save the gharial in the Chambal and North India are as follows:

i) The permanence of political support for gharial and biodiversity conservation in any protected area cannot be taken for granted as the conservation concept still remains detached from the socio-economic aspirations of the common people.
ii) The characteristics of dispersal/migration of younger age/size classes of gharial are such that the success rate of supplementation of captive reared gharial within any localized river stretch is low, necessitating protracted and sustained supplementation to successfully restore populations.
iii) Gharials do not become permanent residents of unprotected river stretches where there is conflict and disturbance due to people.
iv) The biotic pressures on gharial are increasing at rapid rates exacerbating the complexities and dimensions of the problem of gharial conservation.

In view of the political mutability of India, any strategy to conserve the gharial should therefore be independent of anticipated permanent and sustained political support for its implementation. The following strategy is proposed for international adoption and support to save the gharial from extinction and guarantee its demographic health.

Continual and Definite Monitoring of all Surviving Gharial Populations

As seen in the Chambal, gharial population declines can be quite rapid. So, there is the need for continually updated accurate information on the status of all surviving gharial populations. So far, this information has been available due to efforts of a few devoted workers who appreciate the significance of scientific population monitoring. But this is not yet an institutional activity undertaken by the main agencies responsible for gharial conservation in the Chambal viz. the state Forest Departments. The practice of survey and census at regular intervals along with all financial and other support to conduct these requires to be ensured, so that status of different gharial populations is monitored without break and gharial population reductions become known at the earliest.

Extension of Gharial Population Restoration through Head Start Programs, in all Existing Parks with the Potential for Population Restorations

Presently, apart from the Chambal River, only the Girwa River in the Katerniaghat Sanctuary in northern Uttar Pradesh and the Ramganga River in the Corbett National Park in the state of Uttaranchal has breeding populations of gharial. Of these two populations, the Katerniaghat WLS encompasses a river section less than 5 km in length that forms prime gharial habitat. In nearly three decades, this population has not been observed to expand and colonize adjacent river sections. As such, the Girwa River in the sanctuary is a fragile and vulnerable gharial habitat where long-term conservation does not appear to be viable. Precise information about the breeding status of the Ramganga population is not available and the extent of prime gharial habitat is also believed to be extremely limited. Considering therefore, the immensity and complexity of the problems faced by the Chambal sanctuary a worst case scenario exists in which, wild gharial populations can once again decline to the level of extirpation or critical endangerment as had occurred in 1975 if conditions in this sanctuary continue to deteriorate.

A safeguard against such a situation needs to be developed by restoring the gharial populations in the two other potential gharial conservation areas, viz. the Ken and the Sone Rivers, to breeding status. Both these areas have been legally protected for over a decade or more but it has not been possible to restore their populations to breeding status (Sharma, unpublished information). This is mainly due to lack of sustained supplementation of the population with captive reared gharial. In this respect the Sone Sanctuary notified in 1981, which includes a section of the Sone River some 200 km in length and some prime gharial habitat, has the best potential for consolidated population restoration. The Ken Sanctuary, which is much smaller than the Sone and includes a relatively small river section comprising prime gharial habitat, presents a situation like the Girwa River in the Katerniaghat Sanctuary already mentioned, but considering the precarious situation confronted by the species every opportunity for developing buffer populations should be exploited to the maximum. Potential gharial conservation areas in other states such as Assam and in northeastern India and West Bengal where reintroductions of gharial in former habitats have been attempted also need to be vigorously followed up. Husbandry know-how for the captive rearing of gharial exists in north India and may be used to extend ex-situ operations wherever necessary.

Sustained Research on Dispersal and Migration of Gharial and Refinements of Supplementation Techniques

Because of the linear nature of gharial habitats the species, especially the younger size classes that are used in

supplementation programs, are disposed to rapid and extensive emigration that is believed to occur pre-dominantly in the down stream direction. However, there have been almost no sustained studies of the phenomenon by either mark-recapture or telemetric methods that will facilitate refinement of supplementation techniques and aid higher retention rate of released animals in sanctuaries. Many aspects of gharial biology and ecology remain largely unknown and research is required to acquire more elaborate knowledge of these as well.

Research on River Water Management and Impact of Water Abstraction

The impact of water abstraction needs quantification and study to determine the extent and rate of habitat degradation. Also the potential and implications of rainwater harvesting and storage in the Chambal catchment may be a potential solution to prevent the ultimate inhabitability of the river for gharial. This information is also extremely important for all gharial conservation areas.

Research on Environmental Impact of Different Biotic Pressures on the Chambal River as well as other Gharial Habitats and Conservation Areas

Such research is required for making management decisions that are not arbitrary and therefore do not lead to avoidable conflict with human populations residing in or on the periphery of gharial conservation areas.

Innovative Eco-Development to Raise Standards of Living of Imporetant Target Groups of Local Residents and Eliminate their Dependence on Natural Resources required for Gharial Conservation

Eco-development is a key tool for reducing dependence of stakeholders residing in and around core gharial conservation areas on resources occurring in gharial habitats. Eco-development has not yet been an unqualified success where experimentally initiated but the impedimental problems can be identified and solved if the implementing agencies are adequately motivated have the required resources at their disposal.

Sustained and Adequate Awareness Campaigns for Different Target Groups and Stakeholders in Resources Required for Conservation of Gharial

Although the effectiveness and feasibility of awareness programs may be questioned, it is vital that every north Indian stakeholder know about the highly endangered state of the gharial and appreciates the participatory role that has to be played in conserving this species. So far efforts at increasing awareness about these issues have been opportunistic, sporadic and grossly inadequate at best. There is need to carry out a well planned, well designed campaign using all potential, formal as well as non-formal media to achieve this, and of sustaining the campaign until this has been achieved.

Mobilization of Resources to Achieve the Above

Very little financial resources, either indigenous or foreign have been forthcoming to support conservation of gharial unlike that made available for charismatic mammalian wildlife like the tiger. The quantum of funds required to exhaustively implement all the above strategies in letter and spirit, will probably require international financial assistance. Even if the international community shows willingness to contribute the necessary resources, the modalities of this assistance will require a great amount of careful consideration and reflection by both the donors and the acceptors and should have foolproof safeguards to ensure that the resources are efficiently and effectively utilized.

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Progress in India and Bangladesh

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Up until the 1970s, the three crocodilians of South Asia were seriously endangered, with main causes being the killing of animals for skins and meat, eating of their eggs, and the loss of habitat. In India the GOI/FAO/UNDP Crocodile Conservation Project, the Madras Crocodile Bank Trust, and State Forest Departments reversed this decline. However, after showing so much promise in its initial stages with the creation of crocodile sanctuaries and the release of over 9000 gharial, saltwater crocodiles and mugger, the project has grinded to a standstill as the Central Government has withdrawn support for crocodile conservation … a shame after so much has been achieved. Of critical importance is the situation of the gharial in the Chambal River, with a 50% decline in numbers from the last survey done in 1996. There is the emerging seriousness of crocodile/human conflict, with people being killed in Gujarat, Kerala, and Rajasthan by mugger, and at least one person a year by saltwater crocodiles in Bhirarkanika. With regards to Bangladesh, a proposal for commercial farming of saltwater crocodiles (imported from Malaysia) has recently met with approval. The Madras Crocodile Bank will be supplying mugger crocodiles as founder stock for a captive breeding program for future re-introduction into the wild.

Status of Crocodilians in South America

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The South American continent has the greatest diversity of crocodilians: 8 (35%) of the world's 23 recognised species (Ross 1998; Table 1). The status of each species differs (Table 2). All 8 species are listed under CITES Appendix I or II, but only 3 are listed in the latest IUCN Red List (IUCN 2003).

In general all species are well studied in each country (Velasco 2000; Velasco and De Sola 2000; Velasco and Denis 2002) covering abundance, size classes, reproduction, genetics, nutrition, adaptability to captive breeding, incubation, growth in captivity, reintroduction, mark and recapture programs, human-crocodile interactions and management programs.

Table 1. South American countries containing crocodilians.

Species	Countries
Caiman crocodilus	Brazil, Colombia, Ecuador, Guyana, French Guinea, Peru, Suriname, Venezuela
Caiman yacare	Argentina, Brazil, Bolivia, Paraguay
Caiman latirostris	Argentina, Brazil, Bolivia, Paraguay, Uruguay
Melanosuchus niger	Bolivia, Brazil, Colombia, Ecuador, French Guinea, Guyana, Peru
Paleosuchus palpebrosus	Bolivia, Brazil, Colombia, Ecuador, French Guinea, Guyana, Paraguay, Peru, Suriname, Venezuela
Paleosuchus trigonatus	Bolivia, Brazil, Colombia, Ecuador, French Guinea, Guyana, Peru, Suriname, Venezuela
Crocodylus acutus	Colombia, Ecuador, Peru, Venezuela
Crocodylus intermedius	Colombia, Venezuela

Table 2. IUCN and CITES species status.

Species	IUCN Red List	CITES
Caiman crocodilus	Not listed (LC, Least Concern)	Appendix II, except *C. c. apaporiensis* - Appendix I
Caiman yacare	Not Listed (LC, Least Concern)	Appendix II
Caiman latirostris	Not Listed (LC, Least Concern)	Appendix II (ranching) in Argentina Appendix I in all other countries
Melanosuchus niger	LR/cd (Low Risk: Conservation Dependent)	Appendix II (ranching) in Ecuador subject to quota since 1997, Appendix I in all other countries
Paleosuchus palpebrosus	Not Listed (LC, Least Concern)	Appendix II
Paleosuchus trigonatus	Not Listed (LC, Least Concern)	Appendix II
Crocodylus acutus	VU A1ac (Vulnerable)	Appendix I
Crocodylus intermedius	CR A1c C2a (Critically Endangered)	Appendix I

Some species support sustainable use programs, such as wild harvest in Bolivia (Velasco 1998), Guyana, Paraguay and Venezuela (Velasco and De Sola 1999) with *Caiman crocodilus* and *Caiman yacare*. Other species have ranching programs, for example *Caiman latirostris* in Argentina (Larriera 1998, 2002) and *Melanosuchus niger* in Ecuador.

The other crocodilian species are subject to conservation programs. These are summarised by species and country.

Melanosuchus niger

With this species the situation is very interesting. On one side all international institutions agree with the IUCN and CITES classification (Low Risk: Conservation Dependent and Appendix I). But we found the species listed on Appendix II for ranching purposes in Ecuador with zero commercial quota.

In Bolivia, we found an unofficial commercial program where jail prisoners in Trinidad City, produce handmade belly skins and other products. In Brazil, principally Amazonia, Da Silveira and Thorbjarnarson (1999) report that the species is subject to harvest for meat consumption in great quantities.

Da Silveira (2001) published his PhD dissertation which proposed a sustainable use program for *M. niger* in two different areas in Brazil (Archipelago of the Anavilhanas Ecological Station and in the Mamirauá Sustainable Development Reserve, located in the Amazonas State) after 10 years of studies demonstrated an excellent population.

In the Colombian Amazonia region, a national management and conservation program is being considered, which in the short-term would change the status of the *M. niger* from endangered to vulnerable, and in the long-term transfer it to a category of low concern. The framework for the program is based on the Treaty of Amazon Cooperation TCA (1997) and the Colombo-Peruvian Plan for the integral development of the basin of the river Putumayo PPCP (1998). The plan involves indigenous communities that inhabit the region directly into the management process so that sustainable use of the species is achieved.

Crocodylus acutus

We found different management programs in South America. For example, Peru implemented a captive breeding program in Tumbes region. In Colombia we found two lines of work, one of captive breeding activities supported by the government with the goals to implement farms in sustainable use programmes and reintroduce crocs to wildlife. Two *C. acutus* farms are presently registered by CITES in commercial phase and another one is in the process of being registered. The Ministerio del Ambiente, Vivienda y Desarrollo Territorial have designed a National Conservation Plan for the species that includes reintroduction programs and sustainable use linked with captive breeding activities.

In Venezuela *C. acutus* have been subject to a National Action Plan since 1995 (Velasco *et al.* 2000), that includes several components:

- Populations survey
- Captive breeding and ranching
- Reintroduction
- Monitoring

One of the most important results of this program has been restocking the wild population (Velasco and Lander 1998), where it was demonstrated that released crocodiles had adapted perfectly after a year's evaluation.

By 2003 Venezuela had released 429 *C. acutus* in wild habitats (Table 3), principally in protected areas by the Ministry of Environmental and Natural Resources (MARN) such as Wildlife Refuges.

In 2002 the Universidad Central de Venezuela, through the Faculty of Science, Coordination of Extension, evaluated the natural populations of *C. acutus* to determine the abundance, size structure, and available occupied and potential habitats. The goal was to propose reintroduction areas for the species. In total 23 locations were visited inside the historical distribution area.

In 2003 this National Action Plan was subject to an update by the Biodiversity National Office of the Ministry of Environmental and Natural Resources (MARN), where the original goal "*recovering the wildlife population through collecting eggs to breeding and reintroducing the juveniles"* was consolidated (MARN 2003).

Table 3. Numbers of *Crocodylus acutus* released by year and place.

Year	Cuare Wildlife Refuge	Los Olivitos Wildlife Refuge	Turiamo Bay	Játira-Tacarigua Dam	Pueblo Viejo Dam	Tucurere Wildlife Refuge	Del Banco Lagoon	Total
1986				23				**23**
1987					9			**9**
1991				29				**29**
1992				16				**16**
1993							2	**2**
1995	48		15					**63**
1996	22			19				**41**
1997	41							**41**
1998		32	1					**33**
1999	33	11	5					**49**
2000	29							**29**
2001	23							**23**
2002	46							**46**
2003						25		**25**
Total	**242**	**43**	**21**	**87**	**9**	**25**	**2**	**429**

The actions planned to achieve this goal, are:

1. Populations surveys.
2. Collecting nests from the wild.
3. Increasing the number of farms and captive breeding facilities.
4. Releasing and/or reintroducing crocodiles to the wild.
5. Monitoring.
6. Evaluating the species status for CITES.
7. International cooperation.

Crocodylus intermedius

This species is one of most endangered in the world, found only in Colombia and Venezuela. Colombia classified the species as critically endangered in 1997 and designed a national plan for its recuperation and conservation (MA 2002). Based on the studies done between 1994 and 1997, a population of around 250 individuals was found in 70% of the natural area of distribution (Rodríguez 2000).

This national plan has a general goal "*to prevent the extinction and to promote their recovery in the natural area of distribution.*" The specific goal is to increase the population in 10 years by 50% in 500 km^2 and have a population around 2500 adults in the wild (MA 2002).

To achieve these goals, Colombia will implement the following actions:

1. Recovery of eggs and hatchlings from the wild.
2. Building 1200 m^2 of infrastructure to breed 2500 individuals.
3. Identify habits for reintroduction.
4. Define a reintroduction protocol.
5. Monitoring the reintroducted populations.
6. International cooperation.

In Venezuela the situation is better, the most recent studies reporting recovering populations in different natural habitats (Seijas and Chavez 2000; Llobet 2002; Seijas *et al.* 2002).

Table 4. Numbers of *Crocodylus intermedius* released by year and place.

Year	Caño Guaritico Wildlife Refuge	Capanaparo Cinaruco National Park	Aguaro-Guariquito National Park	Arrau Wildlife Refuge	El Cedral Ranch	Tucupido Dam	Cojedes River	Manapire River	Total
1990	30								**30**
1991	56	13							**69**
1992	99	258				18			**375**
1993	247	197			4				**448**
1994	62		30						**92**
1995	128		69				19		**216**
1996			76						**76**
1997	10		43						**53**
1998	250				15				**265**
1999	168								**168**
2000	248				10				**258**
2001	179	54	160		40			20	**453**
2002	37		298					10	**345**
2003	185		111	166				84	**546**
Total	**1699**	**522**	**787**	**166**	**69**	**18**	**19**	**114**	**3394**

In 1993 Fudena together with several institutions and scientists developed an Action Plan for the recovery of *C. intermedius* populations. In the following year Profauna (1994) of MARN designed a Strategic Plan with the same goal, but introducing action in the short time.

In 1990 the *C. intermedius* reintroduction program began (Velasco 1999) and to date has released 3394 crocodiles into the wild (Table 4), principally in Wildlife Refuges (2) and National Parks (2).

One of the best results of the reintroduction program occurred in the Caño Guaritico Wildlife Refuge, a natural habitat of the species but prior to 1990 no *C. intermedius* were found. In 1997 the first nest from reintroduced crocodiles was found. El Frío ranch established the first ranching program with the species (Ayarzagüena, pers. com.) where eggs were collected from the Wildlife Refuge.

In 2001 a Bi-National Workshop was held between Colombia and Venezuela to coordinate the conservation programs between both countries. Meetings between CITES Administrative Authorities began in 2003 to design the best manner of collaboration to recover the populations (Velasco 2001).

However, Seijas (2000, 2003) published two papers evaluating the status of the Program for the Conservation of the Orinoco caiman in Venezuela. The author believed that many of the original goals are compliment, is necessary "*redefine the goals and strategies in order to achieve the recovery of the species.*"

In 2003 this Conservation program was subject to an update by the Biodiversity National Office of the Ministry of Environmental and Natural Resources (MARN), where the original goal "*recovering the wildlife population through collecting eggs to breeding and reintroducing the juveniles"* was consolidated (MARN 2003).

The actions planned to achieve this goal, are:

1. Collecting eggs from the wild.
2. Increasing the number of farms and captive breeding facilities.
3. Releasing and/or reintroducing crocodiles to the wild.
4. Evaluating the species status for CITES.
5. International cooperation.

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The Management of *Caiman yacare* in Range States (Argentina, Bolivia, Brazil, Paraguay)

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The yacare (*Caiman yacare* or *Caiman crocodilus yacare*) is a small crocodilian found in four countries in South America; Brazil, Argentina, Paraguay and Bolivia. The species is abundant and widely distributed in all kinds of water bodies [lakes, rivers, swamps, wet savanas (Pantanal)]. The species was exploited heavily for leather during the 1960s and 1970s but by 1990 a combination of national legislation and CITES regulations reduced legal trade. The species continues to be exploited for meat for local use and a continuing trade in illegal skins is alleged, but difficult to verify.

Caiman yacare is listed in Appendix II of CITES and as threatened under the U.S. Fish and Wildlife Service. Even though this species is not listed within the IUCN Red List of Threatened Animals, and according to the Status Survey and Conservation Action Plan (1998), is a low risk and minimum concern species.

In Brazil the only authorized exploitation it is based on ranching, mostly in the Pantanal region. In Argentina, even thought there is one project for the utilization of the species through a hunting program, the only current utilization is also by ranching and as a complement of *Caiman latirostris* ranching operations. On the other hand, Paraguay and Bolivia's programs are fully based on hunting and despite the fact that apparently there is no risk for the wild populations, they clearly need further strengthening, mainly at the institutional level and general communication among stakeholders.

During the Caiman Management Program Evaluation in Paraguay (October 2001), and the Workshop for the Caiman Sustainable Use National Program Evaluation in Bolivia (April 2002), the general agreement was that populations of *C. yacare* in Bolivia and Paraguay are in good state in their major areas of distribution; however, lack of communication among the different sectors involved and lack of information by users with respect to the aim and changing technical aspects of the program were recognized as serious problems.

Finally, a workshop was held 3-5 October 2002 in Gainesville, Florida, USA, to discuss management, conservation and trade in *Caiman yacare*. Twenty-five official participants represented the four yacare Range States (Argentina, Bolivia, Brazil, Paraguay), Venezuela, USA, the meeting sponsors (US Fish and Wildlife Service, CITES Secretariat, Louisiana Fur and Alligator Council), TRAFFIC South America and the Crocodile Specialist Group. The recommendations of this workshop are still in the implementation process.

Status of *Crocodylus porosus* and *Crocodylus novaeguineae* Conservation and Management in Papua New Guinea (1981-2004)

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Abstract

Following the non-conduct of the *C. porosus* survey since 1998 and *C. novaeguineae* survey since 1999, the overall management program was under scrutiny by CITES and the CSG in terms of the PNG Governments efforts, through its Management Authority the Department of Environment and Conservation to sustain this highly technical component of the monitoring program. Scientifically, economically, socially and culturally, PNG has an obligation to justify the dispensation that was agreed to in Costa Rica in 1979 to ensure that regular monitoring is being implemented to assess the effects of harvesting of both the species from the wild.

The Department was able to raise support for funding to be able to conduct both the *C. porosus* and *C. novaeguineae* surveys in 2003 and the *C. porosus* survey in 2004. Although there is missing data in the previous years due to the non-conduct of the surveys because of the limited funding support from the Government, the results from both the surveys indicate that the wild population densities of both species are healthy rather than declining. This may suggest that the increased awareness in habitat conservation and the value added incentives being derived from the resource through the 12 year *C. porosus* egg harvest program is being practiced at the community level.

However, from the trade data figures the number of skins exported from the wild excluding the ranched skins from Mainland Holdings have been consistent for the last 7 years since 1997 at approximately 25,000-30,000 skins annually. Thus, the status of the PNG population level in terms of wild harvests is considered viable for the current dispensation to enable the commercial exploitation to continue.

Introduction

The two species of crocodiles occurring in Papua New Guinea (Fig. 1) are the endemic New Guinea freshwater crocodile *Crocodylus novaeguineae* and the Indo-Pacific saltwater crocodile *Crocodylus porosus*. Their habitats extends throughout most of the lowlands of the main island of PNG landmass, with *C. porosus,* the only species occurring on the offshore larger islands.

