freshwater management plans	To include river dolphins in the terms of references for the design and implementation of management Plans in Protected areas						

Goals	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve protective legislation in each country taking into account the regional legal frameworks	**Formulation of national plans for the conservation of river dolphin or the inclusion of the species within freshwater management plans**	Inclusion of river dolphins in the reference terms of the Ministry of Environment - MAVDT, Action Plans for River Dolphins						
		To include river dolphins in environmental impact assessments for development projects (hydrocarbons, hydroways, so on)						
		To include river dolphins in Fisheries agreements and Plans						
		National Action Plan for River Dolphins Conservation. Tri-Annual Regional Action Plans (Environmental Authorities)						
To improve and support the Agencies in charge of the enforcement of environmental policies to assist them to accomplish their functions properly.	**Update, control and enforcement of legal frameworks (Freshwater ecosystems and resources)**	To submit legislation and legal instruments to the government, parliament and Ministry authorities						

Goals	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve and support the Agencies in charge of the enforcement of environmental policies to assist them to accomplish their functions properly.	**Update, control and enforcement of legal frameworks (Freshwater ecosystems and resources)**	Update and modification of the legal and legislative framework in each country, according to regional conservation priorities of river dolphins and their ecosystems.						
		Analysis of the legal frameworks in each country and of the signed International Agreements .						
		National Policy on Wetlands, Tri-Annual Action Plans of the Environmental Authorities, Departmental Land Use Plans.						
		To strengthen environmental entities (environmental nurseries)						
		Expansion of actions of control and surveillance						
		To strengthen public instruments for law enforcement, legislation, disclosure and education						

Goals	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve and support the Agencies in charge of the enforcement of environmental policies to assist them to accomplish their functions properly.	**Update, control and enforcement of legal frameworks (Freshwater ecosystems and resources)**	To implement legislation and law enforcement in each country						
		Modification of legislation of EIA studies						
		To strengthen public instruments for law enforcement, legislation, publicity and education						
	Stakeholders Network improvement	Meetings and Workshops with administrative entities (National Natural parks - Inparques)						
		To present scientific arguments to PRODUCE and INRENA to include them within Management Plans for Protected Areas.						
		To check and set up Management Plans in collaboration with the CMA and technicians						
		Workshops with the Fisheries Authority - ICA and fishermen's associations.						
		To participate in workshops and meetings on fisheries and aquaculture.						

Goals	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve and support the Agencies in charge of the enforcement of environmental policies to assist them to accomplish their functions properly.	**Stakeholders Network improvement**	Meetings between Enterprises and the Ministry of Environment.						
		CMA participation in the formulation of reference terms, roles, definition, etc						
To involve all countries in international meetings about cetacean conservation.	**Strengthen connections between countries within South America and with Asia**	Multilateral meetings among south american and asian countries						
		Workshops with the public administrators, strengthening existing agreements						
		To subscribe and adhere to international agreements and regional treaties that promote the conservation of river dolphins						
		To work together in the acquisition of funding for river dolphins conservation						

Table 35. Strategic line 3. Communications.

For 2012, the communication strategy of river dolphin conservation will be through a regional network and will position the river dolphin as an emblematic species and thus diminish their threats through the education of the public opinion and decision makers.

Goal	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve methods of communication and the dissemination of information among researchers and the general public	**Strengthening of lines of communication and the diffusion of information**	To develop a communication strategy for the conservation of river dolphins and an inter-institutional plan for its implementation						
		Distribution of the results of scientific investigations involving tourism enterprises						
		Diffusion of the economic benefits from tourism activities using dolphins as an attraction.						
		To encourage local participants to feel closer to the resource						
		To create a network to share available information about this topic, and to select a network manager						
		Discussion groups, frequent progress reports						
		To create inter-institutional forums to socialize and share experiences, data bases and to collaborate in management strategies						

Goal	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve methods of communication and the dissemination of information among researchers and the general public	**Strengthening of lines of communication and the diffusion of information**	To develop mechanisms of communication between involved institutions.						
To involve the general public in the conservation of river dolphins and their habitats	**Use of communication strategies to allow the general public to get closer to the river dolphins and their habitats**	Campaigns to prize the dolphin as a tourist attraction						
		To produce didactic material for public discussion						
		Implementation of interpretative centers, fairs and workshops						
		To plan trips for journalists to areas of distribution of dolphins and educate them about their biology and conservation						
		To generate synergies for the development of publicity campaigns. Ex. The Week of the Dolphin or the International Day of Freshwater cetaceans						
		Publicity campaigns to the general population about the dolphin as a flagship species						

Goal	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To involve the general public in the conservation of river dolphins and their habitats	**Use of communication strategies to allow the general public to get closer to the river dolphins and their habitats**	Publication of educational brochures, radio programs, fairs, workshops to involve local participants in conservation strategies.						
		To develop promotional material to support project presentations about dolphin conservation in their areas of distribution						
		To develop regional and local campaigns about indirect threats: fisheries, mining, oil, agrochemical pollution, industrial wastes, deforestation, and infrastructure developments						
To find support in the media for the conservation work in order to diminish threats to the species and their habitats	**Communication as a tool to diminish threats**	To develop regional and local campaigns about direct impacts such as incidental catches, negative interaction with fisheries, use of dolphins as bait, and navigation						
	Fundraising	Organization of excursions for current and potential donors						
		To use media strategies to get funding for the species						

Table 36. Strategic line 4. Administration and institutional strengthening.

To constitute an integrated and transnational administration system for the conservation of aquatic ecosystems, considering river dolphins as flagship species and contemplating strategies for the strengthening of stakeholders involved in the conservation and use of aquatic resources.

Goal	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To improve the administration of financial resources, especially directed at river dolphins	**Improvement of the administration of fund**	To articulate within the framework of international convention agreements (CMS, OTCA, CBD, etc.) the approval of the present Action Plan						
		To create a regional fund to support conservation initiatives aiming at the protection of river dolphins						
		To systematize projects and funded programs						
To strengthen stakeholders in conducting and managing programs and conservation projects at a local level	**Bring together decision makers and local stakeholders, focusing on freshwater resource users**	To inform and educate the general public on the importance of river dolphin conservation						
		Building local and governmental capacity						
		To identify leaders in each country to influence conservation policies						
		To integrate the private sector in management strategies (ecotourism, industry, enterprises)						

Goal	Strategic lines	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To strengthen stakeholders in conducting and managing programs and conservation projects at a local level	**Bring together decision makers and local stakeholders, focusing on freshwater resource users**	To identify and map co-management strategies						
To create tools to improve administration and management at a continental and national level	**Integrate conservation strategies among research teams in different South American countries**	Regional GIS, bank of projects						
		Participative instruments of integrated use, using river dolphins as a flagship migratory species						
		To integrate National Action Plans						
To share management experiences and public policies between the countries involved.	**Involvement and inclusion of international experiences**	Binational, transnational and intercontinental meetings to present lessons learned, progress evaluation and to discuss indicatores						

Table 37. Strategic line 5. Education and community participation.

To change attitudes towards the conservation of the river dolphins and the aquatic ecosystems, through environmental education and the promotion of effective community participation in sustainable management initiatives that guarantee collective benefits.

Goals	Strategiese	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To promote and strengthen environmental education programs for the conservation of river dolphins according to the needs and problems in each country	**Improvement of current and proposed educational programs**	To diagnose the current educational programs and perceptions of local people about the species and their ecosystems in their area of distribution						
		To conduct training workshops related to aquatic ecosystems and river dolphins, especially for people interested in environmental education and school teachers in the region						
		To create and maintain a supporting network among countries in order to share experiences, technology and information about the species and their ecosystem						
		To construct environmental interpretation centers to strengthen current knowledge in countries where actual and potential conservation problems exist						

Goals	Strategiese	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To promote and strengthen environmental education programs for the conservation of river dolphins according to the needs and problems in each country	**Improvement of current and proposed educational programs**	To start initiatives that validate cultural traditions and knowledge related to the proper use of aquatic resources						
To involve local communities in the development and implementation of strategies for conservation of river dolphins	**Working together with local communities to strengthen educational strategies**	To establish environmental education strategies with the natives for each locale						
		To inform and promote any initiative that directly involves local communities and their territory						
		To strengthen the capacity among local people to monitor and control the species and their ecosystems						
		To support common initiatives to mitigate problems associated with the conservation of river dolphins and their ecosystems						