There is some evidence that the central cordillera has effectively isolated the north and south populations in PNG; giving rise to distinct populations perhaps enough to merit subspecies classifications (Cox 1984, cited in Frazier 1988), however, no actual work has been carried out to confirm this report. Although the species share a similar geographical distribution, it can be generalized that there are more *C. porosus* in the coastal populations and more *C. novaeguineae* in the upper river systems of the Sepik, Ramu, Fly and Kikori/Purari catchment systems and isolated swamps and channels as most of the crocodiles harvested are freshwater crocodile skins that forms the majority of skins exported from PNG.

This paper discusses the significance of the implementation of the monitoring program, management and the commercial trade in compliance with the CITES and CSG requirements being implemented by the Government of PNG through the Management Authority, which is the Department of Environment and Conservation (DEC). The integral part of this program was to carry out research and monitor both the species during their peak nesting seasons and assess the effects of harvesting on the wild populations through trade, and to get the understanding needed to make adjustments and corrective decisions on the commercial trade. We are not able to provide a representative indication of the wild population throughout the country due to the major factor in funding and logistical support requirements by the Government. However, the extrapolation of the annual data from the Sepik survey with the long-term monitoring data has been presented as the indicator for the PNG situation. Both the PNG species are currently listed under Appendix II of CITES since the dispensation that was granted at the Contracting Parties of the CITES Convention meeting in Costa Rica in 1979.

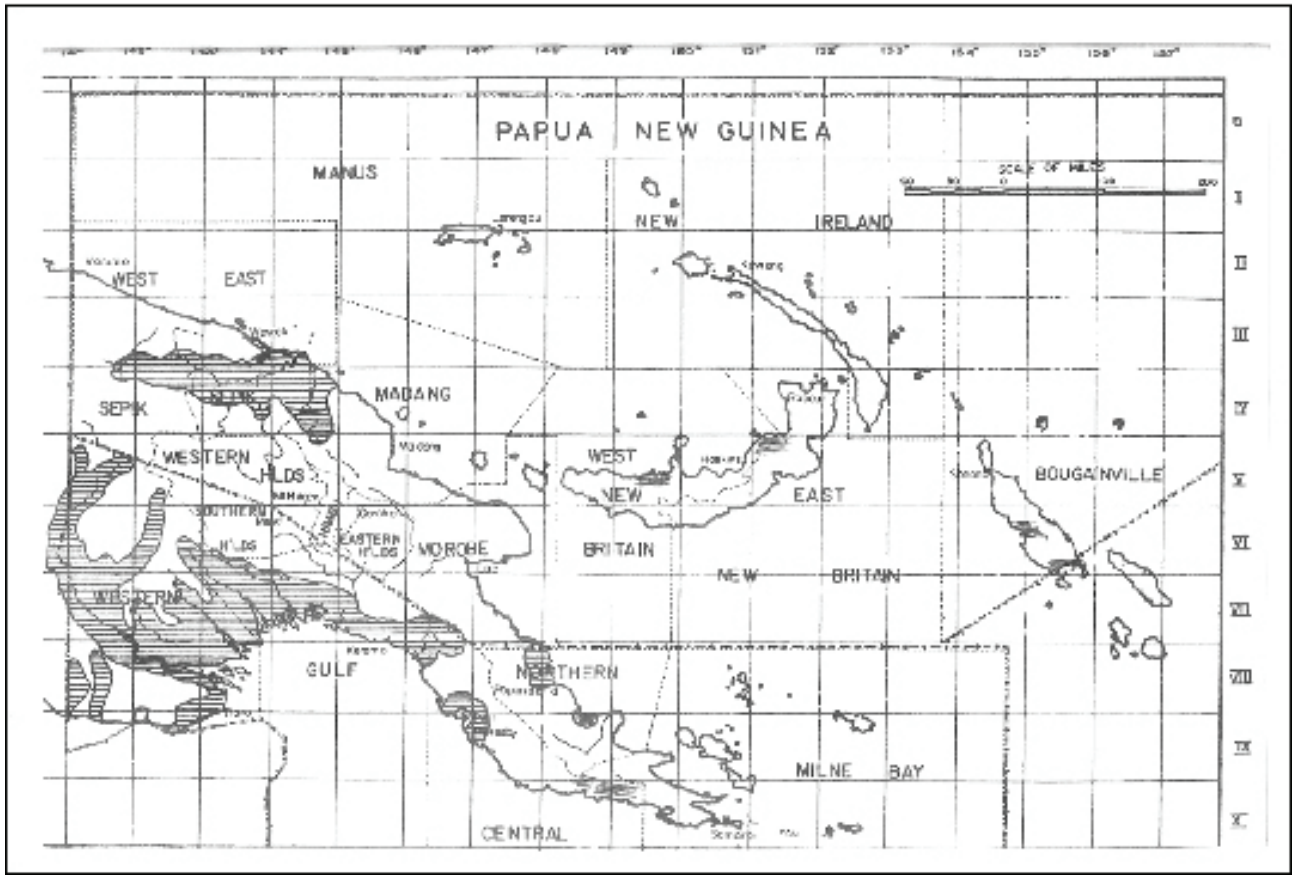

Figure 1. PNG map indicating the major areas of alluvial riverine plains, swamps and tidal swamps containing crocodile abundance. *C. porosus* also exists on the estuaries and tidal swamps of the offshore islands from the mainland. (Map: DASF Wildlife Manual 1975).

The Management Program in PNG

Since the mid-1960s Papua New Guinea's populations of *C. porosus* and *C. novaeguineae* have been actively managed to improve the biological efficiency of harvesting. In recognition of the significance of the commercial aspects of the industry and the exploitation and conservation of the wild populations, this led to the development of a legal frame work in 1966 and the enactment of the legislation as the Crocodile Trade (Protection) Act, Chapter 213 in 1969 and later amendments were made in 1974, 1982, and 1986 and recently in 2003 some amendments are now submitted to the National Executive Council (NEC) for approval and gazettal. There are thirteen regulations under the Act, dealing with control over licensing, buying, farming and exporting. Other components of the enforcement in facilitating the regulation of the industry; included relevant sections of the Fauna (Protection) and Control Act, Chapter 154, International Trade in (Fauna and Flora) Act, Chapter No. 391 and general customs regulations under the Customs Act, Chapter No. 101, and Customs Tariff (Exports) Act, Chapter No. 103.

The significant component of management retained to date by the National Government through the Management Authority are the enforcement of regulations and monitoring of the wild crocodile populations, with the exception of extension services being devolved to the Provincial Governments to be implemented by the Division of Primary Industry's (DPI) under the Government's reforms policy for the rural sectors. PNG has a population of 5 million people and a third of the population live in the major wetland and the mangrove estuaries. The communities living in the wetlands are subsistence farmers and depend on the crocodile industry through wild harvesting as a means of cash income to sustain their livelihood. The current funding that is available from the Government cannot assist to fund major interests of research and expansion of monitoring work to other areas due to the geographical isolations of remote crocodile habitat areas. The management recognizes this and has to refocus on the strategies for the future of the program on conservation and utilization in that crocodiles are generating sustainable revenue for the Government in terms of the commitment to investment on the long term monitoring efforts of the resource and the industry in general.

Monitoring Efforts of PNG's Wild Populations

Whilst, determining the wild crocodile populations in PNG is of long-term significance to the industry it has been a real challenge for many years specifically since 1994 for the crocodile monitoring officers. The program has been confronted with a lot of logistical and fiscal hurdles and sometimes with methods for accurately estimating population size that are typically evasive or difficult and expensive due to geographical locations for implementation throughout the country. Funding has been a real problem that besets the consistency in implementation and the extrapolation of the raw data from the field and in instances some surveys over the recent years were not being implemented for both crocodilian species. However, cost effective and accurate alternatives has to be derived from the existing data set (Britton *et al.* 1998), in which for the longer term we are working towards implementing the alternate procedures for this program in that the Government understands the approach that is to be implemented.

The status of the wild populations of PNG's two crocodile species have been estimated by aerial nests counts over approximately 75-80 km stretch along the Sepik floating vegetations as with the majority of the wild crocodilian populations being observed to be associated with intact habitat conditions elsewhere.

Timing of the nesting varies both between the species and within the species. In the Sepik area, *C. novaeguineae* nests during the short dry season and lays an average of 35.3 (17-51) eggs/clutch. In contrast, *C. novaeguineae* on the southern portion of the island nest during the wet season and lays only 21.7 (8-36) eggs/clutch (Hall 1983; Cox 1985; Hollands 1987 cited in Staton *et al.* 1992). Using the number of skins and animals taken from wild populations as an indicator, it can be approximated that *C. novaeguineae* out numbers *C. porosus* by a ratio of 4 or 5 to 1. From an economical standpoint, this is unfortunate as the skins of the former species are roughly 2 to 3 times more valuable that those of the latter.

The results of the survey years in this presentation highlighted the exclusion of the data that were not collected, which included; 1999-2002 for *C. porosus* (4 years) and 1997-1998, 2000-2002 for *C. novaeguineae* (5 years). The non-conduct was attributed to the down turn in the country's economy and that the allocation for this program has been difficult to secure although numerous presentations have been made to the Government. However, this has not affected the analysis and the interpretation of the data with the regression method over the longer term with the exclusion of the missing survey years.

The current program allows for the selective harvesting of wild populations within the regulations in, which skins may be taken directly from the wild, or indirectly - after animals (or eggs) originating in the wild have been reared on a farm. In Papua New Guinea a large number of people are dependent on crocodiles as the only foreseeable source of income. In view of this, and the fact that the crocodiles have never been "on the verge of extinction" PNG has adopted a highly flexible attitude in continually reviewing management options from the available knowledge from the 23 years of monitoring and utilisation of this resource.

Survey results for *C. novaeguineae* and *C. porous* populations (1981-2004)

The helicopter monitoring program for *C. novaeguineae* and *C. porosus* commenced in 1981 and 1982 respectively. The survey results as compiled to 2004 are summarised in the DEC internal reports and involves counts over 48 *C. novaeguineae* sites and 41 *C. porosus* sites. The Bell Jet Ranger-206 was hired to fly the permanent established transect lines for some sites depending on the site's configurations. Flight paths were consistent over time and that search, speed, height and recording procedures were also maintained as reported in earlier internal and external reports. Most importantly the survey personal has also been maintained over the years for the conduct and to improve cost effectiveness in these times where the costs of helicopter hourly rates are very excessive.

The raw counts on the *C. novaeguineae* and *C. porosus* nesting effort in the wetland systems through the overlays has enabled us to detect changes and to evaluate the status of specific sites in terms of habitat conditions, the use of wetland sites, interactions between species and hunting pressures. It was observed that some sites have maintained consistent number of nest between species at each sites (eg Nyngium is a saltie site that has recorded 12 nests and 15 nests in 2003 and 2004 respectively). Simultaneously for the same site the *C. novaeguineae* nests observed in 1999 and 2003 were 2 and 3 respectively. Similarly other sites that were being observed had similar trends with increases in the number of nests where the other species is not being present or where the habitat conditions do not suit the other species.

Thus, the survey results indicated in Figure 2 represent the overall nesting effort for the (N= 21) primary sites that is representative of the 48 sites that have been consistently surveyed since 1981. The trend indicated where (x = number of years the surveys were being conducted and y = nest numbers counted for each index), the data is being inferred that for the primary sites although is declining it is considered not significant as demonstrated here that there is no significant relationship between nests counts and years; (r^2= 0.056, p= 0.378). Some sites are considered as *C. porosus* nesting sites and that the dispersal of the non-aggressive species the *C. novaeguineae* through interactions with *C. porosus* is evident as reported in Manolis (1995). Thus, for this set the regression equation inferred that there is only 5.6% variation in *y*.

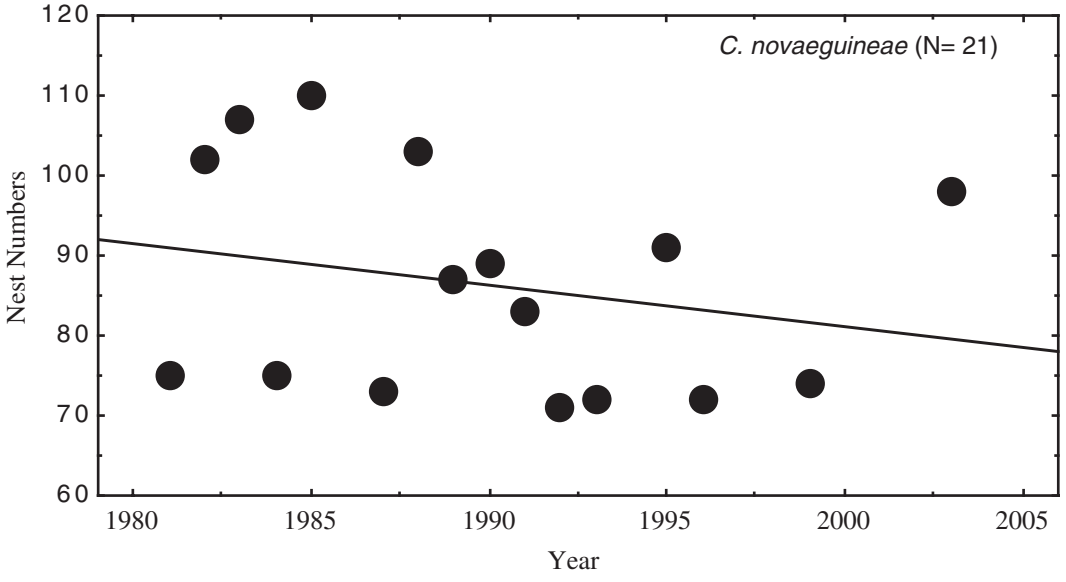

Figure 2. The trend indicating the 21 *C. novaeguineae* primary nesting sites consistently surveyed from 1981-2003.

The other subsets (N= 31) and (N= 36) (Fig. 3), are secondary sites that were consistently surveyed since 1987 and 1988 respectively. With the inclusion of 2003 results in the analysis for both subsets that have been added as the survey progresses over the years, the data rendered both the relationships to be not significant where; (r^2= 0.0046, p= 0.843 and r^2= 0.0059, p= 0.833). The survey over the years consistently replicated sites within three different habitat types (scrolls, oxbow lakes and overgrown channels) in which *C. novaeguineae* normally nest.

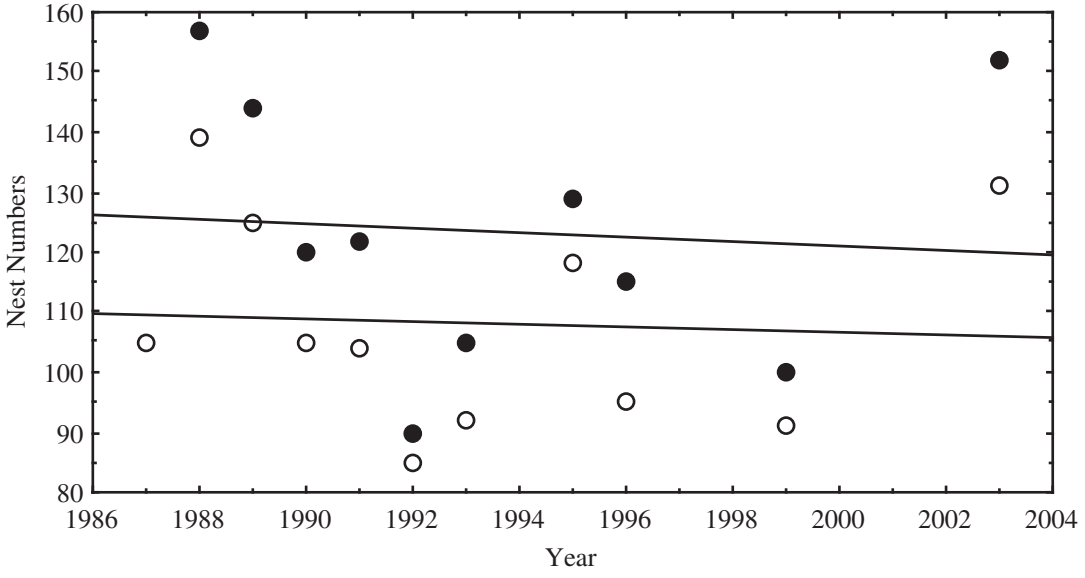

Figure 3. Secondary sites [N= 31 (open circles) and N= 36 (closed circles)] that have been surveyed consistently over the years and is representative of the 48 sites.

The *C. porosus* nesting effort (N= 12; Fig. 4) for the long-term over the survey period of 22 years in which the sites have been consistently surveyed. The current set of data were regressed from 1984 including the 2004 survey results depicted the following results where; r^2= 0.3509, p= 0.0156. Clearly with the inclusion of the 2003 and 2004 survey results the trend renders the relationship to show significant increases as against the 1998 data, which appear to reflect the extreme seasonal effects from the preceding year in 1997.

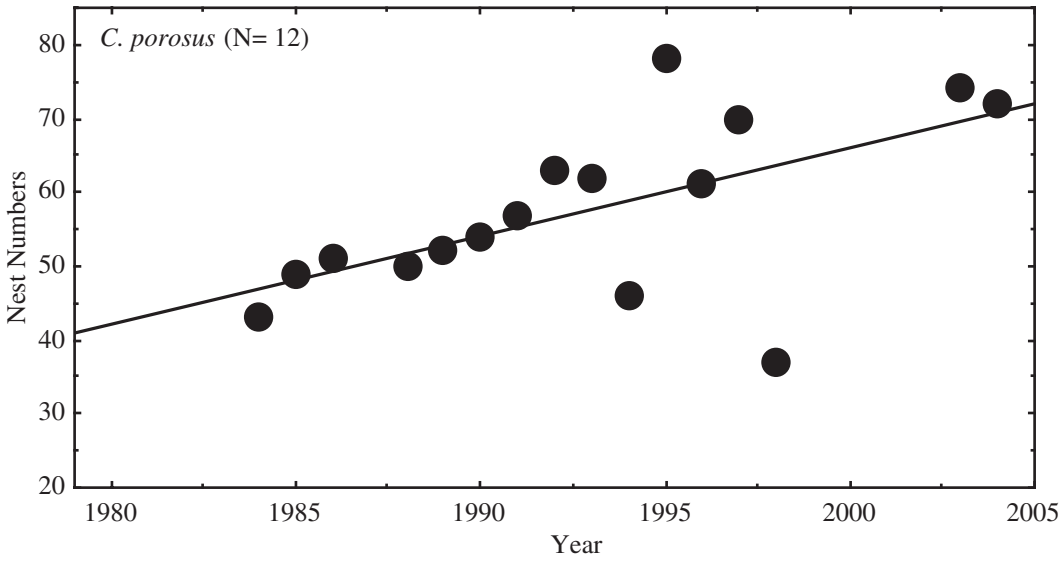

Figure 4. Regression relationship between *C. porosus* nest counts and year for the 12 primary sites that were consistently surveyed since 1984.

There was an extended 12 months of dry period (El Niño) that affected the whole country. Most of the wetlands and overland oxbows and lagoons discharged into the main Sepik River, leaving the survey sites exposed and dry where extensive burnings were evident following the 1998 survey.

Two other subsets (N= 15 sites) included in 1984 and (N= 29 sites) being added in 1988, are represented in Figure 5. When regressed both relationships exhibited significant increases in nesting effort, where; r^2= 0.3621, p= 0.0136; and r^2= 0.3038, p= 0.0508, although there were no results from the 4 years after the 1998 survey, the nesting effort is dramatically being influenced by the 1997 seasonal effects. Thus, it can be assumed that the *C. porosus* nesting effort in the wild is still healthy and that the population is still abundant for the representative sites for the species.

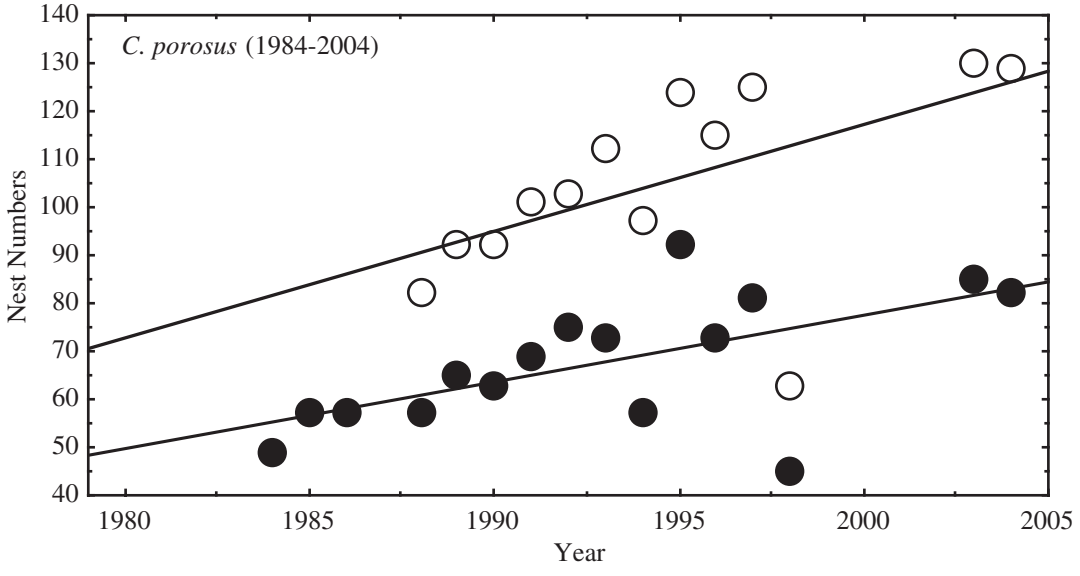

Figure 5. Regression relationships between *C. porosus* nest counts and year, for 2 subsets of data; 15 sites (closed circles) surveyed from 1984-2004 and 29 sites (open circles) surveyed from 1988-2004.

It is observed that regardless of which datasets are used for both species, when the sites are regressed with the 2004 data, the results for both species indicate that the wild populations are healthy rather than decreasing or stable nesting. The *C. novaeguineae* (N= 36) and the *C. porosus* (N= 29) nesting effort could be considered to be more representative of the whole nesting habitat in the region that is perhaps more applicable to the breeding populations as a whole for both species.

Saltwater crocodiles responded in two ways to the loss of nest sites; some apparently did not breed at all (or may have bred later in the year, but we have had no indication of this), and some moved to less disturbed, remoter, areas away from the open water. This movement is indicated by the fact that the changes that were observed in nest numbers in 1997 before the El Niño and after the El Niño, were not uniform across habitats. In the most accessible habitat, the floating mats fringing open water, there was a drop of 50%, in the numbers in overgrown oxbows and channels remained constant, and there was actually a rise in the numbers of nests in the remote scroll swales. By the following seasons (ie in 2003 and 2004) the floating mats had recovered and there was a move back to the lake fringes, with scroll nests dropping in number despite the increases in nesting, indicating such areas are only sub-optimal reserve nesting sites.

When the sites were regressed given the saltwater results they indicate there was about 20% rise in nest numbers from 1998, showing that the drop that occurred in some habitats during 1998 was mainly attributable to the temporary loss of nesting habitat and not to the killing of breeding stock. It is therefore considered reasonable to assume that both species are increasing in numbers perhaps through the recruitment of younger females in to the breeding population.

Egg Harvest Program

The conservation aspect of the crocodile management program in PNG depends heavily on the sustained utilisation of the wild resource. Some of the most successful crocodile management programs (eg Louisiana and Florida in USA, Northern Territory of Australia, Zimbabwe) rely on wild harvested eggs as the basic stock for ranching programs (Cox and Solmu 1996). The PNG program offers similar programs and presents advantages for both conservation and commercial interest, and reduces high egg mortality in the wild also requiring less hunting effort of dispersed juveniles and providing *ex situ* incubation with control over fecundity and sex.

The baseline data on the nesting biology of the two crocodilians in the Sepik, including interactions with the local communities, was provided by a preceding five year investigation (Cox 1985). Combining with the analysis of the data from the aerial nests counts in those years from 1980-1985, this knowledge of nesting parameters enabled the potential costs and benefits of eggs extraction to be gauged quantitatively. At least we were able to note that 35% of surveyed *C. porosus* and a similar proportion of *C. novaeguineae* nests in the middle Sepik were harvested for human consumption. (Hollands 1985). Reported losses through other causes are also reported in Cox and Solmu (1996) and results of the harvests over the years are presented in Table 1.

Table 1. Wild *C. porosus* eggs harvest in the Sepik Region (1985-2004). #= Nests being harvested without aerial nests counts in 2002 and cannot be quantified on % surveyed; *= Egg collections were done within survey and non survey areas.

Year	Nests Harvested	% of Nests Surveyed	Total No. of Eggs	No. of Viable Eggs	% Viable Eggs	Mean Clutch Size
1985	14	19.4	795	661	83.1	56.8
1986	17	23.9	1061	859	81.0	62.4
1988	13	16.1	793	647	81.6	61.0
1989	20	20.6	1329	1198	90.1	66.5
1990	29	29.6	1613	1324	82.1	57.6
1992	35	24.6	2066	1656	80.2	59.0
1994	29	25.4	1726	1545	89.5	59.4
1996	47	33.3	2722	2145	78.8	57.9
1998	36	47.5	1983	1591	80.2	55.08
2002#	62		3542	2772	78.3	57.13
2003	*138	*76.2	*8364	*6807	*81.4	*60.61
2004	*215	*46.5	*12,756	*10,261	*80.4	*59.3
Totals	655		38,739	31,467	81.23	59.14

As initially designed the helicopter used in conjunction with the aerial nests counts was chosen over ground transport as the means to harvests clutches. The helicopter offers the advantages of rapid conduct and control over handling and transport. Flight time devoted to harvesting would be paid for by Mainland Holdings and placement from outside the Sepik pro-rated accordingly.

The ground based harvesting with canoes was investigated in 1990 and 1992. The method was found to reduce costs and add safety compared to aerial collection, and to be more effective and applicable on a wide scale. However, with the introduction of the Sepik Wetlands Initiative program to encourage conservation of habitats with added value being placed on the eggs harvesting program, the introduction to ground harvesting was introduced in 1998 (Table 1). The impact of reducing hatchling recruitment by harvesting eggs could be expected to be detected in 51-60 cm and 61-65 cm in one or two years later.

Spotlight surveys have not been conducted within the accessible parts of all harvested areas due to capacity and logistical support problems. However, the general aim is to reduce densities and to facilitate the extraction of sustainable yields (Webb *et al.* 1989) From figures presented in Table 1, it can be noted that there is an average of 80% viable eggs being achieved from every harvest from an average of about 60 eggs per clutch. It can be inferred that the resource owner earns more from the clutch if they are viable eggs with not time spent for catching crocodiles and that there are larger and older reproductive adults in the wild.

Ground eggs harvesting was considered as a good initiative as eggs are also being harvested from non survey sites, which allow for participation by all communities to benefit from the eggs collection program. In this way a wider community support is being encouraged in terms of minimising habitat degradation through burning during extended dry periods.

We were not able to analyse the effects of sites that were harvested and sites that were unharvested, however similar studies showed no significant effects (Webb *et al.* 1989).

Taken together there were 38,739 eggs *C. porosus* collected from 655 wild nests from 1985-2004. Although most nests up to 1998 were collected within the survey area, the later harvests also collected outside of the survey area. Studies are now needed to quantify subtle or longer term effects whilst collections is still being encouraged during the nesting season to enhance habitat conservation, however, results from harvests to date are consistent with predictions of a minor impact.

In the program there were only 128 *C. novaeguineae* nests collected from 1988-1989, with a total of 4236 eggs. Due to the investment and economic decisions of Mainland Holdings and the successful existing ranching operation in PNG, it decided to abandon the *C. novaeguineae* eggs harvest program. This may have been attributed to the current world market prices affecting the *C. novaeguineae* wild skins and the return on its investment and management to collect and farm *C. novaeguineae* eggs.

Exports

Since 1981 when the International Trade in (Fauna and Flora) Act took effect, the exports of crocodilian products from PNG were regulated under the provisions of the Convention of International Trade in Endangered Species (CITES). With that regulating mechanism in place PNG has implemented enforcement activities at all levels of trade based on controlled, sustainable, and legal harvest within the limits to encourage healthy wild populations.

The trade in crocodilian skins from PNG for *C. novaeguineae* since 1983, indicated that the maximum exports was around 29,682 in 1990 and the minimum was 21,981, with the *C. porosus* at a maximum of 8150 in 1991 and a minimum of 3910 in 1986 (Luxmoore and Collins 1994). Japan still remains the number one importer of PNG wild crocodilian skins and by continually having a consistent market it is healthy for the industry to be regulated under legislation with harvests from a sustainable program that assist conservation in PNG for the long-term.

The number of skins exported from PNG for both species that included wild and ranched skins has been consistent over the years. It should be noted that the 1997 harvests recorded the largest ever export from PNG with a total of 41,683 skins, (Fig. 2) and the majority of these were wild *C. novaeguineae* skins due to the El Niño and the extensive dry spell throughout the country.

Although the graph did not indicate the category of the *C. novaeguineae* and *C. porosus* skins from ranched and wild skins, the majority of current ranched skins are *C. porosus* due to the current market forces. *C. novaeguineae* ranched skins constitute a very small proportion; the highest was in 1998 with 6211 skins and since then has declined to only 6 in 2002.

Although we do not have the capacity and the resources to provide the figures on the harvest data from the wild for juveniles and skins that have been purchased through the current regulations however, these information were submitted by all licence holders as conditions under the regulations by DEC for the renewal of licences.

PNG has consistently maintained its trade on legal, sustainable basis with the linkages of this to the conservation of wild crocodilians. Although PNG has produced a lot of *C. novaeguineae* wild skins there has been a shift in demand and emphasis on high value classic skins that is reflected by quality consumer products and this is reflected back down the chain of trade to the producers at the community level. Thus, the emphasis is now being placed on the farming and ranching of *C. porosus* skins to meet the demand and quality in the market place.

Conclusions

An indirect indication to the status in the wild population on a national level can be taken from trade statistics; it was in fact these that initially drew attention to problems of overexploitation in the 1960s. It has long been known that water levels throughout the year have a strong influence on the number of crocodiles harvested and we now know that there is also a marked correlation between the price of skins and the number exported. Due to these factors and the gradual shift towards ranching, the annual harvest totals (Fig. 2) are of little use in assessing trends in the wild population. However, the size structure of the harvest are currently being compiled to give a useful indication and that PNG is aware that both crocodiles are long lived and takes up to 10 years to reach sexual maturity for slow growing *C. novaeguineae* at 1.8-2.0 metres in length for females and 2.5 metres for males, whilst the fast growing *C. porosus* takes up to 10-15 years to reach sexual maturity at 2.2 metres for females and 2.5 metres for males. Thus, where there is a need to review the lower and the upper limits of the legal sizes of exports, the Management Authority will consult with the industry.

With the current observations from the long term monitoring data many of the nesting sites for *C. novaeguineae* are also nesting areas for *C. porosus*. Using the data from 1988, the period in which the nesting effort by *C. porosus* increased significantly, a regression analysis was carried out using the number of nests for each species in those sites where both species have nested at some time. It was observed that from 1988-2004, there was a trend although not significant is towards decreasing number of *C. novaeguineae*. Should *C. porosus* nests counts continue to increase with the current trend, it is possible that because the species is highly territorial in nature, it may prevent or exclude completely *C. novaeguineae* from nesting in areas where they currently both nest.

It is emphasised that the monitoring programme in PNG is currently in its 23rd year and the indication to date is that both species of crocodiles in Papua New Guinea are increasing in numbers. Although the cost of this highly technical component of the program is expensive due to the depreciation of the PNG Kina against the USD$, the current management programme should therefore be continued. The three surveys that have been conducted so far since 2003 has accumulated about K295,000 which is equivalent to about USD$88,500 and that the Department does not have that appropriation to facilitate for the surveys annually. However, alternative assessments in terms of the regular conduct of these surveys are being reviewed by the Management for implementation with the consideration that the program meets CITES requirements to continually monitor the species. Both species gives considerable benefit to the country, particularly to the very remote communities and that cropping should be maintained within the sustainable limits.

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Indication of Crocodile Recovery and Management Implications in Crocodile Conservation in Sabah

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Abstract

Sabah Wildlife Department (SWD) conducted crocodile surveys in 1984 and 2002. The results from the recent surveys suggest that there has been a steady recovery of the population in the last 10-15 years. There are also unsubstantiated reports of the existence of the Malaysian Gharial (*Tomistoma schlegelii*) from the Klias Peninsula (southwestern Sabah). Another indicator of the recovery has been the increase in attacks in Sabah rivers that becomes the social issue. SWD has been trying to conserve the remaining riverine habitats in Segama River by establishing conservation area to provide the habitats not only crocodiles but also other protected species, with JICA assistance. The fragmentation and agricultural development pressure especially by oil palm plantation to wetland and riverine habitats that are represented in Segama River becomes significant issues in Sabah. Moreover, not many breeding sites has been confirmed. The confirmation and conservation of the breeding sites become urgent issues in crocodile management in Sabah.

Crocodile Conservation Status and Indication of Population Recovery in Sabah

A single species of crocodilian, the Estuarine Crocodile (*Crocodylus porosus*) is recorded from the state of Sabah in Malaysian Borneo, although there are unsubstantiated reports of the existence of the Malaysian Gharial (*Tomistoma schlegelii*) from the Klias Peninsula (southwestern Sabah) and Kinabatangan River. Both species are Totally Protected Species (Schedule 1) under the Sabah Wildlife Conservation Enactment, 1997.

During a survey undertaken in 1984, a total of 56 wild crocodiles were seen along approximately 1156 km of rivers in eastern and western Sabah. Surveys in 2002 revealed 253 crocodiles along approximately 223 km of many of the same rivers, an indication that *C. porosus* populations in Sabah, have undergone significant recovery over the past 10-15 years. Another indicator of higher crocodile densities has been the increase in sightings and attacks in Sabah rivers over the past five years.

Comparison of raw densities, and those corrected based on detectability of size class (Bayliss 1987) is given in Table 1. The comparison of the 1984 surveys and those by Stuebing *et al*. (1993) with recent data indicates that the Sabah population has undergone a recovery, based on:

- A ten-fold increase in observable crocodile densities for some rivers in Sabah since 1984;
- Indications of successful reproductive effort (based on percentages of small juvenile crocodiles observed); and,
- A crocodile population currently estimated to be 13,000 to 15,000 animals, a significant portion of which appear to be mature reproductive adults.

Table 1. Estimated crocodile densities in Sabah (per km of river bank). * Whitaker's figure of 0.46/km used a formula based on Caughley (1977), which does not take into account differences in detectability based on size. ** Approximate figure, adapted from Bayliss (1987): Class 1, 0.693; Class 2, 0.735; Class 3, 0.460; EO, 0.153; Total = 505 crocodiles. Hatchling = <0.5 m total length; Class 1 = 0.5-1.0 m; Class 2 = >1.0-2.5 m; Class 3 = >2.5 m; EO = Eyes only.

Survey	Distance surveyed (km)	Class				No. of crocs sighted	Mini. relative density (per km)	Corrected relative density (per km)
		1	2	3	EO			
Whitaker 1984	1146.0	13	9	3	31	56	0.05	0.21*
Stuebing *et al*. 2002	222.8	178	29	3	31	241	1.1	2.27**

The highest densities and overall number of crocodiles are found in Sabah's largest river, the Kinabatangan, which also has the largest area of floodplain habitat. The conspicuous recovery of Sabah crocodiles is probably attributable to several factors or influences over the past two decades, including:

- Legal protection of *C. porosus* in Sabah since 1982 (Amendments to the Fauna Conservation Ordinance 1963) and subsequent conservation measures taken by the Wildlife Department (including the gazetting of the Lower Kinabatangan Wildlife Sanctuary, one of the most extensive areas of excellent *C. porosus* habitat in Sabah). Most rural residents in Sabah know crocodiles are protected by law, and illegal hunting has decline substantially.
- Decline of the timber industry, and a related decrease in habitat disturbance and river traffic.
- Siltation from land clearing or other habitat disturbances upriver, leading to the transformation of downstream sections (shallower channels, increase in broad muddy bank, changes in fish fauna), providing ecological situations favourable for colonization by *C. porosus*.
- Stabilization of oil palm estates, whose development originally caused severe ecological disturbance when large tracts of degraded forest were felled and burnt. River banks in these areas are recovered with a stable community of secondary growth including grasses and herbs used by female crocodiles for nest construction.
- Opening of extensive areas of closed canopy swamp and riverine forest, including the loss of such forest to fires during drought in 1983, 1986 and 1998, creating larger area of suitable nesting habitat ("Padang" vegetation).
- The El Niño - southern oscillation episode of 1997-98, which may have virtually eliminated a major source of crocodile mortality, the flooding of nest, during that year.
- Beginning in the early 1990s, the progressive decline of international prices for crocodile skins by more than 60% in 2001.

Although no single factor can be identified as the primary one involve in the recovery of Sabah's crocodile populations an inadvertent moratorium on hunting may have been among the most important. With time, a cohort of traditional crocodile hunter has passed on, and probably few if any of these local people, have been replaced.

Crocodile Representation in Protected Area

Sabah Parks, Wildlife Sanctuaries and other types of conservation reserves cover a broad range of habitats, including the riverine, freshwater swamp and mangrove areas inhabited by *C. porosus*. The protected areas in Sabah are shown in Figure 1. Though the breeding has not confirmed, the only three small protected areas contain significant areas of crocodile habitat:

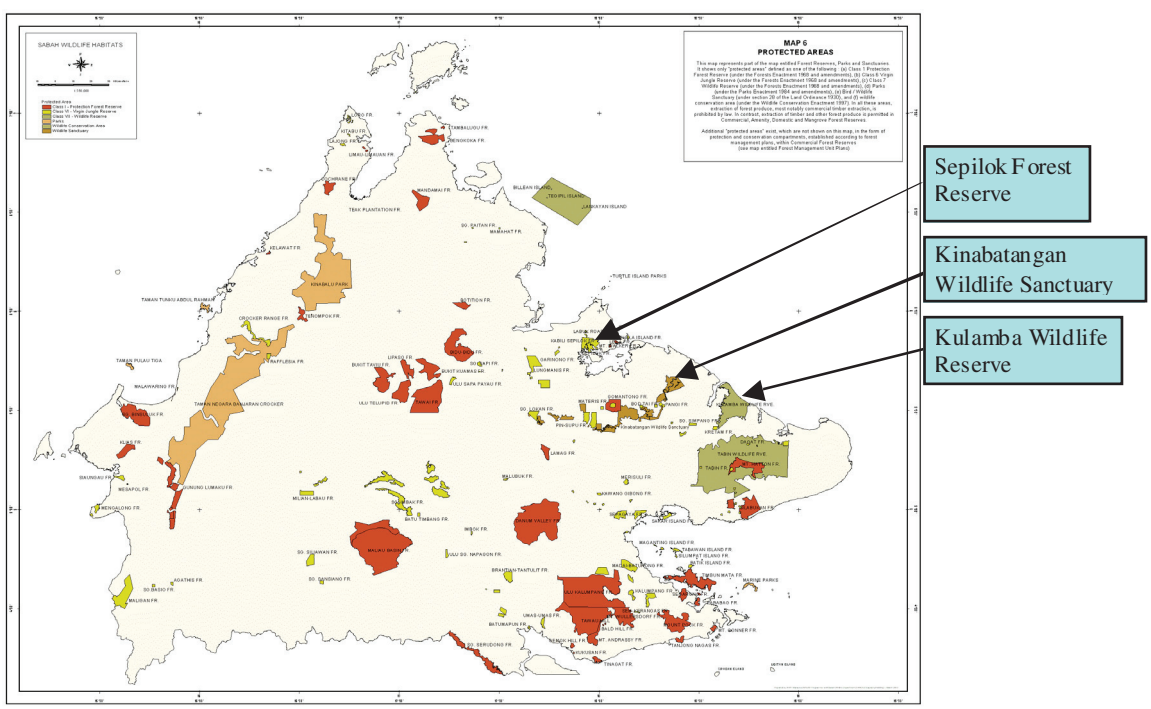

Figure 1. National Parks and protected areas in Sabah.

- Kinabatangan Wildlife Sanctuary - 270.0 km^2
- Kulamba Wildlife Sanctuary - 206.82 km^2
- Kabili-Sepilok Forest Reserve - 42.94 km^2
- In addition to these areas are several mangrove forest reserves (eg the Labuk-Sugud River estuary) and riverine reserves as dictated under Forest Department Enactment, totalling greater than 6800 km^2.

Based on the result of the survey conducted in 2002, a Sabah Crocodile Management Programme was developed and adopted by the Sabah Wildlife Department. The key elements addressed in the programme are summarized as follows;

- Identify and conserve breeding areas.
- Expand protected area in potential breeding areas.
- Reduce and control crocodile and human conflict.
- Public awareness on crocodile conservation.
- Confirmation and conservation of Malayan False Gharial.
- Promotion of the sustainable use programme (eg farming, ranching, eco-tourism).

A five-year Bornean Biodiversity and Ecosystem Conservation Programme (BBEC), a joint collaboration with Sabah State Government Agencies, University of Malaysia and NGOs, supported by Japan International Agency (JICA) commenced in February 2002. The Programme consists of four components namely Research and Education, Park Management, Habitat Management, and Public Awareness, aims to establish comprehensive and sustainable approach for conservation. Habitat Management Component Project led by Sabah Wildlife Department aims to establish integrated approach for habitat management in the target area. The target area for the project is Tabin, Kulamba Wildlife Reserve and adjacent area that are the potential breeding area of crocodiles. Based on the accumulated information and the survey conducted, it was identified that the lower part of Segama River is one of the few remaining wetland habitats and therefore was proposed to be a Wildlife Conservation Area under the Sabah Wildlife Conservation Enactment, 1997 (Mustafa and Kusan 2003). The map of the proposed conservation area is shown in Figure 2.