Goals	Strategiese	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To involve local communities in the development and implementation of strategies for conservation of river dolphins	**Working together with local communities to strengthen educational strategies**	To implement environmental education projects linked to community development processes and productive initiatives (tourism, handicrafts, food processing, etc)						
To guarantee the participation of governmental and non-governmental institutions in programs of conservation for river dolphins	**Involvement of all stakeholders in educational programs**	To identify institutions that are currently conducting operations to protect river dolphins and their ecosystems and to involve them in the strategy						
		To engage the participation of the Government (Environmental and Agriculture ministries, national parks, etc) in the construction and implementation of conservation strategies						
To ensure that educational programs and community participation have financial sustainability and appropriate personnel at least until 2020	**Funding**	To identify potential and actual sources of funding to ensure the continuation of the environmental education strategy.						

Goals	Strategiese	Priority Actions	Venezuela	Peru	Colombia	Ecuador	Brazil	Bolivia
To ensure that educational programs and community participation have financial sustainability and appropriate personnel at least until 2020	**Funding**	To identify professional and volunteering personnel to ensure the continuity of the environmental education strategy						
		To initiate publicity campaigns and international promotion emphasizing the importance of the species and their ecosystem to get financial help						
		To identify an image and slogan to strengthen the conservation strategy at the national and international level and to procure financial and personnel resources						

Chapter 6
Recommended research, conservation and education initiatives

The Action Plan for South American River Dolphins 2010 - 2020

Recommended research, conservation and education initiatives

Previous recommended projects by IUCN Action Plans and the IWC small cetaceans subcommitte

During the last 20 years several recommendations for scientific research and conservation has been made around river dolphins and reflected in Cetaceans Action Plans (Perrin 1989, Leatherwood & Reeves 1994, IWC 2000, Reeves *et al*. 2003) (Table 38). Some of these priorities have been developed, in most cases as individual efforts of organizations and researchers more than governamental programs. In fact, most of the recommendations focus on management of areas, mitigation of fragmentation and pollution, and even planning of dams and water ways has not been considered.

Table 38. Priority actions proposed for river dolphins from 1986 to 2003 and the level of development in each country.

	Action	Ongoing	Not initiated
	Perrin, W.F.; Brownell, R.L.; Kaiya, Z. & Jiankang, L. Biology and conservation of the river dolphins. Workshop on biology and conservation of the platanistoid dolphins held at Wuham, Republic of China. Octobre 28-30, 1986. Occasional papers of the IUCN species survival commission. (SSC). No. 3.		
1.	Establish and standardize research techniques appropriate to conduct monitoring initiatives		
2.	Environmental assessment of dams in the early stages of their construction and planning		
3.	Determine the level of genetic differences between the populations of the Amazon and Orinoco basins and between the populations that inhabit the tributaries of the Orinoco River	Bolivia Colombia Peru Brazil	
4.	Studies on the toxicicity of pollutants (pesticides and metals) in dolphins and their preys. Leves must be associated to factors such as sex, age, reproductive condition and health.	Colombia Venezuela Brazil	
5.	Monitor incidental death in fisheries	Colombia Peru Brazil	
6.	Keep complete register of the animals hold in captivity and the corpses of dead animals must be used in research		
	Conservation and Management		
1.	The species must be classified as vulnerable in the red books of the IUCN	Bolivia Colombia Peru Venezuela Brazil Ecuador	
2.	Big parks or conservation areas must be established in wetlands containing significant populations of *Inia*.		
3.	The legislation must be promoted in countries where *Inia* is not totally protected.Including Perú, Colombia, Venezuela and Guyana.	Colombia Peru Venezuela	
4.	Efforts must be done to ensure law enforcement to protect the species.		

	Action	Ongoing	Not initiated
5.	These species (and other freshwater fauna including manatees, turtles and crocodiles) must be included in International Agreements and Conventions as valuable species subject to protection from long term development projects.	Bolivia Colombia Peru Venezuela Brazil Ecuador	
6.	Diminish the impact of dams on aquatic ecosystems, concentrating them to a few rivers.		
7.	In countries where *Inia* is present (Brazil, Peru, Venezuela, Colombia, Ecuador, Guyana and Bolivia) it must be promoted the exchange of information about the populations and to cooperate in research and regional planning conduction. This exchange must occur through the Amazon Cooperation Treaty Organization (ACTO).	Bolivia Colombia Peru Venezuela Ecuador	
	Dams		
1.	Dams´planning must include all involved countries		
2.	A few selected tributaries must be used to establish dams.		
3.	Some tributarias should preserve as natural reservoires for river dolphins		
4.	The main channel of the river must be protected as a vital and integral part of the complex freshwater system.		
5.	International Funding Agencies (World Bank, Monetary Fund, Inter-American Development Bank and others) must be informed of the vulnerable position of the species and they must be required to give appropriate guidance to use it in the environmental impact assessments commisioned by them		
6.	When a Dam construction is proposed to an international agency, this information must be passed on to national and international conservation agencies before the funding is approved.		
7.	Research groups working on the impact of dams on river dolphins, must collaborate in keeping a constant flow of information.		
8.	Educational campaigns must be carried out to promote the intrinsic value of these species as vital part of the ecosystem and world heritage.		

	Action	Ongoing	Not initiated
	General Recomendations		
1.	River dophins are ideal indicators of the condition of freshwater ecosystems, due to tha fact of being top predators and sensitive to environmental changes.		
2.	Efforts done to preserve the habitats of these species will help to preserve many other aquatic species		
3.	River dolphins must be considered as an emblem of the efforts to preserve the most quantity of river systems and a high priority to avoid their extinction.	Bolivia	
	Action Plan 1994-1998		
	Reeves, R. & Leatherwood, S. Action plan for the conservation of cetaceans. Dolphins, porpoises and whales.		
1.	Asses and monitor the killing of botos in all parts of their range where such killing is known or suspected to occur	Colombia Peru Brazil	
2.	Establish a system for handling photographs and tissues to be used in studies of Amazon and Orinoco dolphins	Colombia Brazil	
3.	Conduct a simposium on the impact of dams on river dolphins: problems and solutions		
4.	Prove the vality of the folk believes about the appropriateness of the products obtained from the species and to find proper substitutes.		
5.	Workshops on methods to estimate freshwater and coastal dolphins´populations.		
6.	Promote the importance of riverine fauna in funded international developments		
	Action Plan 2002-2010		
	Reeves, R. & Smith, B.; Crespo, E.A. & Norbartolo, G. 2002-2010. Conservation action plan for the world's cetaceans. Dolphins, whales and porpoises. IUCN/SSC Cetacean specialist group. 2003.		
1.	Investigate interactions between river dolphins and fisheries in Amazonia and Orinoquia.		
2.	Assess existing and planned water development projects and gold mining in the Amazon and Orinoco basins	Brazil	

	Action	Ongoing	Not initiated
3.	Develop a conservation strategy for South American river dolphins	Bolivia Colombia Peru Venezuela Brazil Ecuador	
4.	Assess fishery interactions with cetaceans in Brazil.	Brazil	
6.	Investigate stock identity of endemic species in South America	Bolivia Colombia Peru Venezuela Brazil	
7.	Conduct Cetacean abundance estimation workshops in Latin America	Bolivia Colombia Peru Venezuela Brazil Ecuador	
	IWC Recomendations		
	2002		
	IWC Report of the scientific commitee. 52nd meeting of the international whaling commission, Adelide, Australia. 2000.		
	Generales		
1.	Assess the impacts of water development and future plans of projects including the development and use of it within the range of the species. Habitat requirements must be taken into account and implications in population´s fragmentation.		
2.	Any future Protected Area or any type of restriction attempting to preserve freshwater cetaceans must have the correct size and location, potential threats must be eliminated or reduced and the proper recommendations conducted		
3.	Estimate the magnitude of fisheries as a threat where it is necessary and to develop management strategies for its reduction	Colombia Peru Brazil	