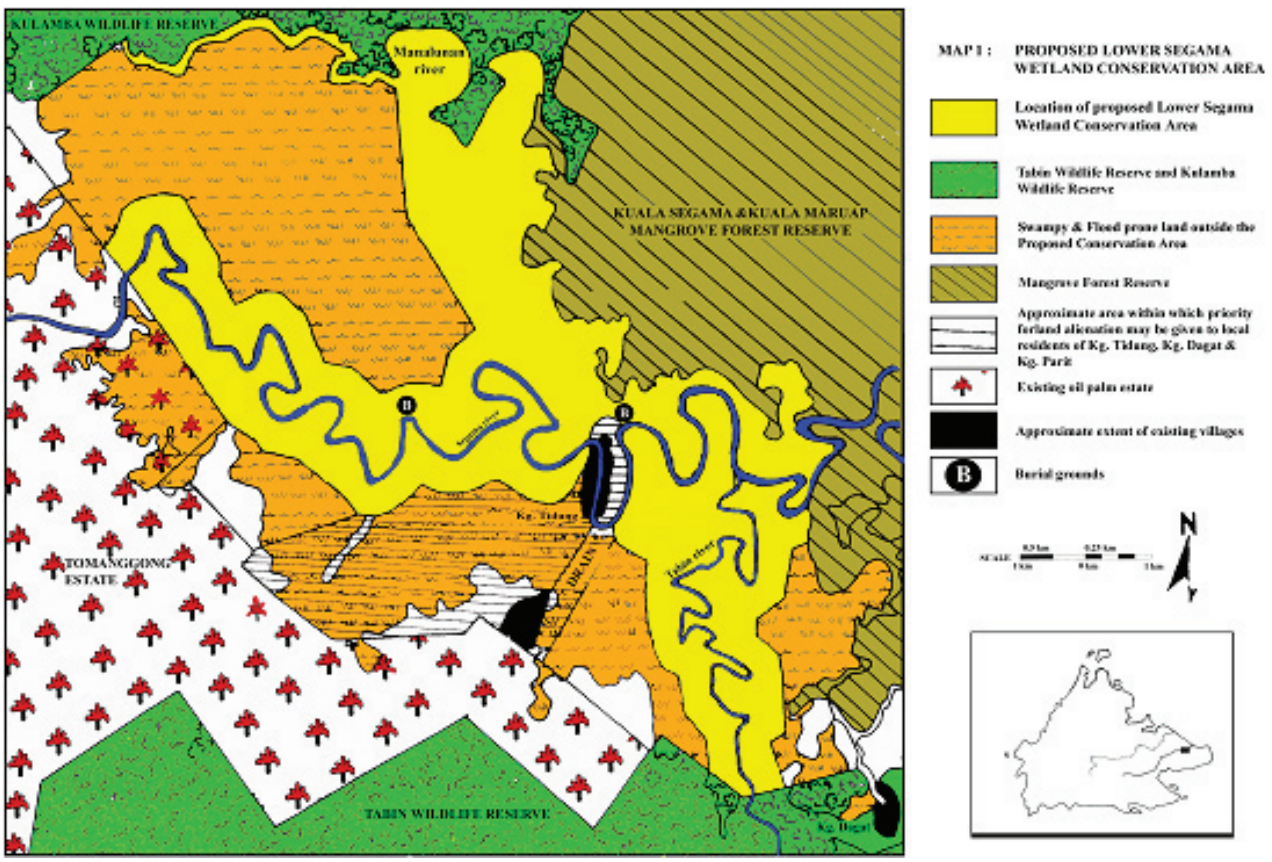

Figure 2. Proposed Lower Segama Wildlife Conservation Area.

The proposed area is approximately 3800 ha with 60-80% wetland, periodical salinity invasion and the three villages of minority group of people Tidong Tribe. It is obvious that the fragmentation of wetland and riverine habitats by agricultural development especially by oil palm plantation is a significant issue that is occurring in the lower Segama River. Though the proposed area is rather small, the success of the proposal is a milestone step toward the crocodile conservation and would facilitate the expansion to other potential breeding areas in Sabah. Currently, the proposal is under the process of gazetting by the Government of Sabah State.

Forward Direction of the Crocodile Management in Sabah

Though the past surveys conducted indicate that there is a significant recovery of the crocodile population in Sabah, the many challenges in crocodile management still remain to be tackled. Sabah Wildlife Department prioritizes the activities in the programme focusing on the following challenges;

- Identify and conserve more breeding habitats.
- Expand wetland conservation area to ensure the crocodile existence in Sabah (especially to Klias wetland).
- Promote sustainable use programme for local community.
- Monitor and manage human-crocodile conflict in crocodile areas.

These activities could only be achieved with smart partnership with private sector and communities.

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Effects of Sustained Harvests on Wild Populations of *Caiman crocodilus crocodilus* in Venezuela

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Abstract

Venezuela's commercial use program for *Caiman crocodilus crocodilus* began in 1983. It allowed the harvest of mature males greater than 1.80 m total length (class IV males), on private lands. Approximately ten million hectares, involving several different ecological regions, are now included in the program, although not all areas are actually harvested. This study compares harvested and non-harvested populations, within the same ecological regions. We found that both absolute density and relative abundance of class IV males was higher in the harvested populations than in the non-harvested populations, supporting the view that sustainability has been achieved, probably through various compensatory responses of the population to the reduction, through harvest of larger males.

Resumen

El programa de aprovechamiento comercial de la baba se inicia en 1983, permitiéndose cosechar individuos que conforman la clase IV, con una longitud total superior al 1.80 m, representados únicamente por machos adultos, en tierras de propiedad privada. El área de implementación es aproximadamente diez millones de hectáreas, divididas en regiones ecológicas, pero no toda la superficie se cosecha el recurso. Este estudio realiza una comparación en áreas donde se cosecha versus áreas donde no se aprovecha el recurso. Se encuentra que en las áreas donde se aprovecha la especie, los valores de densidad y porcentaje de la clase IV, son mayores, al compararlos con los valores encontrados en áreas donde no se cosecha el recurso. Estos resultados muestran que programas de manejo bien diseñados, permiten la sustentabilidad del recurso baba y el efecto positivo sobre las poblaciones manejadas, a través de la cosecha de ejemplares adultos mayores de 180 cm de longitud total (clase IV).

Introduction

In 1971, all 23 known species of true crocodiles, alligators, caiman and gavials were considered to be endangered, threatened or declining in abundance and/or distribution. By 1996, 25 years later, 16 of those species were once again abundant and widespread, a conservation success due in no small part to incentives to conserve created through sustainable use (King 1999), and to the steady decline in illegal use and trade (Hutton and Webb 2003)

The role of economic incentives in promoting crocodilian conservation has been well established (Joanen *et al*. 1997; King 1999; Hutton and Webb 2003). Consumptive use, such as commercial harvesting can positively influence the conservation of wild populations. In Venezuela's case, conservation can be enhanced in two major ways:

a. The ability to extract an economic return from a wildlife population, on private lands, where landowners are the primary beneficiaries, can provide tangible economic incentives for landowners to maintain healthy populations and habitats, and to invest in the prevention of illegal use and trade; and,

b. The selective removal of large, dominant males from the population, which are suspected to constrain the growth and attainment of maturity of sub-adult males, could be expected to lead to a series of compensatory mechanisms likely to increase the wild population (Velasco *et al.* 1995).

Consumptive use of crocodiles within different management programs typically involves one or more of the following strategies: "cropping", "ranching" or "captive breeding" (Thorbjarnarson 1992; Ross 1998). Direct hunting of adults or sub-adults in the wild (cropping) is one of the major ongoing forms of consumptive use in some countries (Magnusson 1997), yet there have been few rigorous evaluations of the effects of harvest on the structure and abundance of wild crocodilian populations (Mourão *et al*. 1996).

Regulated harvesting of wild spectacled caimans (*Caiman crocodilus crocodilus*) has been permitted in Venezuela since 1983, under a program directed by the Ministry of the Environment and Natural Resources (MARN), through the general direction of fauna (Velasco and De Sola 1997; Thorbjarnarson and Velasco 1999). The program allows harvesting, on authorized private cattle ranches, of a proportion of the class IV caimans: that is, *C. c. crocodilus* with a total length (TL) greater than 1.80 m, which are all adult males (Velasco and De Sola 1999).

The selective harvesting of large, mature males was designed to minimize the effects of the harvest on the reproductive potential of the wild populations, by steering the harvest away from the mature females. It was also considered likely that such a harvest would allow a larger number of younger males to grow more rapidly, reach larger sizes more quickly and become reproductively active sooner than if the large, dominant, males remained in the population (Velasco *et al.* 1995).

This study reviews survey data from the main harvest areas in Venezuela which for various reasons, contain both harvested and non-harvested populations. It attempts to quantify likely effects of harvest by comparing densities (caimans per hectare of total land) and population size structures. The null hypotheses was that harvesting would reduce densities generally, and specifically the numbers of class IV individuals.

Study area

The study was carried out in the western Llanos (plains) of Venezuela, abutting the Colombian border (Fig. 1). This area is subdivided into seven regions, each of which has different ecological qualitative characteristics, as described by Velasco and Ayarzagüena (1995) and six of which we examined in this study (Table 1).

Information on *C. c. crocodilus* densities and population size structures were gathered during monitoring programs undertaken by the Facultad de Ciencias, Universidad Central de Venezuela (UCV) and MARN. Information was gathered from five regions in 1996 (Alto Apure, Aguas Claras, Cajón de Arauca, Llanos Boscosos and Hoya de Arismendi) and from the Bajo Apure region in 1999. The Guárico ecological region was not evaluated because no harvest took place for 5 years (1992-1996).

Figure 1. Ecological region in Venezuelan plains.

Table 1. Dominant ecological characteristics of the seven regions included within the harvest program.

Ecological Regions	Garcersos[1]	Loam vs Sandy[2]	Grade Flooded Savannahs[3]	Delta-type[4]	Water Quality[5]
Alto Apure	Present	Medium	Medium	Not Present	Rich
Bajo Apure	Present	High	High	Present	Rich
Aguas Claras	Not Present	Low	Low	Not Present	Poor
Cajón de Arauca	Present	Low	Low	Not Present	Medium
Hoya de Arismendi	Present	High	Medium	Not Present	Rich
Llanos Boscosos	Not Present	Medium	Low	Not Present	Rich
Guárico	Present	High	High	Present	Rich

[1] Wetlands in which herons congregate which suggested an abundance of the food used by *C. c. crocodilus*
[2] Relation between loam vs sandy plains
[3] Is the extent of flooded savannahs
[4] Areas where the mainstreams break into ramifying channels
[5] Qualitative water nutrient richness

Surveys occurred over 532,447 hectares of total land or 4.9% of the total region. Of the area surveyed, 281,082 hectares (52.8%), contained harvested populations of *C. c. crocodilus,* and 251,365 hectares (47.2%), contained non-harvested populations (Table 2).

Table 2. Area of harvested and non-harvested habitat surveyed in each ecological region. ns= not surveyed in this study.

Ecological Region	Region Area (ha)	Area Surveyed Harvested (ha)	Area Surv eyed Non-Harvested (ha)	Total Area (ha)
Alto Apure	2,662,296	59,935	44,208	104,143
Bajo Apure	571,389	50,118	41,415	91,533
Aguas Claras	1,009,890	60,895	30,650	91,545
Cajón de Arauca	252,189	16,101	6,290	22,391
Llanos Boscosos	3,114,384	66,130	59,385	125,515
Hoya de Arismendi	615,342	27,903	69,417	97,320
Guarico	2,620,800	ns	ns	ns
Total	10,846,290	281,082	251,365	532,447

Methods

All surveys were carried out during the annual dry season (March to May) in 1996 and 1999 when *C. c. crocodilus* are concentrated in remnant water bodies. Areas with both harvested and non-harvested populations were selected in each ecological region, and the population parameters were quantified as follows:

- Population abundance was estimated by night-light counts (Chabreck 1966 and Woodward and Marion 1977). A powerful spotlight was scanned over waterbodies and the number of eyeshines counted. The caimans sighted by this method represent a very high proportion (80-90%) of the total number present (Staton and Dixon 1975; Ayarzagüena 1980; Seijas 1986), and so this was taken as the measure of absolute abundance. Density was calculated as the sum of total number of animals counted at night per ecological regions divided by the sum of total land area surveyed for each ecological regions. In other words, the spotlight counts on waterbodies for particular ranches are added and divided by the total land area of those particular ranches in each ecological regions.

- The population size structure was estimated by allocating as many of the caiman sighted as possible into one of

four general size classes (Ayarzagüena 1983):

Class I - hatchlings and animals <60 cm TL
Class II - >60 cm and <120 cm TL
Class III - >120 cm and <180 cm TL
Class IV - >180 cm TL

Bar histograms with the proportions of individuals in each size class (II, III and IV) allowed two types of age structures to be defined (Velasco and Ayarzagüena 1995): one with pyramidal form, which indicates a population not subjected to harvesting, and another with a staggered form indicating an exploited population, where the percentage of individuals in class IV is less than 15% of the total population (Fig. 2).

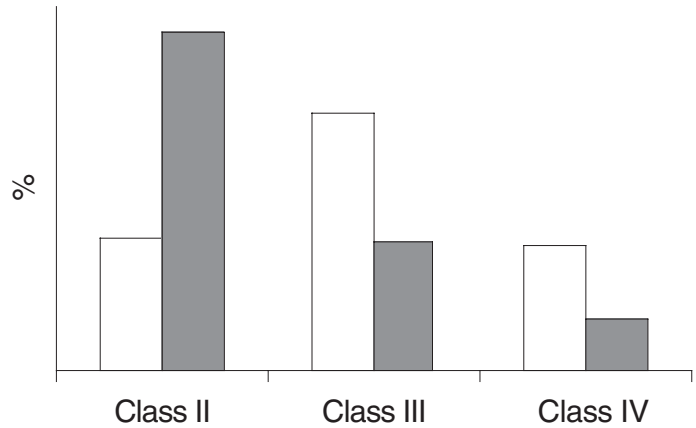

Figure 2. Bar histogram. Open bars natural population not subjected to harvesting, closed bars population over exploited (Velasco and Ayarzagüena 1995).

Individuals in class I were excluded from analyses, because numbers are highly variable from year to year, and are depend on the month in which surveys are undertaken. In addition, there is a high mortality rate for hatchlings during their first year of life, and they are generally excluded from these types of analyses (Webb and Manolis 1992).

We do not use in this study statistical analysis to analyze the population abundance, because the MARN uses absolute values to calculate de densities in each ecological regions and to determinate the harvest quota in each cattle ranch (De Sola *et al.* 2000; Velasco and De Sola 1999).

Results

Alto Apure

Density in the harvested areas (0.30 caimans/ha) was higher than in the non-harvested areas (0.20 caimans/ha) (Fig. 3), and when adjusted for areas (Table 2) abundance in the harvested areas was twice that in non-harvested areas. The size structure in harvested and non-harvested populations had a similar, declining general form (Fig. 4), but with a higher proportion of class IV individuals in the harvested (20.60%) versus non-harvested areas (13.52%).

Bajo Apure

The density was higher in areas harvested (0.21 caimans/ha) than in non-harvested areas (0.17 caimans/ha)(Fig. 3), and the size distribution was pyramidal in form in both areas. Areas with harvest had a higher proportion of class IV individuals (31.18%) than those without harvest (25.91%) (Fig. 4).

Aguas Claras

Density in harvested areas was higher (0.17 caimans/ha) than non-harvested areas (0.12 caimans/ha) (Fig. 3).The size distribution showed differences in the relative number of classes II and III individuals (Fig. 4), but class IV made up similar proportions in both harvested (20.49%) and non-harvested in harvested areas (21.32%).

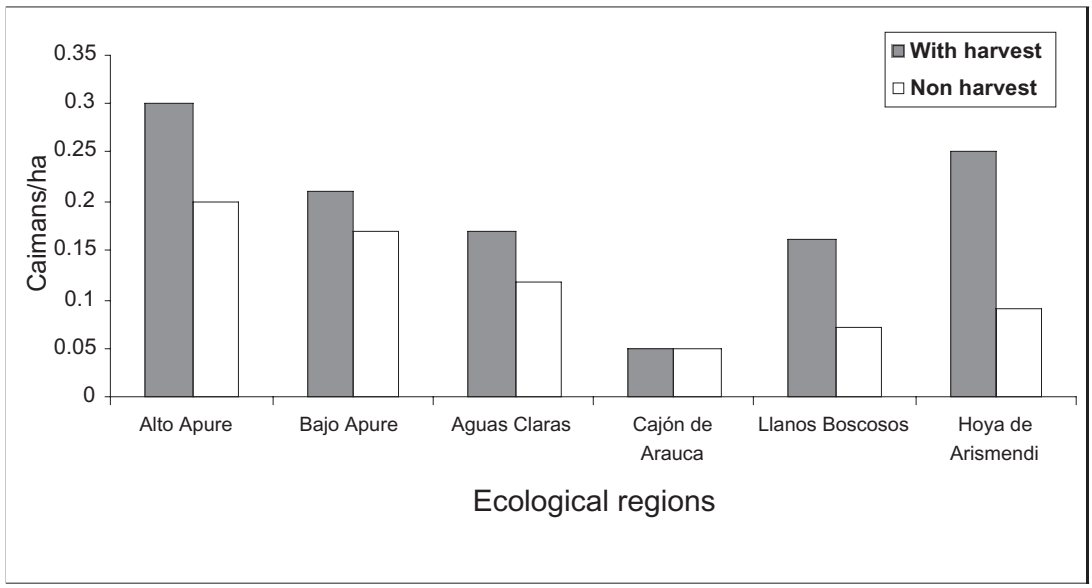

Figure 3. Density in ecological region with harvest or non-harvest.

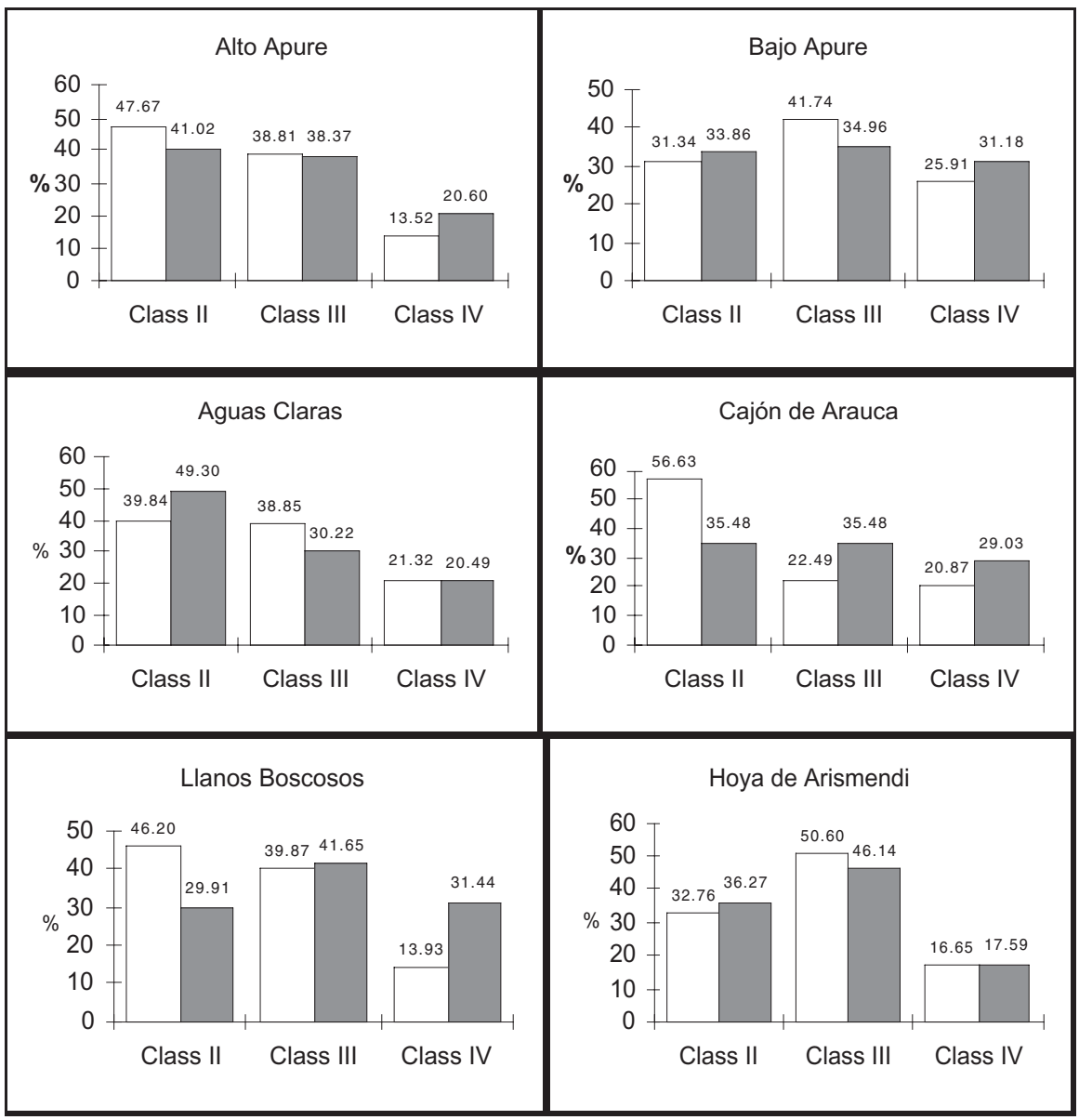

Figure 4. Size class histogram for ecological region in areas with or non-harvest. Closed bars = with harvest; open bars = non-harvest.

Cajón de Arauca

This area had the lowest densities, and there was no difference in those recorded from the harvested and non-harvested areas (0.05 caimans/ha) (Fig. 3). In the harvested area (Fig. 4) proportions of classes II and III individuals were similar, but there was a high proportion of class IV individuals (29.03%). In non harvested areas, the size structure was dominated by class II (56.63%) individuals and classes III and IV were relatively reduced (22.49% and 20.87%, respectively).

Llanos Boscosos

Density in the areas with harvest (0.16 caimans/ha) was much higher than in areas without harvest (0.07 caimans/ha)(Fig. 3). In harvested areas (Fig. 4), the size structure was pyramidal in form with a high proportion of class IV (31.44%) individuals relative to non harvest areas with a declining size structure from high percentages of class II and III individuals, and a low proportion of class IV (13.93%) individuals.

Hoya de Arismendi

Density in harvested areas (0.25 caimans/ha) was much higher than in non-harvested areas (0.09 caimans/ha), although total populations were similar due to respective areas (Table 2). The size structure in both harvested and non-harvested areas was pyramidal (Fig. 4), which is normally associated with non-harvested populations (Velasco and Ayarzagüena 1995). The proportion of class IV individuals was similar in harvested 17.59%) and non-harvest (16.65%) areas, but low relative to most other regions.

Discussion

At the beginning of the program of commercial use of caimans in Venezuela, a census was undertaken to estimate caiman densities on each of the properties that requested permission to hunt. With time it became impossible to visit all the properties involved and so, a samples was chosen for future surveys (Seijas 1986). In these surveys, the density of caiman was expressed as caimans/ha of water. In the early years the density was reported as the number of animals per hectare of total land, including waterbodies areas (Velasco and Ayarzagüena 1992), without any attempt to distinguish between areas with or without harvest in each. This type of separation began in 1996.

One of the main results of the study is that most high density populations that have been subjected to harvesting for more than 4 years, still contain high densities of caimans, and thus a high degree of sustainability in involved.

In all but one of the regions studied the density of caimans/ha was higher in the areas which had been subject to repeated harvest than in those which had remained unharvested (Fig. 3). This is part reflects the reality that the harvesting program is a voluntary one, which is more likely to be implemented on those cattle ranching properties where caiman are most abundant in the first place. However, it also served to reinforce the observations that caiman densities are highly variable in the wild with low density populations that will never increase even in the complete absence of exploitation.

The proportion of class IV individuals were consistently higher in the harvested areas (>20%) than in the non-harvested areas (<20%). The extent to which this may be biases by differences in the population structure between hunted and non-hunted areas prior to harvest cannot be resolves. However, it does demonstrated that the harvest of class IV individuals is followed by significant recruitment into this size class, which is consistent with the observation made in other species that growth to maturity of sub-adult males may be boosted by removing the larger, older and well established from the population in question (Nichols *et al.* 1976; Craig *et al.* 1992; Velasco and Ayarzagüena 1995; Velasco *et al.* 1994).

It was clear from the results that one region (Aguas Claras) were markedly different to those from the others. Here density and the proportion of class IV animals was smaller in the harvested areas than in the non-harvested areas. Furthermore, the distribution of individuals amongst the size-classes was changing, in both harvested and non-harvested areas, with the highest proportion of individuals in the smallest size classes.

Conclusions

The results obtained in the censuses of 1996 and 1999, in the six management regions, support the view that Venezuela's caiman harvest is being sustained by the wild population, and that the program of commercial use implemented by MARN in 1983, which has now been operating for 20 years, is achieving its goals. There is no indication that populations have declined significantly as a consequence of harvesting, nor that adult males have become rare, which are selectively harvested, are in short supply in the population. The program brings considerable economic benefits to the landowners involved, who now have a vested interest in caring for both caimans and their habitats. The program has also provided some unique insights into the manner in which wild caiman populations respond to controlled harvest, which has broader ramifications to the conservation and management of this widespread species in other countries.

That densities were generally higher in harvested areas than in non-harvest areas could reflect hunting biases to some degree, but does allow rejection of some of the more dire predictions about the likely impacts of harvest. High density caiman populations subject to this type of harvest (class IV males) still exist in high density despite 20 years of harvest. Examination of the population size structures suggests this is being achieved by compensatory mechanisms, favoring recruitment and the enhanced growth to maturity of sub-adult males.

Monitoring at this level of resolution should be adequate for ensuring that the Venezuelan caiman harvest is sustainable, and for giving early warning of any problems, be they related to the harvest or not. The monitoring program is thus sufficient to allow compliance with purpose of Article IV.2b of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which obligates the exporting State to provides assurances that the harvest for international trade is not detrimental to the survival of that species.

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Caiman yacare and *Caiman latirostris* Ranching Programs in Argentina

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Abstract

The sustainable use of wild animals and plants of commercial interest, leading to economic benefit and the stimulus of *in situ* conservation, clearly is, nowadays, the realistic approach to conserving natural ecosystems. Currently, there are three different projects operating in Argentina, through caiman ranching of the two species presents in the country.

The story of legal utilization of crocodilians in Argentina, starts in Santa Fe Province in 1990 with the self-repopulation program of *Caiman latirostris*, and based on it, the transfer of the Argentine population from Appendix I to II of CITES, which occurred in 1997 in Zimbabwe. Following, Chaco Province starts a similar project on a smaller scale, but working with the two species (*C. yacare* and *C. latirostris*) and finally, Formosa Province began in 2001 a project on a bigger scale, also with the two species, which is about to start the commercialisation of its production.

In Santa Fe Province were released over 14,140 yearlings (only *C. latirostris*); in Chaco 1668 and in Formosa 1057 just in the first year (both species in these Provinces). The harvest of eggs is currently of 10,000 per year in Santa Fe; 1000 in Chaco, and 15,000 in Formosa.

In this paper, we present information on the harvested eggs, juveniles releasing, commercial production and evolution of the monitoring of the three projects since its beginning to date.

Introduction

The northern part of Argentina represents the southern-most limit of the distribution of the Broad-snouted Caiman (*Caiman latirostris*) and the Yacare Caiman (*Caiman yacare*). Both species are distributed throughout 9 Provinces (Formosa, Santa Fe, Misiones, Corrientes, Entre Rios, Chaco, Santiago del Estero, Salta, Jujuy) in Argentina, although *C. yacare* occurs in higher densities above the 30º latitude and *C. latirostris* up to the 32º latitude (Larriera 1990).

Ranching of eggs, combined with restocking of the wild population, was considered the safest option to pursue with regard to minimizing the impact on the population. The ranching program was initiated on an experimental basis, but now, it is fully implemented as a commercial option.

Listed in Appendix I of CITES, international trade in *C. latirostris* products was prohibited until the Santa Fe *C. latirostris* ranching proposal was approved at the 10th Conference of Parties to CITES (Zimbabwe, 1997). In 1999 it was incorporated to the program the Chaco Province, and lately, Formosa Province did start also with the production. The species *Caiman yacare* is already listed in the Appendix II of CITES.

Santa Fe Program

The program it was carried out since its beginning from an agreement between the Agricultural Ministry of the Province of Santa Fe, and an NGO called “Mutual del Personal Civil de la Nación”. This work start in 1990 as an experimental stage, becoming commercial in 1999.

In Table 1 are shown the all numbers of harvest, juveniles releasing and commercial rearing in the Province of Santa Fe. In Table 2 we show the results of the night counts in Santa Fe since the beginning of the program

Chaco Program

The project runs here supported by an agreement between the Dirección de Fauna y Parques del Chaco, Fundación Vida Silvestre Argentina, and a cattle ranch called “El Cachapé”.

Table 1. Details of harvests and releases in Santa Fe Province.

Year	Harv. Nests	Ident. Nests	Harv. Eggs	Hatchlings	Released	Commercial
1990/91	10	14	372	237	205	
1991/92	25	32	903	701	655	
1992/93	24	33	926	589	541	
1993/94	50	62	1936	1196	1022	
1994/95	60	71	2211	1646	1451	
1995/96	84	112	3120	2262	1980	
1996/97	97	123	3572	2394	2072	
1997/98	58	107	1954	1448	1123	100
1998/99	70	128	2347	1902	1521	333
1999/00	76	152	2397	1833	1058	667
2000/01	73	143	2227	1526	670	830
2001/02	188	225	6392	4494	927	2992
2002/03	228	304	7560	5638	915	4524
Totals	**1043**	**1506**	**35917**	**25866**	**14140**	**9446**

In this province the project combine the harvest of both species (*C. latirostris* and *C. yacare*). The first studies start here in 1996, and the results of the eggs harvest since 1998 are showed in the following Table:

Year	*C. latirostris*	*C. yacare*	Total
1998	242	96	338
1999	457	201	658
2000	1362	148	1510
2001	574	306	880
2002	1236	625	1861
2003	848	475	1323
2004	148	287	435
Totals	**4867**	**2138**	**7005**

The total number of animals released and commercially reared is showed on the next Table:

Year	Released			Commercial Rearing	
	C. latirostris	*C. yacare*	Total	*C. latirostris*	*C. yacare*
1998	178	78	256	23	7
1999	195	93	288	129	65
2000	325	36	361	622	68
2001	103	61	164	307	191
2002	262	104	366	574	277
2003	147	86	233	275	248
Totals	**1210**	**458**	**1668**	**1930**	**856**

Table 2. Cayman counts from 1990 to 2002; Class I <50 cm, Class II 50-140 cm, Class III 140-180 cm, Class IV >180 cm; Density refers to Class II-IV animals per km; *Day count during dry season in 2000.

Location	Date	Class				EO	Total	Dist.	Density
		I	II	III	IV			(km)	(/km)
Los Molles	04/11/90		6	2			8	4.5	1.77
Lote 5	06/11/90	21	6	5	2	2	36	6.8	2.20
Dientudo	10/11/90	14	3	4	2	4	27	5.3	2.45
Los Molles	02/12/91	2	2	3	2	3	12	4.5	2.22
Caminos A	04/12/91	4		3	2	1	10	3.9	1.53
Lote 5	08/11/92	57	28	17	14	13	129	6.8	10.58
Dientudo	09/11/92	43	19	14	6	8	116	5.3	13.77
Caminos A	02/12/92	17	12	4	3	4	40	3.9	5.89
Fisco	15/12/92		2	1	1		4	12.3	0.32
Dientudo	17/11/93	38	19	21	7	5	90	5.3	9.81
Caminos A	21/11/93	52	31	28	17	7	135	3.9	21.28
Lote 5	27/11/93	15	8	6	3	2	34	6.8	2.79
La Colorada	03/12/94	38	27	28	8	9	110	9.2	7.82
Fisco	07/12/94	17	12	11	3	5	48	12.3	2.52
Dientudo	16/12/94	61	31	22	14	9	137	5.3	14.33
Los Molles	02/11/95			1	4	3	8	4.5	1.77
Dientudo	10/11/95	8	23	28	26	42	127	5.3	22.45
Caminos A	21/11/95	6	20	4	2	7	39	3.9	8.46
Caminos B	21/11/95		5	2			7	1.4	5.00
La Colorada	27/12/95	23	31	22	19	15	110	9.2	9.40
Fisco	05/01/96	9	16	18	2	3	48	12.3	3.17
Lote 5	12/11/96		8	12	2	4	26	6.8	3.82
Dientudo	12/11/96		8	28	9	4	49	5.3	9.24
Fisco	03/01/97	12	14	33	18	10	87	12.3	6.09
Dientudo	04/01/97		18	26	6	8	58	5.3	10.94
Espin	02/12/98		25	23	12	4	64	1.4	45.71
Dientudo	03/12/98	31	36	42	31	5	145	5.3	21.50
Los Molles	12/12/98		24	17	11	9	61	4.5	13.55
Caminos A	07/11/99		7	33	16	13	69	3.9	17.69
Caminos B	07/11/99		2	3			5	1.4	3.57
Lote 5	30/11/99	6	42	17	11	12	88	6.8	12.05
Los Molles	30/11/99		16	15	4	10	45	4.5	10.00
Espin	09/01/00			177	203		380	1.9	200*
Lote 5	15/11/00		23	31	6	8	68	6.8	10.00
La Colorada	17/11/00	22	14	31	19	4	90	9.2	7.39
Dientudo	04/12/01		62	41	29	14	146	5.3	27.54
Fisco	15/12/01	9	23	34	31	22	109	12.3	8.13
Caminos A	22/12/01		32	72	28	16	148	3.9	37.94
Caminos B	22/12/01			6	4		10	1.4	7.14
Los Molles	11/11/02		25	19	14	12	70	4.5	15.55
Lote 5	15/11/02		9	23	37	4	73	6.8	10.73
La Colorada	06/12/02	3	9	20	18	7	57	9.2	5.21

Formosa Program

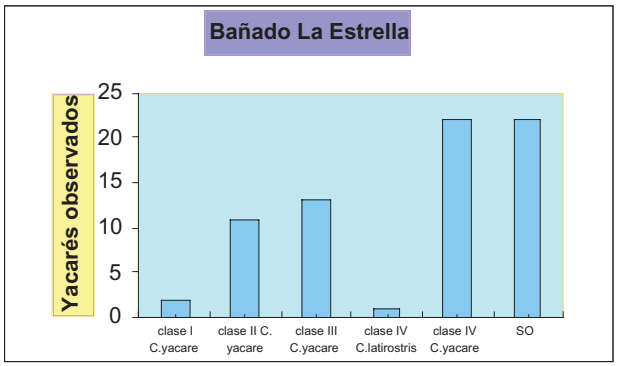
The ranching program did start in this Province in 2001 based on an agreement between the "Dirección de Fauna y Parques de Formosa" (Ministerio de la Producción), and a company called "Caimanes de Formosa SRL".

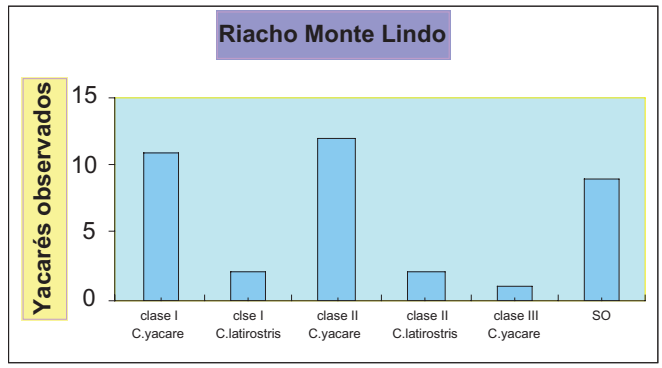
The first harvest of eggs was carried out during 2002. In this Province the eggs of both species (*C. latirostris* and *C. yacare*) are harvested, due to the fact that they leave in the same areas, and that it is not possible to distinguish between the nests of everyone.

The stock of animals of one year after the release of 1057 on November 2003 at the rearing station in the "Parque Industrial Formosa" is 7358 animals (5361 *C. latirostris*, 1997 *C. yacare*).

The number of animals hatched in this last season is 15,918 (7689 *C. latirostris*, 8229 *C. yacare*).

The cayman populations were and are studied in a total of 18 locations in Formosa Province. As an example we show following a couple of the graphic generated from this information:





Benefits to Landowners and Conservation Value in Argentina

Experience from Santa Fe (also seen in Chaco and Formosa) indicated that most landowners are not interested in financial gain from the programs. They appear more interested in the fact that people involved in the program do work on their land, and that they obtain good publicly from it, seen as an integral part of the conservation program. They have gained an understanding that the drying of swamps also impacts negatively on cattle production in the long-term.

The situation is different for the local inhabitants, that as employees of the cattle ranches, benefit directly from the program through payments for each nest ($USD7) that they locate and mark. Incentives have been created for the employees to not allow the killing of caimans, and to protect nesting areas, that in the past were regularly burned. Caimans now have a positive value to them. Between the three Provinces, there are about 500 people involved with the projects in one or another way.

National Level

The enforcement of the national and international regulations in Argentina, is under the responsibility of the Dirección Nacional de Fauna y Flora Silvestres, which is also the CITES Management Authority in the country. All the three projects are supported by a regular monitoring system annually carried out by Crocodile Specialist Group members in the different provinces, through the standard night counts and the analysis of the annual egg collection.

His office is also in charge of the administration of the universal tagging system and the national tagging system, which imply a double tagging, the first one at the slaughterhouse, and the second one as CITES tag, before the exporting if so.

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Geographical Study of the Commercial Management Program of *Caiman crocodilus* in Venezuela

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Abstract

The geographical variables influencing spatial distribution of Baba (*Caiman crocodilus*) in Venezuela were studied, using the data produced by the harvests and monitoring of wild population during the application of MARN Program of commercial management of this species, during the last decade. The main geomorphologic, vegetation, hydrograph, and climate conditions of the seven "ecological regions" in which the Program is currently applied are described, taking into account its influence on the biological characteristics of the species. Social-economical conditions, including the impact of the Program on the employment, land tenure and productivity also are discussed. As results of this spatial-historical analysis, a re-delimitation of the "ecological regions", best administrative procedures and other recommendations linked to the biogeography of the species are proposed, in order to improve the Program.

Resumen

Se estudiaron las variables geográficas que influencian la distribución espacial de la Baba (*Caiman crocodilus*), utilizando los datos de cosechas y censos de las poblaciones silvestres producidos la última década, durante la aplicación del Programa de Uso Comercial de esta especie por el Ministerio del Ambiente y de los Recursos Naturales (MARN). Se describieron las principales condiciones geomorfológicas, de vegetación, hidrografía y clima de las siete "Regiones Ecológicas" en las cuales el Programa es aplicado actualmente, tomando en cuenta su influencia en las características biológicas de la especie. También se discuten las condiciones socioeconómicas, incluyendo el impacto de Programa sobre el empleo, la tenencia de la tierra y la productividad. Como resultado de este análisis espacial-histórico, se propone una re-delimitación de las "regiones ecológicas", mejoras en los procedimientos administrativos y otras recomendaciones vinculadas a la biogeografía de la especie, en función de mejorar la aplicación del Programa.

Introduction

There is a need of understand the human activities related with wildlife as important components of the tropical ecosystems, to obtain adequate and sustainable management models including the geographical wildlife distribution. Traditionally, the wildlife management in tropical species is only directed to the administration and conservation of game species. Fortunately, as the valorization of these resources increases, the development of more precise concepts of management had improved the studies on the historical impact of the commercial use activities and the geographical distribution of the resources (Azpúrua and Gabaldón 1982; Delgado and Méndez 1996). Leopold in 1933 defined the management as "the art of using land to produce yearly sustainable harvests of wildlife animals" (Ojasti 2000). This definition involves the geographical unit (land) in the wildlife management.

The sustainable management of a wildlife resource can be defined as an application of the geographical, ecological, social-economical and cultural knowledge as basis for the decision taking on the manipulation of the structure, dynamics and habitats of the resource's population. The sustainable use, control and conservation of the resource are directly involved with the human communities (Reed 1996; Posada *et al.* 1997; Nebel and Wright 1999; Ojasti 2000).

The CITES international regulations on trade and IUCN efforts on conservation, constitutes a general framework that needs the support of scientific and economic information on the wildlife management programs. Currently, the Venezuelan Government through the Ministry of Environment and Natural Resources (MARN) is developing since

1983 the Program of Commercial Use of wild populations of *Caiman crocodilus*, based upon the national and international legal regulations (included in Appendix II of CITES). The Program is applied in private and public properties located at the "Llanos", floodable plains in the southwestern side of the country. *C. crocodilus* is the most abundant crocodile in Venezuela and the only one subjected to a commercial management program under government control (Velasco and De Sola 1999, 2000; Rodríguez and Rojas-Suárez 1995).

The goal of the present study is to produce recommendations to improve the Program. It encompasses data of the Program application from 1992 to 2000, to determine the geographical and ecological main characteristics of this extensive area, and also the social-economical conditions that possibly has influence on the application of the Program at the seven "ecological regions" defined by Velasco and Ayarzagüena (1995). The study includes the analysis of anthropogenic variables with influence on this species and habitats: human settlements, active human population, land tenure and use, infrastructure, and economical handling of the species derivatives (meat and skin); and also natural variables: climate, vegetation, hydrograph and geomorphology. Also, the limits of the seven "ecological regions" are discussed under geographical criteria to propose new definitions.

Methods

This descriptive work is directed to specify the main properties of the Babas populations under exploitation by the Program, defining the response and correlation of two numerical variables under study (Sampieri *et al*. 1991): harvests and field censuses, during the lapse of study (1992-2000) in the spatial dimension of the seven "ecological regions", in order to establish trends and predictions.

The wild population monitoring results and the harvest data were obtained from the MARN and from the Universidad Central de Venezuela - Coordinacion de Extension, to prepare a geo-referenced database of the "ecological regions". This database was deployed on cartographic charts scaled 1:500,000 for spatial analysis and 1:100,000 for more detailed vision of specific areas, using Geographical Information System (GIS) MAP-INFO Ver. 6.0. For the presentation of results a scale of 1:3,600,000 was used, including digitalized coverings of vegetation, geomorphology, hydrograph, and law-protected areas within the study area.

Data on Wild Population Monitoring

The data obtained from monitoring results started with the study of 1991-92 funded by CITES (Velasco and Ayarzagüena 1995), after nine consecutive harvests, which covered 922,581.27 ha (10.24% of the total area of the Program). From these results, the seven "ecological regions" were defined taking into account some habitat characteristics (bird concentrations, inner deltas, nutrient in water, degree of savanna flooding, and type of soil). These regions are: Bajo Apure, Alto Apure, Cajón del Arauca, Aguas Claras, Llanos Boscosos, Hoya de Arismendi, and Guárico, which still are in use by MARN for the administrative and technical functioning of the Program.

Since 1995, a cooperation agreement between MARN and the Universidad Central de Venezuela (UCV) has been scientifically supporting the Program. Under this agreement, the UCV is performing the population status and size structure of the wild populations (Profauna-IZT 1995; Colomine *et al*. 1996).

In 1996 the commercial hunt was paused, suspending all the Program activity (Quero and Velasco 1995), in order to develop a full population study considering that there were 110,000 skins in stock for the international market and the Program, considered as a model for sustainable wildlife management in tropical areas, needs to be improved with technical-scientific studies (Profauna-IZT 1996). Part of the results of this study was presented in Villarroel *et al.* (1996), including habitat evaluation and variations between regions. Other source of data includes the monitoring of ecological regions between 1999 and 2000 (UCV 1999; De Sola 2002).

Data on Harvests

Velasco and De Sola (1999, 2000) presented the evolution of the normative and controls applied by the MARN to the Program since 1983, including also the main information about harvests. Using these data on meat and skins produced, industrial categories, price and other information proportioned by MARN, the database on harvest was prepared.

A preliminary comparison of data from monitoring and harvests was presented in Colomine *et al.* (2002), applying SIG to analyze these variables but without take into account the geographical information about the ecological regions.