	Action	Ongoing	Not initiated
4.	Assess the effect of environmental pollutants as mercury, pesticides and oil on the species	Colombia Venezuela Brazil	
5.	Abundance estimation with robust statistical support and reproductible techniques	Bolivia Colombia Peru Venezuela Brazil Ecuador	
Recomendations to Inia			
1.	Identify stock structures and their studies must be published as soon as they are obtained		
2.	Establish a distribution register, including river systems and locations of all current and proposed dams, as well as large scale development projects and other type of threats like fishery operations or oil extraction.	Bolivia Brazil	
3.	Document abundance tendencies through statistical support	Bolivia Colombia Peru Venezuela Brazil Ecuador	
5.	Collect information associated to mortality levels, associated to different fishing techniques	Colombia Peru Brazil	
Recomendation for Sotalia			
1.	Research to detect the abundance tendencies, making estimations with statistical rigurousity and reproductible in other regions and habitats	Colombia Peru Venezuela Brazil Ecuador	
2.	Collect information that allow the assessment of the incidental mortality of the species associated to fishing tecniques	Brazil	
3.	Determin the type of *Sotalia* who inhabits the basins of the Amazon and Orinoco	Colombia Peru Brazil Ecuador	

Recommended projects for the Action Plan for South American river dolphins

As one of the main goals of the workshop in Bolivia, all the proposed projects were evaluated and updated with the aim of establishing new priorities that help to implement the South American river dolphin action project (2010-2020). As a result, 14 projects were identified covering scientific research, conservation, communication, legislation and policy and environment education and community participation (Table 39).

Table 39. Proposed projects.
Short term: within the next three years, Medium: within the next five years, Long term: within the next ten years.

Scientific Research and Conservation

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
1	Abundance estimation of river dolphins in the Amazon and Orinoco River Basins	To estimate the abundance and densities of river dolphins in geographic areas where there is no data available using standardized methods To define a set of key conservation sites at regional scale to focus management initiatives	Putumayo (Colombia, Ecuador, Peru), Guaviare, Caquetá (Colombia), Pastaza (Ecuador, Peru), Purus, Negro, Tapajos, Xingu, Madeira (Brazil), lower part of the Orinoco (Venezuela), Essequibo (Guyana), lower part of Mamore (Bolivia)	INPA (Brazil), Fundación La Salle (Venezuela), FAUNAGUA (Bolivia), Fundación Omacha (Colombia), WCS, other national and international NGOs, Universities, Research Institutes, Government	US$ 10.000 per survey (at least)	Short term
2	Evaluation of the taxomic status of *Sotalia* sp in the River Orinoco	To evaluate the taxonomic status of *Sotalia* in the River Orinoco in Venezuela	River Orinoco in Venezuela from the Delta to the Parguaza Rapids.	Fundación SEAVIDA, Fundación La Salle, Universities.	US$ 10.000 per survey (at least)	Medium term

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
3	Evaluation of negative interactions between river dolphins and fisheries	To evaluate negative interactions between river dolphins and fisheries in the Amazon and Orinoco basins To assess the impact of the mota fishery over river dolphins' populations To develop and test alternative baits for the mota fishery	Rivers Putumayo, Caquetá, Meta (Colombia), Purus, Javari, Amazon (Brazil), Orinoco (Venezuela)	INPA (Brazil), IIAP, DIREPRO, Fundación La Salle (Venezuela), FAUNAGUA (Bolivia), Fundación Omacha (Colombia), other NGOs, Universities, Research Institutes, National Fisheries authorities	US$ 30.000 each river	Short term
4	Assess the impact of other human activities on river dolphin populations	To assess the impact of dams on biological and ecological processes of river dolphins' populations, Assess the impact of mercury and other heavy metal's discharges in aquatic ecosystems in the Amazon and Orinoco basins	Brazil, Bolivia, Colombia and Venezuela	INPA (Brazil), FAUNAGUA (Bolivia), Environment Ministries, Universities, NGOs (Fundación Omacha, Fundación LaSalle, WWF, CI) and other Research institutes in both countries.	US$ 8.000 per survey (at least)	Medium term

Conservation initiatives and human communities

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
5	Regulation of tourism activities focused on river dolphin watching	To standardize dolphin watching protocols and to socialize them with tourist agencies	River Amazon (Brazil), Rivers Mamore and Itenez (Bolivia), River Amazon, Orinoco, Inirida and Meta (Colombia), River Amazon, Ucayali, Pacaya and Samiria (Peru) and River Napo and its tributaries (Ecuador).	WWF, WCS, Fundación Omacha, FAUNAGUA, Governments, Tourism Ministries		Short term
6	Identification, development and implementation of alternative economic initiatives encouraging river dolphin conservation as part of human wellbeing	To generate economic alternatives based on the implementation of innovative productive project in areas where anthropogenic activities are threatening river dolphins' populations and their habitats	Brazil, Peru, Bolivia, Colombia, Ecuador and Venezuela	INPA (Brazil), FAUNAGUA (Bolivia), Fundación Omacha (Colombia), Fundación La Salle (Venezuela), WWF, WCS, Universities and Research Institutes.	US$15.000 at least per project	Short term
7	Implementation of best fishing practices to reduce river dolphin by catch	To formulate and implement fisheries management plans based on best practices reducing negative impacts on endangered species	In areas of all countries where a conflict between fisheries and river dolphins exists	Fisheries Authorities, Fundación Omacha, FAUNGUA, CI, WCS, Local Communities	US$ 15.000 per targeted area	Short term

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
8	Identification of priority areas for river dolphin conservation with implementation of actions and networks	To identify key areas in aquatic ecosystems suitable for the conservation and maintenance of river dolphins' populations, their preys and ecosystem processes, and to implement actions for their conservation and management	Brazil, Bolivia, Colombia (Putumayo and Caqueta Rivers), Peru, Venezuela and Ecuador	INPA (Brazil), FAUNAGUA (Bolivia), Fundación Omacha (Colombia), Fundación La Salle (Venezuela), WWF, WCS, CI, TNC, National Parks' Units, Universities and Research Institutes.	US$7.000 at least per area	
9	Definition, creation and implementation freshwater protected areas network, which include river dolphin as conservation objectives	To consolidate a freshwater protected areas network	Brazil, Bolivia, Peru, Ecuador, Colombia and Venezuela.	WDCS, Fundación Omacha (Colombia), WCS, Fundación SEAVIDA (Venezuela), INPA, WWF and National Parks' Units in every country	US$ 20.000	Long term

Education, Communication and community participation

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
10	Disseminate for the general public information on river dolphins´ distribution, threats, conservation or management initiatives ate regional scale, using internet geo databases systems	To consolidate a free online geo database platform to publicize selected relevant river dolphins' information such as distribution, threats, and conservation initiatives. To conduct training workshops related to aquatic ecosystems and river dolphins, especially for people interested on environmental education and school teachers	Brazil, Bolivia, Peru, Ecuador, Colombia and Venezuela	INPA (Brazil), FAUNAGUA (Bolivia), Fundación Omacha (Colombia), Fundación La Salle (Venezuela), WWF, WCS, CI, TNC, National Parks' Units, Universities and Research Institutes.	US$ 45.000	Short term
11	Implementation of environmental educative projects linked with productive initiatives	To implement environmental education projects linked to community development processes and productive initiatives (tourism, handicrafts, food processing, etc)	All countries	Fundación Natutama (Colombia), Fundación Omacha, WDCS, WWF, WCS, FAUNAGUA, Universities, Schools, Education Centres, local communities and other NGOs	US$ 10.000 per year	Short term

	Proposed project	Objective	Geographic location	Stakeholders	Budget	Priority
12	Develop a regional communication campaign for river dolphin conservation	To develop and implement a regional communication strategy focused on river dolphin conservation as key migratory species	All countries	WDCS, WWF, WCS, WDCS, FAUNAGUA, Fundación Omacha, Universities, Research Institutes.	US$ 50.000	

Legislation and Policy

	Proposed project	Objective	Geographic location:	Stakeholders	Budget	Priority
13	Develop a standardized protocol to assess the impact of development projects on river dolphins and their habitats	To set up a protocol to assess river dolphins' populations (abundance, densities and different behaviors) in areas where development projects are set in motion or proposed to be, and to evaluate the impact of those on the species.	Brazil, Bolivia, Ecuador, Venezuela, Putumayo River (Colombia/ Peru) and Meta River (Colombia).	WWF, Fundación Omacha (Colombia), FAUNAGUA (Bolivia), Environment Authorities, Universities, research institutes and NGOs.	US$ 10.000	Short term
14	Evaluate the legislation in each country and at regional level and propose specific regulation to conserve river dolphin populations	To legally ban the use of river dolphins as bait in specific fisheries	All countries	Government, national and international NGOs	US$ 10.000 (each country)	Medium term