Results

Area of Study

The area of application of the Program, located at the southwestern Venezuelan Llanos (Map 1), was calculated in 10,846,290 ha (Velasco and Ayarzagüena 1995), between 9º 39' 36" - 6º 00' 00" North and 71º 26' 24" - 65º 30' 00" West. The authors defined on these extents the "ecological regions" accepted by the MARN for the application of the Program (Map 2).

One of the main problems was to establish an accurate estimation of surface and geographical limits of these "regions". Velasco and Ayarzagüena (1995) made the first approach using a visual calculation on maps, still currently used by the MARN in the administration of the Program. The surface of the Guarico Region was lately modified (De Sola 2000). Using the SIG technique, the surfaces were re-calculated in the present work. Always trying to keep the main criteria applied by Velasco and Ayarzagüena (1995), the results show quantitative differences (Table 1).

Table 1. Original surfaces and SIG calculated surfaces of the "Ecological Regions" (in hectares).

Ecological Region	Velasco and Ayarzagüena (1995)	SIG Calculation
Alto Apure	2,662,296	2,555,000
Bajo Apure	571,389	553,800
Aguas Claras	1,009,890	3,440,000
Cajón de Arauca	252,189	219,900
Lllanos Boscosos	3,114,384	2,901,000
Guárico	2,620,800	2,291,000
Hoya de Arismendi	615,342	922,500
Total	10,846,290	12,883,200

A remarkable difference of about 2 million hectares can be observed from these two estimations, mainly caused by the case of "Aguas Claras" because in 1995 there was not included the surface of a National Park and other areas in which there was no activity of the Program. The definition of "ecological region" used in the present work includes all the land within the limits of the region without any exclusion, but it is still under discussion if an "effective" area can be used instead, including only the land surface in which the Program is currently applied (De Sola 2000).

With the results of the GIS application to the geo-referenced database, a new proposal on limits of the "Ecological Regions" is presented in Map 11.

In this proposal, the "Alto Apure" region is integrated with "Cajón de Arauca", conforming a new "Alto Apure-Arauca" region to the following limits:

North: Apure River
West: curve level of 200 m
South: basin division of the Arauca and Capanaparo Rivers
East: Road Fernando - San Juan de Payara

Taking into account the geomorphology of southern Apure State, the "Aguas Claras" including the dunes of Capanaparo-Meta Rivers is also renamed as "Hydrographic Complex Capanaparo-Cinaruco", with the following limits:

North: Alto Apure-Arauca Region
West: limit Venezuela-Colombia
South: Meta River
East: Orinoco River

The "Bajo Apure" region is renamed as "Bajo Apure-Arauca" region, with the following limits:

North: Apure River

West: Road San Fernando - San Juan de Payara
South: basin division of the Arauca and Capanaparo Rivers
East: Orinoco River

The "Guárico" region is reduced to the spatial application of the Program, excluding the eastern sector (Aguaro-Guariquito National Park and Cabruta-Santa Rita zone). Also was excluded protected area of Estero de Camaguán The region is reduced to the following limits:

North: Curve level of 100 m
West: Road Calabozo - San Fernando
South: Apure River
East: Guariquito River

The "Hoya de Arismendi" region was renamed as "Arismendi" region and its limits are:

North: Curve level of 100 m until Papelon
West: Road Calabozo - San Fernando
South: Apure River (until Bruzual)
East: Chirgua and Portuguesa River

The "Llanos Boscosos" region is delimited as follows:

North: Curve level of 100 m until the Apure River
West: Curve level of 100 m until the Apure River
South: Apure River (until Bruzual)
East: Road Papelon - Bruzual

This new proposal on the "ecological regions" keeps the main ecological factors expressed by Velasco and Ayarzaguena (1995), and offers more precise limits and geographical characteristics, which will help to improve the technical and administrative operations of the Program.

Climate

The yearly mean precipitation is ranging between 1350 mm and 2100 mm in the study area (11 years observations from 6 meteorological stations, Map 3). The rainfall is not uniformly distributed in the whole area of application of the Program, causing local climatic variations between and within the "regions" that could affect the distribution of the species. Also, the rainfall is in general concentrated between May to October, with local differences in the moment of beginning of the rainy season.

Nevertheless, all the study area is classified as Climate Type Aw (Koeppen). Also, the area is located in a Macrothermic Zone (Thornthwaithe) with yearly mean temperatures between 25.7ºC (August) and 29.0ºC (March), maximum and minimum of 33°C and 22°C respectively. The mean difference of temperature between day and night are above 9.5 ºC.

This relative climatic homogeneity at the whole area, with two yearly rain-drought well-defined periods and moderate temperature variations, allows habitat conditions to keep stable and abundant populations of *C. crocodilus.* The "regions" Alto Apure, Bajo Apure and Hoya Arismendi has comparatively better conditions (high amount and diversity of water bodies and floodable savannas).

Hydrography

All the land is crossed by rivers with high hydraulic charge during the rainy season, including the Cinaruco, Capanaparo, Apure, Guanare, Portuguesa, Guárico, Arauca, and Meta Rivers (Maps 4 and 5). All these rivers are derived from the Andean and Central Cordilleras.

With few exceptions, the rivers show an upstream dendrite drainage pattern, becoming parallel after cross the mountains and flow until a meander pattern when reach the lowlands, with frequent changes in course and formation of ponds near the banks. After the rainy season, the flooded areas are drained by numerous channels that disappear during the

drought, reducing to minimum the amount of water bodies. These hydrographic conditions of all the area allows the formation of a wide variety of primary habitats that can be occupied by abundant and stable populations (Villarroel *et al.* 1996).

There are some variations in the conditions and frequency of the water bodies and aquatic environments, related with geomorphology and soil characteristics of each region. Generally, in the regions of Alto and Bajo Apure, Cajon de Arauca and Hoya Arismendi is very frequent the physiographic unit of flooded savannas, whereas the southern units (Aguas Claras) are dominated by dunes of eolic origin with few flooding areas, and at the northern regions Llanos Boscosos and Guarico also there are few flooding areas. This is related with the amount of favorable habitats for the species.

Geomorphology

A very homogenous flat landscape is present in the area of study (Map 5), but if Venezuelan Government through the Ministry of Environment and Natural Resources (MARN) is developing since 1983 the Program of Commercial Use of wild populations of *Caiman crocodilus*, ive geomorphologic units are present in the study area: high plains, bank complexes, foothills, mesas and low plains (Map 6). The high plains (5% or less slope) are present at the south of the study area on the Meta River banks, and at the north extreme of Llanos Boscosos. The bank complexes are deposited on the river embankments, forming low hills at Arauca River (Alto Apure), Capanaparo and Cinaruco Rivers (Aguas Claras). The alluvial plain (0-2% slope) is the most frequent forming the floodable physiographic unit of "banco-bajio-estero" savannas, with sandy soils and forest-shrub vegetation combined with depressions of clay-silt soils and grasslands, very frequent at Alto Apure, Hoya de Arismendi and Llanos Boscosos; eolic plains are located at southern areas. The foothills belongs to the mountain ranges near to the study area (5% or more slope), present in few locations at north of the study area. Finally, the mesas are wide valleys located only at the eastern side of Guárico. From these units, the plains contain the most favorable habitats for the species.

Vegetation

The Map 7 shows the vegetation covering of the study area (Huber 1999), with four main units: forest, savanna, shrubs and intervened areas. The most important units are savannas and forests (60% and 33% of coverage, respectively). The savannas are composed mainly of grasses and occasionally trees and shrubs are present. About 75% of the forest species are deciduous. The intervened areas are mainly deforested agricultural zones. Differences were found within the "ecological regions" regarding to the vegetation distribution (Table 2).

Table 2. Vegetation distribution within the "ecological regions" (in hectares).

Regions	Forests	Savannas	Intervened Areas	Shrubs	Total
Alto Apure	815,492	1,699,000	40,508	-	2,555,000
Bajo Apure	218,627	332,050	3123	-	553,800
Aguas Claras	629,500	2,810,500	-	-	3,440,000
Cajón de Arauca	59,600	160,300	-	-	219,900
Llanos Boscosos	1,291,090	738,000	853,330	18,580	2,901,000
Guárico	860,000	1,430,531	469	-	2,291,000
Hoya de Arismendi	388,700	533,800	-	-	922,500
Total	4,263,009	7,704,181	897,430	18,580	12,883,200

The savannas are the main coverage in six of the seven "regions", with the exception of Llanos Boscosos dominated by forests. The forest formation is present in all the "regions". The few amounts of intervened areas are located very close to the main cities. The shrubs areas were located only at Llanos Boscosos.

Savannas and forests are the most common habitat conditions to be occupied by this species. The periodical flooding of almost all these habitats and very low human intervention complete this general picture, very favorable for crocodilians.

Economic Features

Job Generation. The economically active human population in the area was estimated in 1,236,463 inhabitants at 2001. From these values, 235,500 (19%) are involved in farming activities. The Program is involving a variable number of public officers, landowners, intermediaries and workers (not including industrial processes). The work in the Program extent from January until July, and teams of some 8 persons of hunters and boatmen performs the extraction of the animals. These teams are contracted by the intermediaries, who are in charge to obtain legal authorizations and products. To calculate the jobs generated by the program among the farmers population, an average of 313 authorizations per year was used and approximately 2500 persons per year are involved in the Program. Other 600 workers are involved in transport activities, to sum 3100 direct jobs (1.32 % of the total involved in farming activities in the area of study).

Land tenure. The property of lands in the study area can be public: municipal and national lands, including two National Parks, three wildlife refuges and three forest reserves (Map 8); Table 3 shows these protected areas (Plan Nacional de Ordenación del Territorio 1988) within each "region".

Table 3. Protected areas within the study area (ha).

Identification	Name	State	Surface (ha)	"Region"	Surface within the "Region" (ha)
PN - 15	Aguaro-Guariquito	Guárico	585,750	Guárico	462,742
PN - 27	Cinaruco Capanaparo	Apure	584,368	Aguas Claras	561,700
				Bajo Apure	22,668
PN - 43	Río Viejo	Apure	68,200	Alto Apure	17,050
RFS - 3	Estero de Chiriguare	Portuguesa	109	Hoya de Arismendi	75
				Llanos Boscosos	34
RFS - 4	Caño Guaritíco	Apure	9300	Alto Apure	9300
RFS - 6	De la Tortuga Arrau	Apure - Bolívar	7575	Aguas Claras	3640
RFR - 1	Turen	Portuguesa	116,400	Llanos Boscosos	116,400
RFR - 2	Ticoporo	Barinas	187,156	Llanos Boscosos	13,770
REFA - 1	Sabanas de Anaro	Barinas	16,331	Llanos Boscosos	4250
Total	-	-	1,575,189	-	1,211,629

It is not allowed by law the commercial use of *C. crocodilus* on these protected areas. Other public lands are under concessions to farming social cooperatives, and the Program can be applied there under special authorization by MARN. The private lands involved in the successive years of the Program are shown in Table 4.

Table 4. Land tenure type and surface of farms involved in the Program in the "ecological regions" (in hectares).

Region	Public Farms	Surface and % in each region Surface (ha)	%	Private Farms	Surface and % in each region Surface (ha)	%
Alto Apure	10	389,706	19.7	299	1,588,355	80.3
Bajo Apure	2	58,364	16.5	67	295,600	83.5
Aguas Claras	15	385,255	40.4	66	568,162	59.6
Cajón de Arauca	1	28,296	14.9	22	162,159	85.1
Llanos Boscosos	30	628,425	39.5	141	962,654	60.5
Guárico	4	595,528	54.8	109	490,900	45.2
Hoya de Arismendi	2	67,799	9.4	175	653,780	90.6
Total	64	2,153,373	-	879	4,721,590	-

The private lands are the most important surface to the commercial use of this species. The data about these public and private farms was obtained directly from the MARN authorizations, some of them more than 10 years ago. This

can be affected by sell or other changes in the farm dimensions, which is important because the MARN is using a classification of the farms involved in the Program accordingly to its extension, as a basis for the assignation of extraction quota (Table 5; Velasco and Ayarzagüena 1995).

Table 5. Classification of farms accordingly to its surface.

Farm	Surface (ha)
Great Ranches	>25,000
Ranches	25,000 - 12,500
Small Ranches	12,500 - 3500
Farms	3500 - 1000
Small Farms	<1000

Roads. A road network has been built in the study area, conformed by national roads, local roads and branches (Map 9), with important effects on the trading of the species products. At north side of the study area the national roads 5 and 13 are found, from which other five local roads are derived crossing all the study area in north-south and east-west directions. From all these national and local roads, a network of small roads is derived to communicate all the towns of the area.

Productivity of the Program

The amount of harvests has been diminished on the recent years since 1992 (Velasco *et al*. 2002), related with a contraction of the local market, and an increase of taxes. During 1998, the economic crisis of the southeastern Asian countries also influences in the reduction of the international demand.

De Sola *et al.* (2000) presented an analysis on the current and potential use of the wild populations of *C. crocodilus* in the country. After monitoring the wildlife populations, a density in individuals per land hectare is defined for each region and the population is divided in four size classes. The density and the proportion of individuals within the largest size class, together with the land dimensions of each farm involved, are the basis to define an extraction quota each region. From these definitions, the extraction potential in the whole area of the Program have been estimated in some 85.000 animals per year, ie 20% of the individuals belonging to the largest size class reported for each region.

Accordingly to these definitions, the potential harvest calculated for each region is summarized in Table 6 [data from 1997, modified from De Sola (2000)]:

Table 6. Population estimated, class IV individuals and potential harvest per year in each 'Ecological Region".

Region	Land Surface (ha)	Population (Individuals)	Class IV (Individuals)	Potential Harvest per Year (20% Class IV)
Alto Apure	1,843,249	636,312	152,715	30,543
Bajo Apure	357,460	163,276	38,043	7609
Aguas Claras	868,002	199,295	39,859	7972
Cajón de Arauca	217,469	62,705	15,300	3060
Llanos Boscosos	1,568,388	446,828	80,429	16,086
Guárico	993,411	203,661	50,304	10,061
Hoya de Arismendi	708,355	287,674	48,329	-9666
Total	6,556,334	1,999,751	424,979	84,997

Note that the De Sola (2000) is using the land surface that "effectively" is used in the Program to calculate the population on the basis of the densities (individuals per hectare) derived from monitoring. The total population is about 2 million individuals, while the potential harvest is calculated as 20% of the largest size class in 85,000 individuals of high quality skins.

This value of potential harvest has been never reached by the program during the last decade. The relative success of the Venezuelan wild population Program in the conservation of the species is depending on its competitiveness in regard to the international ranching production. There is a general trend of the international market to accept skins from captive breeding. The proportion of skins from management of wild populations had dramatically diminished to only 6% of the international yearly trade (MacGregor 1999). Table 7 shows some values of Venezuelan skins trade in three years of activity (Instituto Nacional de Estadistica 2003).

Table 7. Reptile skins traded from Venezuela.

Year	Gross Weight (kg)	Net Weight (kg)	Bolívares	US Dollars
1994	243	227	1,519,425	13,500
1995	1285	1215	9,085,222	53,578
1999	1450	1300	19,753,800	32,800

The Venezuelan Government reduced the taxes derived form this activity (Decree 1.367 2001), in order to increase the sharing benefits to the producers, but this policy is not reflected in an increase of the production, dominated by the international market trend toward the captive breeding skins.

Conclusions and Recommendations

The wild populations of *C. crocodilus* are mainly associated to the floodable plains permanent water bodies, with savanna and forest formations. Special attention must be paid to the protection of those primary habitats to maintain the sustainable Program of Commercial Use on the wild populations of this species.

A yearly monitoring of the populations in the whole area of application of the Program should be developed by scientific personnel, to keep a close watching on the spatial variations and establish extraction quotas not exceeding the current criteria or the potential yearly harvest.

The economical incentives to the Program must take into account the international market situation, and the trend to favor the captive breeding production against the more conservative wild population programs. Some policy actions from international organisms can be taken in order to accomplish this goal.

The current database on monitoring and harvests is useful to develop large-scale studies on the effectiveness of the Program in the sustainable commercial use, and the conservation strategies.

The "Ecological Regions" should be redefined by MARN on the basis of the limits proposed in the present work, taking into account the more precise borders and geographical-ecological criteria to define it with GIS application.

The geographical study, which includes ecological and socio-cultural variables, is a powerful approach to support the decision making on sustainable wildlife resource management, in special when it is developed in large areas.

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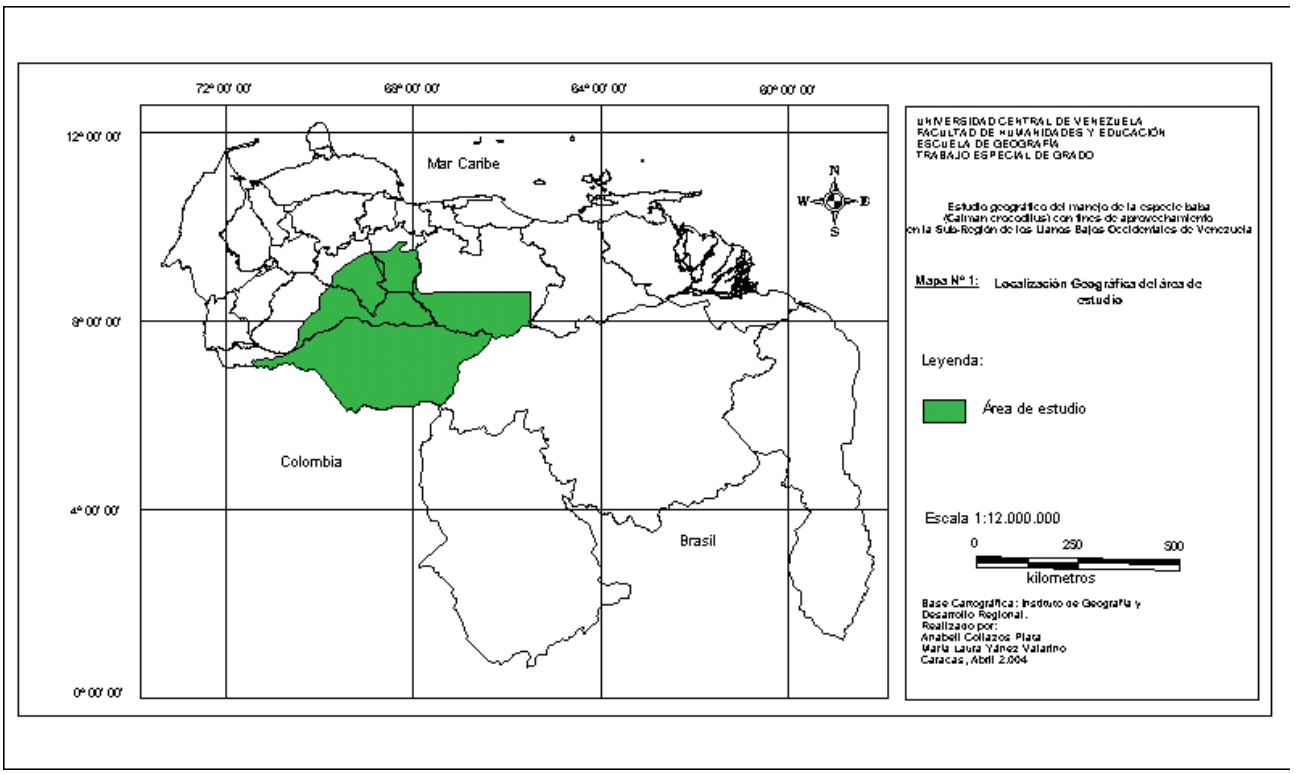
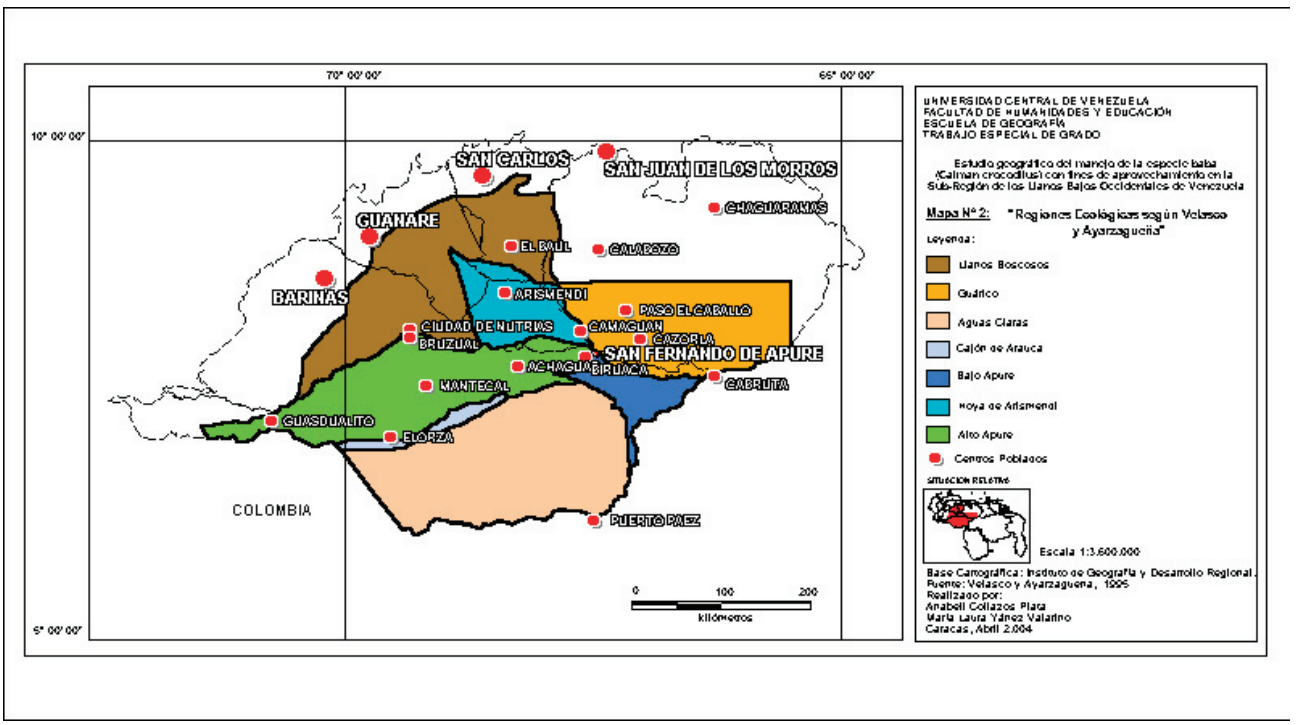
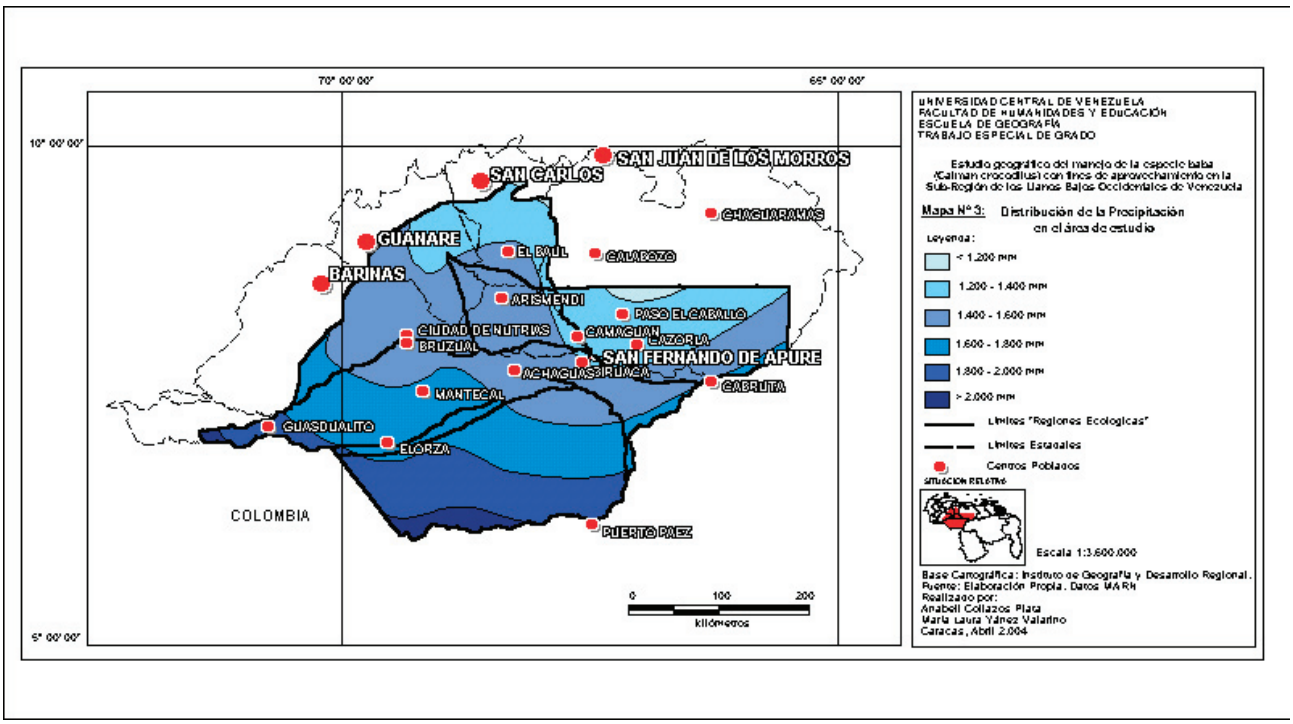


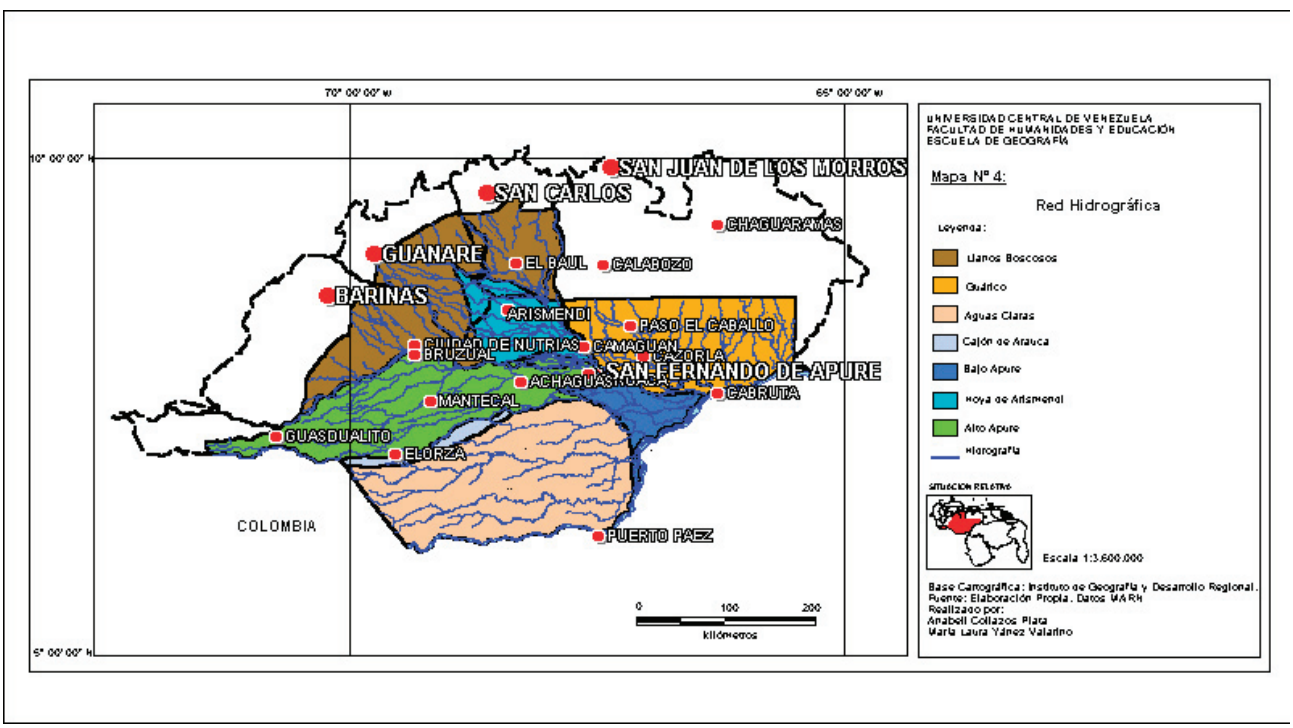
Map 1. Study area.



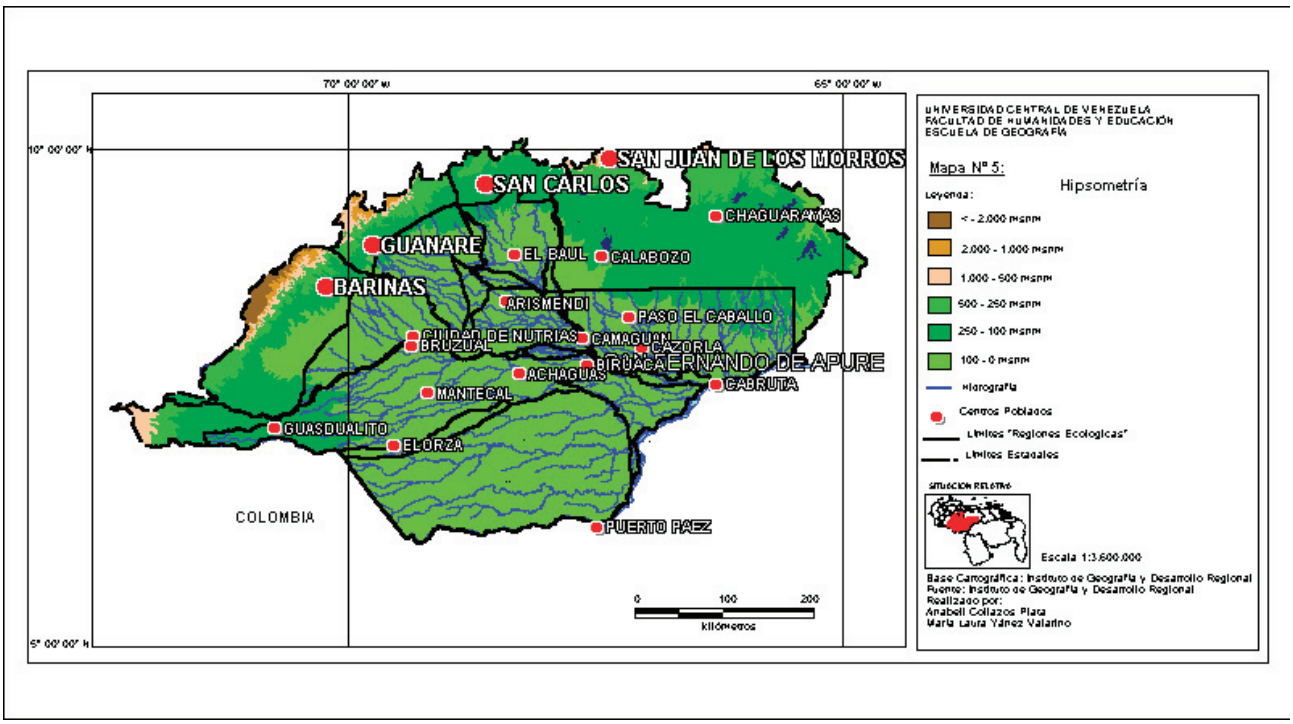
Map 2. Ecological regions (after Velasco and Ayarzaguena 1995).



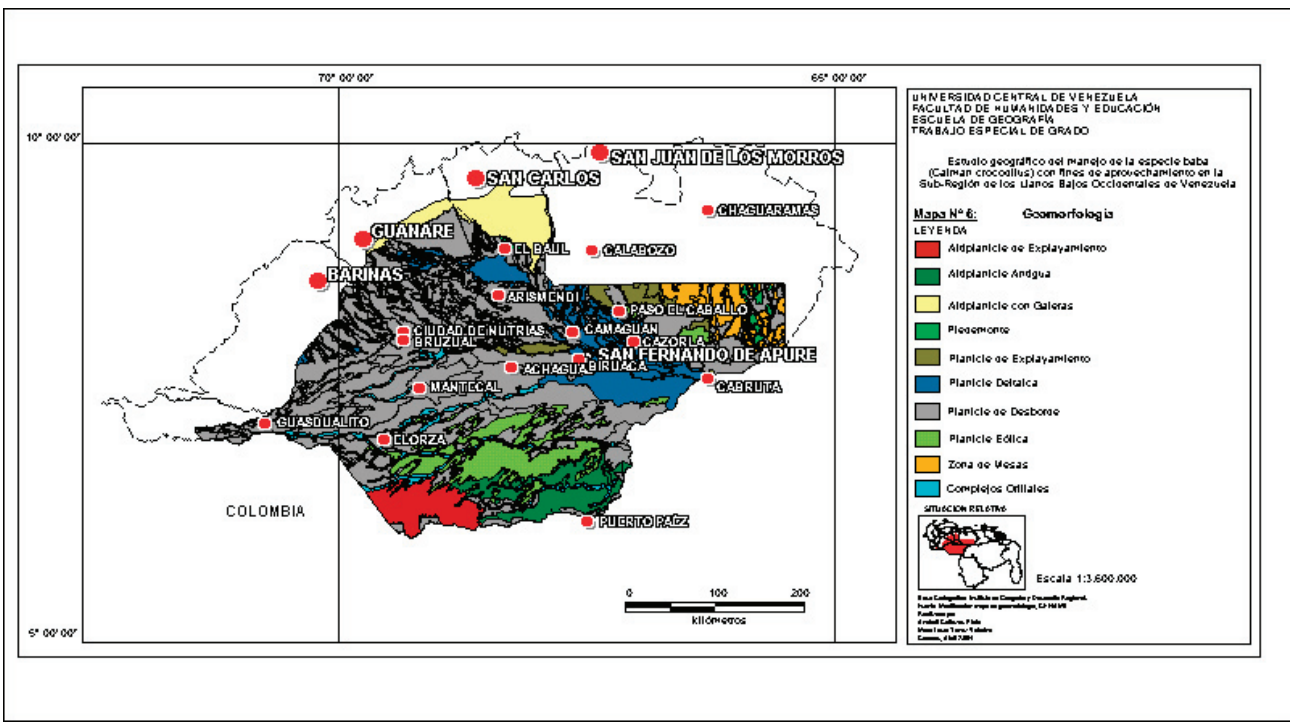
Map 3. Precipitation.



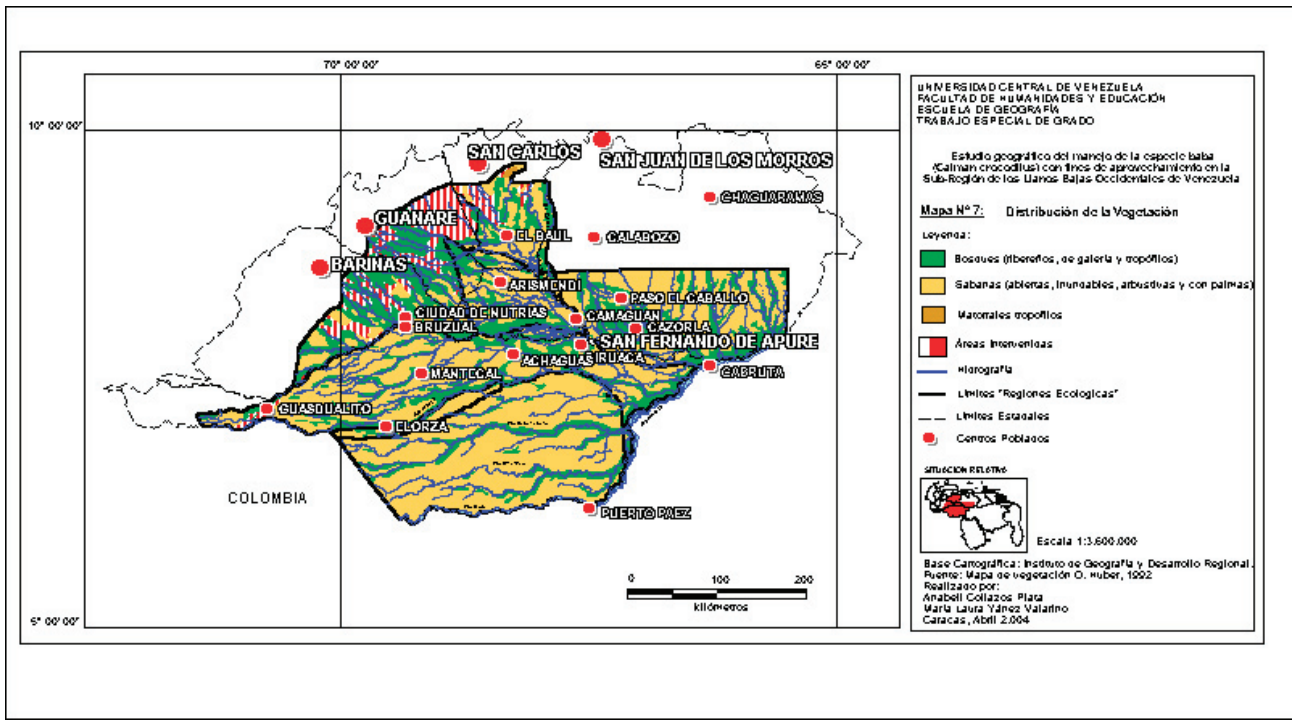
Map 4. Hydrography.



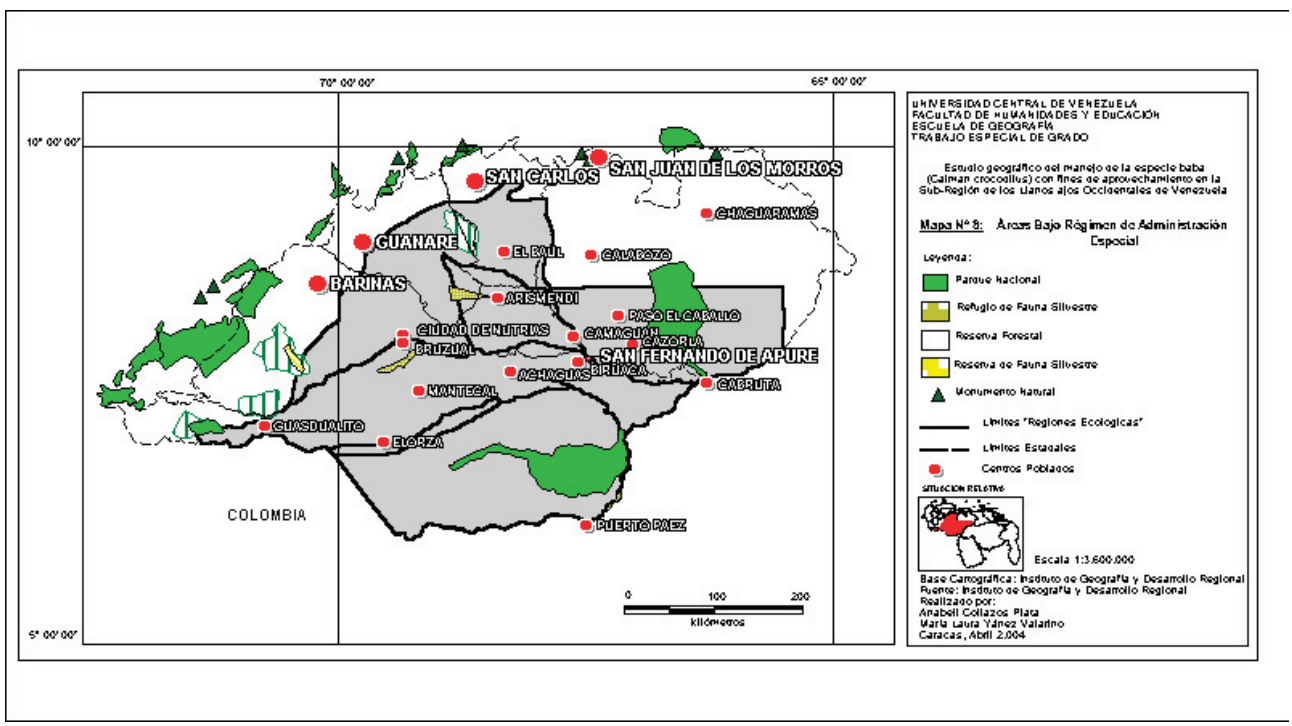
Map 5. Topography.



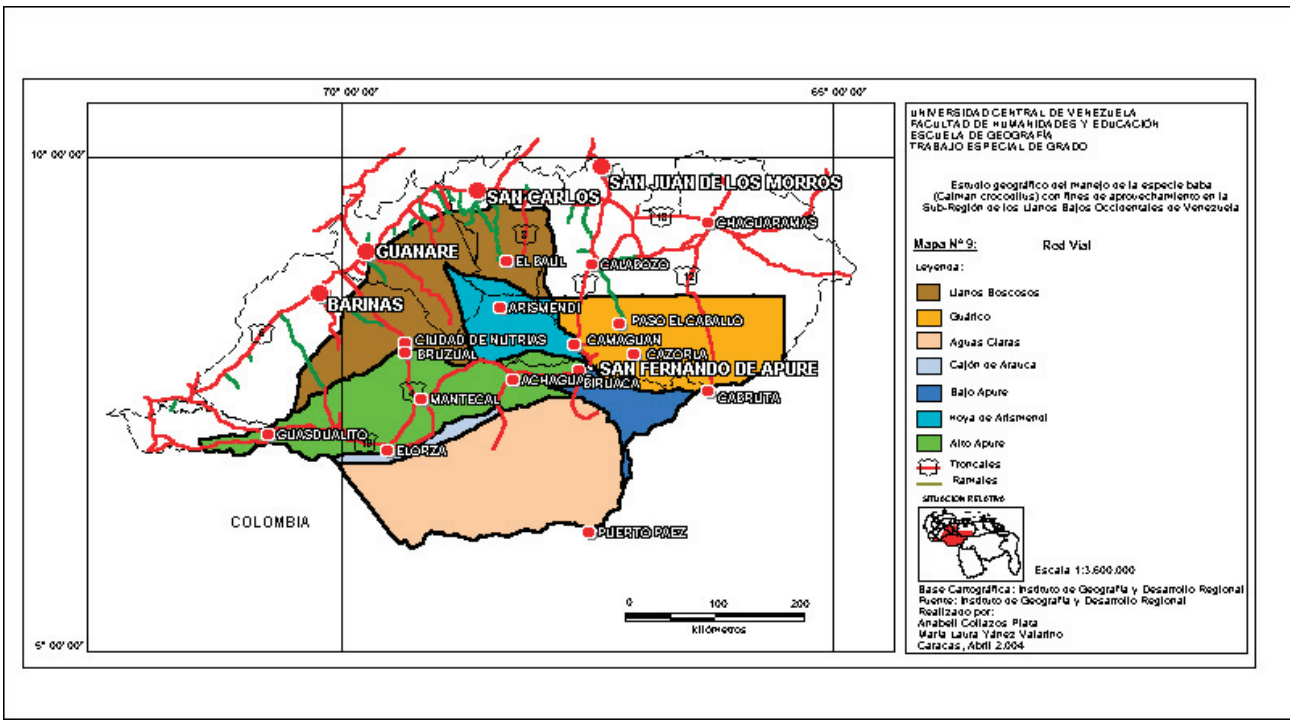
Map 6. Geomorphology.