Chapter 7
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Chapter 8
List of participants – Organizations (Brief summary)

The Action Plan for South American River Dolphins 2010 - 2020

List of Participants - Organizations (Brief summary)

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INSTITUTIONS INVOLVED – Brief Summary

WWF - World Wide Fund For Nature
Is one of the world's largest and most respected independent conservation organizations founded on the 11th of September 1961. WWF as a global organization acts locally through a network of over 90 offices in over 40 countries around the world which vary in their degree of autonomy.

Its mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conducting three main actions:

1. Conserving the world's biological diversity.
2. Ensuring that the use of renewable natural resources is sustainable and 3. promoting the reduction of pollution and wasteful consumption.

www.panda.org

Fundación Omacha
Is a Colombian Non Governmental Organization, with no lucrative goals and dedicated to the research and conservation of natural resources focused on the aquatic ecosystems. Omacha's job is based on the integration of the biological knowledge

generated by its researchers and the cultural knowledge of local communities. Most of the species with which the Foundation works are under a threatened category. Omacha's Action Plan involves three main lines of action: Biological and Ecological Research, Social encouragement and support to productive projects and Environmental Education and disclosure.

www.omacha.org

SOLAMAC - Sociedad Latino Americana de Especialistas en Mamíferos Acuáticos
The Latin American Society on Aquatic Mammals, was founded on the 28th of October 1994. The Society has a scientific character and it does not follow lucrative goals. Its objectives are: 1. To promote the scientific research on different species of aquatic mammals in Latin America. 2. To spread scientific knowledge about the different species of aquatic mammals, through the release of an informative bulletin, scientific meetings and in the future a Scientific Journal. 3. To give scientific opinion when it is necessary and to advise on topics related to these species and the environmental problems affecting the region. 4. To promote the knowledge about aquatic mammals in the mainstream of all South American countries and finally to be a space to reflect on the ethic and cultural aspects involved in the conservation of aquatic mammals.

www.solamac.org

WDCS the Whale and Dolphin Conservation Society
It is the world's most active charity dedicated to the conservation and welfare of all whales, dolphins and porpoises.

Established in 1987, WDCS is staffed by over 70 people, along with many volunteers, located in its offices in Argentina, Australia, Austria, Germany, the UK and the US. This team of people is dedicated and determined to do their best for the animals and proud of the fact that WDCS's operating costs are kept to a minimum. The money raised is spent on urgent conservation, research and education projects that really do make a difference to the daily lives and long-term security of thousands of whales, dolphins and porpoises around the world.

WDCS work is divided into three main areas:

1. WDCS shared purpose and compassion defends these remarkable animals against many dangers - whaling, dolphin hunts, fisheries bycatch, captivity, chemical and noise pollution, climate change and ship strikes. This Institution brings individuals and groups together to create strong local, national and international campaigns to stop these threats. It also engages with international conventions, national governments, other conservation organizations and local communities.

2. WDCS recognizes the needs of individual animals, as well as groups of whales and dolphins. Working with local communities, defend the animals at risk and the places and conditions they need to survive.

   This year alone they have been funding 32 conservation and science projects, spanning 25 countries. On an international scale, determination and diplomacy creates agreements between governments which can address multiple threats and protect species across their entire ranges. 'Action Plans' to address the threats ensure these agreements make a real difference.

3. Through the media, events, exhibitions, visitor centres, websites and more, WDCS spreads the word about the need to protect these incredible animals. And with offices worldwide and an international network of consultants and projects this Foundation's reach is truly global. Locally, education and awareness-raising initiatives range from talking to school children to training educators and whale-watch operators.

www.wdcs.org

WCS - The Wildlife Conservation Society
Founded in 1895, has the clear mission to save wildlife and wild places across the globe. Our story began in the early 1900's when we successfully helped the American bison recover on the Western Plains. With a commitment to protect 25 percent of the world's biodiversity, this institution addresses four of the biggest issues facing wildlife and wild places: climate change; natural resource exploitation; the connection between wildlife health and human health; and the sustainable development of human livelihoods. WCS currently manages about 500 conservation projects in more than 60 countries. While taking on these issues, they also manage more than 200 million acres of protected lands around the world, with more than 200 scientists as staff.

www.wcs.org

FAUNAGUA
Is a Bolivian Association created in 2004 as a Non Governmental Organization with no lucrative goals. Since it was founded, Faunagua has been conducting projects orientated to development within the general framework of the conservation and management of freshwater recourses and wetlands of Bolivia. Faunagua seeks the following objectives:

1. To promote the reconciliation between conservation and development through the sustainable, social, economic and ecologic management of freshwater resources.

2. To promote the access and sustainable use of the freshwater and fish resources with equity, justice and social involvement.

3. To consider the water as a common resource and a social right to overcome poverty.

4. To respect the local knowledge, its structures, dynamics, social rhythms and customs.

www.faunagua.org

Fundación La Salle de Ciencias Naturales
Is a Venezuelan Institution with no lucrative goals and dedicated to grant technical education to develop scientific research related to the natural and social sciences of Venezuela and to transfer to local communities and related, the necessary tools to conduct extension and production programmes that promote its self-development.

www.fundacionlasalle.org.ve

The Whitley Fund for Nature (WFN)
Is a UK registered charity offering a range of Awards and grants to outstanding nature conservationists around the world. WFN locates and recognizes some of the world's most dynamic conservation leaders and support projects founded on good science, community involvement and pragmatism.

Through a process of reference, application and interview, WFN identifies effective national and regional conservation leaders and celebrates them through Whitley Awards, now amongst the most high profile of conservation prizes. Of the Whitley Award winners selected each year, one recipient goes on to also win the prestigious Gold Award, worth an additional £30,000.

WFN aims to provide support throughout the career path of a conservationist. As part of the Whitley Award application process, we offer Associate Awards - small to medium sized grants of up to £10,000 - to team leaders who, though not yet advanced enough to win a full Whitley Award, show outstanding promise.

www.whitleyaward.org

INPA Intituto Nacional de Pesquisas da Amazônia or National Institute of Amazonian Research (Brazil)

Was created in1952 and implemented in1954. This Institute has been conducting scientific research on the environment and the life conditions of the Amazon Region to promote humane welfare and its sustainable socio economic development. Currently, the INPA is a worldwide reference in Tropical Biology.

It is part of the Brazilian Ministry of Science and Technology. This Institute's mission is to generate and spread knowledge and technology and to train human resources for the regional development.

To reach this goal, the Institute conducts research on the following areas: Botanic, Aquatic Biology, Ecology, Aquaculture, Food Technology, Health Sciences, Forest's Products, Natural Products, Entomology, Agronomic Sciences, Climate and aquatic resources and Human and Social Sciences.

www.inpa.gov.br

IUCN/SCG – the International Union for Conservation of Nature/Cetacean Specialist Group

The IUCN, helps the world find pragmatic solutions to our most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice.

IUCN is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries.

IUCN's work is supported by more than 1,000 professional staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world. The Union's headquarters are located in Gland, near Geneva, Switzerland.

Since the 1960s, the **Cetacean Specialist Group** (CSG) has played a major role in identifying problems of conservation of the world's dolphins, whales and porpoises, and brokering approaches to their solution. Some progress has been made in cetacean conservation, but grave threats to the continued existence of many species still exist and some are worsening. The global situation is outlined in Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans produced by the group in 2003 and published by SSC (Species Survival Commission). This provides scientific information about the current status of cetaceans worldwide; identifies threats to their survival, and recommends specific conservation actions.

Providing expert advice for science-based conservation, the Group has made a substantial contribution towards establishing and promoting critical priorities. It is proud of its achievements but also recognizes that its role is really only the first step, and that cetacean conservation depends on the efforts of governments, NGOs, and local communities to take the conservation process to the next level of saving species and populations. Collaborations between the CSG and other groups are essential if progress is to be made. The Group has over 75 members worldwide contributing significant experience and expertise to the growing pool of knowledge about cetaceans.

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