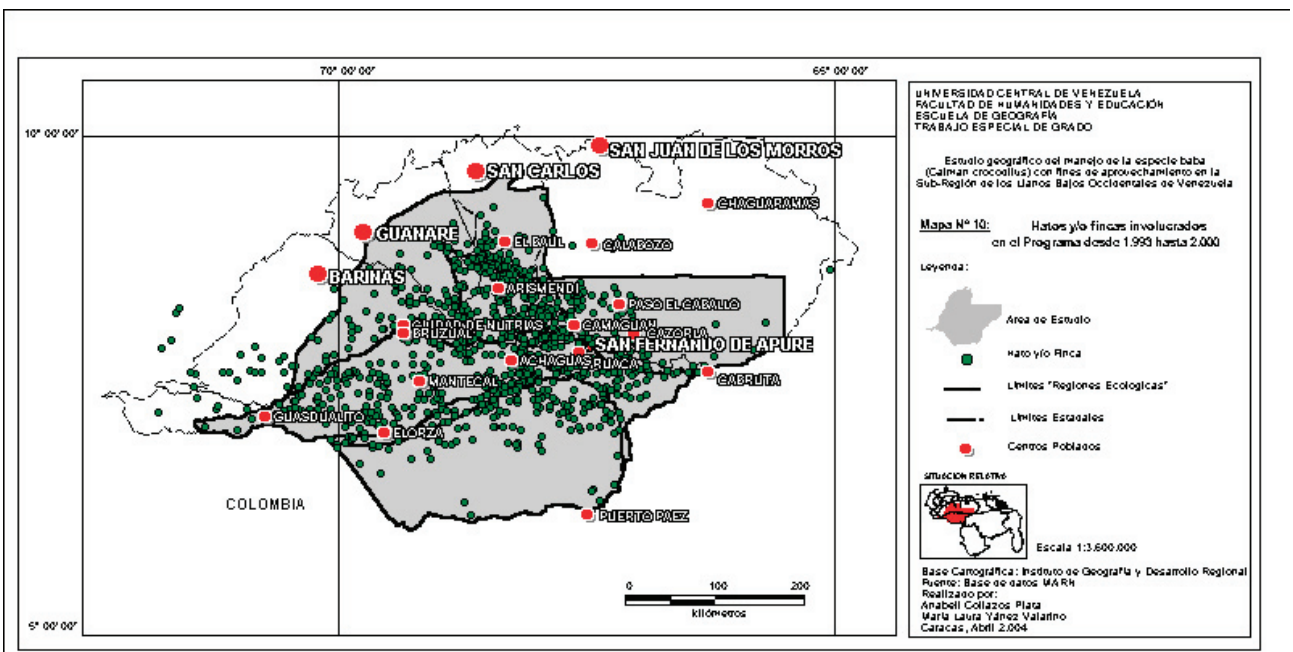
Map 7. Vegetation.



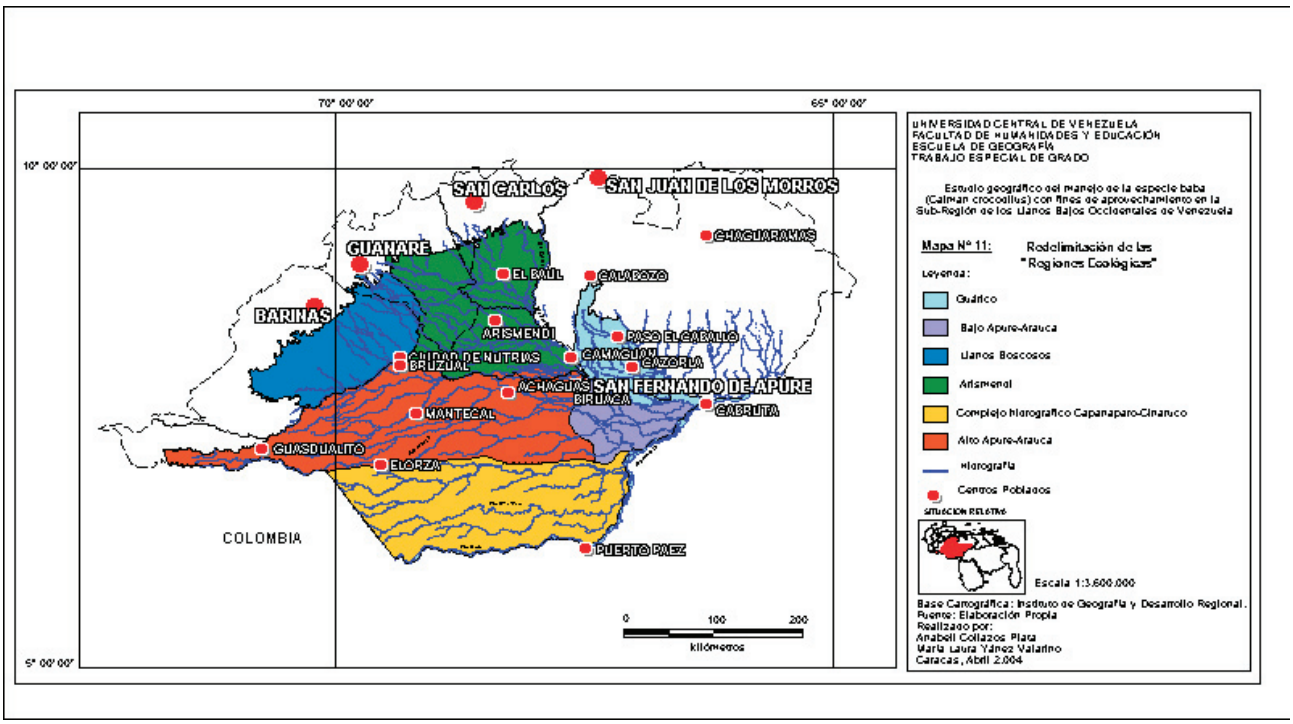
Map 8. Protected areas.



Map 9. Roads.



Map 10. Farms involved in the program, 1992-2000.



Map 11. Proposal on “Ecological Regions”.

Preliminary Examination of Crocodile Bushmeat Issues in the Republic of Congo and Gabon

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Abstract

Over a five week period we visited the WCS programs in northern Congo (Kabo-Pokola and Likouala-Lac Tele areas), and coastal Gabon (Iguela region) to appraise the potential for a research program that would investigate the ecology and natural history of central Africa's three crocodile species and the impact of the bushmeat trade on crocodile populations. In swamp forest habitats of both countries there is a significant harvest of dwarf crocodiles (*Osteolaemus tetraspis*), for local consumption as well as for sale and subsequent transport to regional or national population centers. Of the three species of African crocodiles, the dwarf crocodile is by far the most heavily hunted because its size and non-aggressive nature facilitates capture and transport to markets. Dwarf crocodiles are either bound and transported to markets live or, in the case of Gabon where outboard motors and ice are more readily available, killed and quickly transported to markets where they can be stored on ice for much longer periods. The other two African crocodiles, the Nile (*Crocodylus niloticus*) and slender-snouted (*C. cataphractus*), seem to be hunted less frequently today than they were in the past. They supplied the demand for crocodile skins until the market collapsed in the 1980s, but are still available in bushmeat markets (especially in Gabon). Very little is known about the ecology of any of the three species of central African crocodiles.

Introduction

Crocodiles are widespread in central Africa, inhabiting a wide variety of wetlands where they may play an ecologically important role as top predators. In some energy-poor environments such as swamp forests crocodiles may be one of the most dominant vertebrate species in terms of biomass. Crocodiles are traditionally an important source of protein for rural communities, particularly in low-lying, wet regions. Over the last 20-30 years, crocodile hunting has provided protein for the growing bushmeat trade, and today crocodiles can be regularly found for sale in urban markets throughout the region. Unlike mammals and birds, crocodiles can be tied up and kept alive for long periods (>1 month) which predisposes them for long-distance transport by truck or boat to urban centers. Bushmeat trade in dwarf crocodiles appears to be particularly important in Congo as these animals are relatively easy to catch, are non-aggressive, and are not too large to make transportation difficult. In Gabon, the trade is mostly in dead crocodiles. The two other species of crocodiles from the Congo (the Nile and the African slender-snouted crocodile) are larger species that have been reported occasionally from the bushmeat trade, and are also hunted at low-levels for an artisan skin trade. In the recent past, these two species were important in the global trade in crocodile skin and were hunted extensively.

The status and ecology of all three crocodiles in the region is very poorly known. The dwarf and slender-snouted crocodile are perhaps the least known of the world's 23 species of crocodilians. Nile crocodiles have been relatively well studied in eastern and southern Africa, where they inhabit seasonal rivers and lakes, but the populations in the Congo are found in forest rivers where little is known about their ecology. In other parts of central Africa, including Gabon, Nile crocodiles may be most common in coastal habitats where they live in estuarine areas. The IUCN has listed surveys in Central and West Africa as the top conservation priority for both the slender-snouted and Nile crocodiles (Ross 1998). The impact of widespread hunting for the bushmeat trade is an important question, particularly for the dwarf crocodile.

The lack of systematic surveys makes it impossible to quantify the size of the bushmeat trade in the Congo. Most reports are anecdotal or one-time observations from a single locality. Nevertheless, there are some clear indications that crocodile are an important component of the bushmeat trade:

- In the mid-1980s, it was estimated that during a four-month period some 3500 dwarf crocodiles were transported by boat into Brazzaville (Behra 1987).

- Reports from the early 1990s suggested that large numbers of crocodiles, particularly *Osteolaemus tetraspis*, were being sold in markets in Pointe Noir, Congo (Hutton 1991).
- A WCS sponsored survey of crocodile trade from Impfondo to Brazzaville in 1993 estimated that approximately 2,000 crocodiles a year were being shipped down the Ubangui River into Brazzaville (Efoakondza 1993).
- A study of bushmeat in northern Congo in 1996 found that at one village market, in an area with abundant swamp forest, some 30% of the bushmeat for sale was crocodile (Auzel and Wilkie 2002).
- Work by Marcellin Agnagna confirmed that in Congo the crocodile bushmeat trade continued at high levels in the mid-1990s.

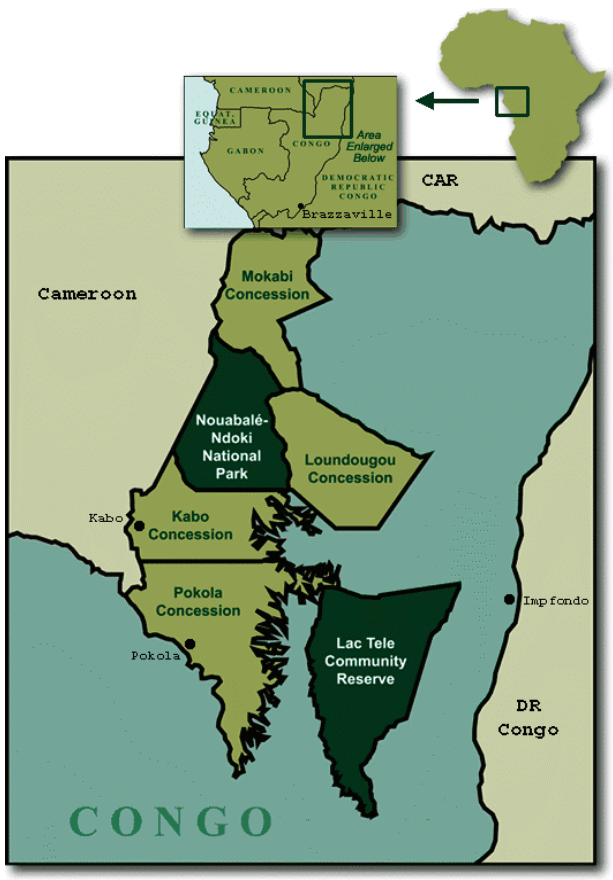
We conducted crocodile surveys, visited bushmeat markets, and interviewed local hunters in the Republic of Congo from 15 May-5 June and in Gabon from 6-25 June. The objective of this trip was to carry out a preliminary evaluation of the status of the three crocodile species in northern Congo and the coastal region of Gabon and the use of crocodiles in the bushmeat trade

Republic of Congo

In Brazzaville we visited a commercial fish market and an artisan market to collect information on crocodile meat and skin trade. We then flew north to Ouesso and, based in the Kabo logging concession, surveyed a variety of wetland habitat types, visited a bushmeat market in the town of Pokola, and conducted interviews with a range of people familiar with crocodiles and the crocodile meat trade. Traveling by pirogue we next visited Epena, the base of the WCS Likouala-Lac Tele project (Lac Tele Community Reserve), and we were able to carry out more surveys and interviews, collect ecological information on crocodiles, and visit meat markets in the regional capital of Impfondo, on the Ubangui River. The diurnal and nocturnal forays in the Likouala region were used to familiarize project staff with techniques for surveying crocodilians and collecting pertinent biological data.

Brazzaville

WCS Brazzaville staff members informed us that the Ouense market principally sold fish and, because crocodiles are considered by Congolese to be more closely related to fish than meat, is the only market to sell large numbers of crocodiles. In a year-long study at Brazzaville's large Poto Poto market, crocodiles were observed only a few times (Richard Malonga, pers. comm.). While a variety of fish was being sold, we only saw one dwarf crocodile, already chopped up and being sold in pieces. The seller indicated she had another crocodile in a freezer nearby. We were told most of the crocodiles arrive via a port on the Congo River and are sold by early morning. Brazzaville's evening market, "Dragont", was reported to sell crocodiles but was not visited.



The main artisan market in the Plateau section of town had a variety of crocodile (*Crocodylus* spp.) skin wallets and bags being offered for sale. The main seller indicated that the skins were from Congo crocodiles that were tanned and manufactured for sale in Brazzaville. We observed approximately 30 items made of crocodile skin.

Kabo-Pokola Region

The Kabo and Pokola logging concessions cover approximately 760,000 ha of *terra firma* (upland) forest just to the south of the Nouabale-Ndoki National Park in northern Congo. Wetland habitats that could be used by crocodilians are principally rivers and streams and small areas of swamp forest, particularly along the eastern and southern limits of the concessions, in inundated swamp forest fringing streams, and open marsh areas (*bais)* associated with streams. Localized depressions in the upland forest (*yangas)* are typically open canopied with water too warm for dwarf

crocodiles but may also provide habitat for some crocodiles (possibly temporary habitat for dispersing juveniles).

The Nile crocodile was historically present in this area but today appears to be very rare. We conducted a nocturnal survey of a 28.7 km section of the Sangha River between Mombongo and Kabo without seeing any crocodiles. The absence of crocodiles from this part of the Sangha was confirmed by local residents, who indicated they could be found further downstream, approximately 40 km below the town of Pokola. Some reports also suggested that a few Nile crocodiles may be found in parts of the heavily vegetated Ndoki River. The slender-snouted crocodile was reported to be found in the *bai* marsh habitats and in open sections of smaller rivers. On 20 May we observed three slender-snouted crocodiles (juveniles and subadults) along an earthen dike road crossing the Ndoki River next to the Ndoki 2 logging camp. All three were in relatively fast moving water where the stream passed through culverts under the road. Dwarf crocodiles are found in swampy sections of forest, including low-lying forests adjacent to streams and *bais*.

Dwarf crocodiles on a river boat in Impfondo, on the Ubangui River. Photo by Connie Clark.

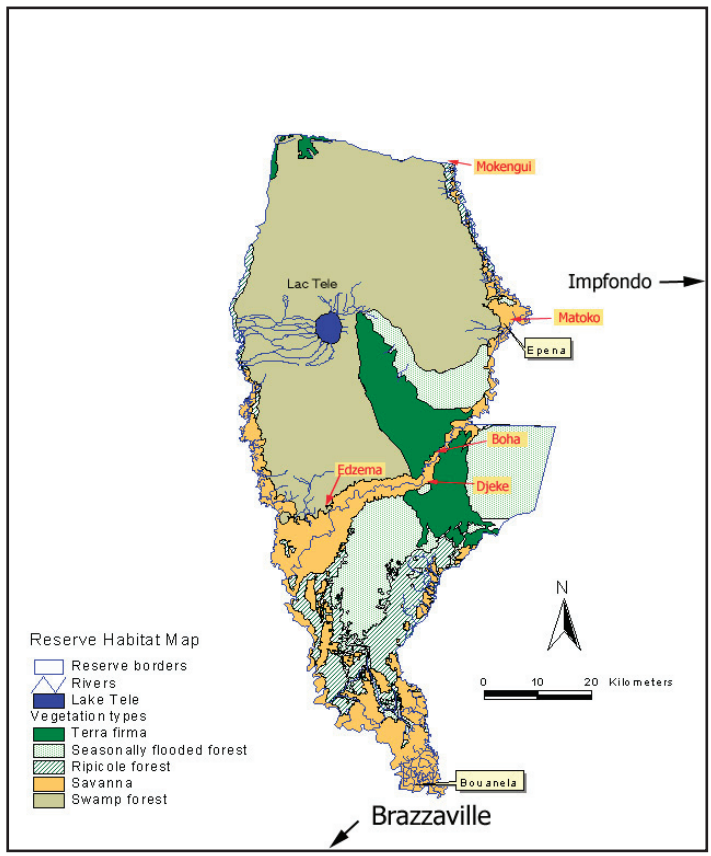
Market studies conducted in this region by WCS and others suggest that crocodiles are not an important component of the bushmeat trade in most parts of the Kabo region, with two exceptions. Crocodiles appear to be hunted widely in the Terre des Kaboungas region, in the easternmost section of concession, where the terra firma projects like a peninsula into an area of extensive swamp forest. Studies in the mid-1990s, when logging roads first entered this area, found that up to 30% of the bushmeat traded was dwarf crocodile (Azuel and Wilkie 2002). The second region where hunting of dwarf crocodiles appears widespread is on the Sangha River, downstream from Pokola, in the area around Pikounda.

Pokola is the headquarters of the CIB logging operation in northern Congo and is the largest village in the region (ca. 13,000 people). One goal of WCS activities in the region has been to eliminate the transport of bushmeat outside its village of origin, and in particular control bushmeat trade from logging camps into Pokola. We visited the Pokola market and interviewed a hunter who informed us that dwarf crocodiles are commonly sold in the market, and most of these come up the Sangha River in a CIB boat that makes a trip from Pokola to Pikounda (136 km downstream) and back every two weeks. Crocodiles, particularly dwarf crocodiles, were reported to be more abundant near Pikounda which lies close to the western margin of the massive Likouala swamp forest block.

Consolidating information from interviews with several hunters, fishermen and pygmies in the Kabo region, it appears that the nesting season for dwarf crocodiles peaks between February and late April and was over by the time of our visit. This period corresponds to the major dry season in northern Congo beginning in January and lasting until March or April. It is likely that all three species build nests in the dry season to time the emergence of hatchlings with the onset of rains. We were unable to find evidence of any crocodile nests, recently hatched or otherwise, during our surveys in the Kabo region.

Likouala Region (Lac Tele Community Reserve)

The Lac Tele Community Reserve (LTCR) is a markedly different landscape from the Kabo-Pokola logging concessions, dominated by vast sections of swamp forest mixed with a range of other habitats including seasonally flooded forest and savannas, as well as some upland terra firma forest. Because swamp forest is difficult to access and contains few commercially valuable trees, the area is of little interest to logging companies and by and large remains intact. The reserve is Congo's one Ramsar site (declared in 1998). In the swamp forest itself, faunal composition is different from upland forests, with most vertebrates being either arboreal or aquatic. Previous studies of bushmeat originating from areas of swamp forest suggest that crocodiles and primates are the principal prey.

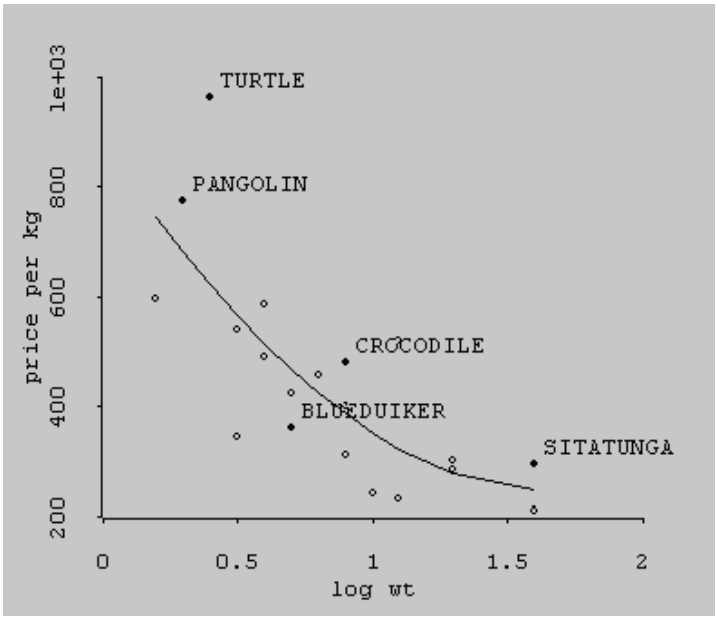


Overall, we found that the Likouala aux Herbes river had a low density of Nile crocodiles in areas downstream from Epena (we observed them between the villages of Edzema and Djeke), and dwarf crocodiles were widespread, but at low densities, in both seasonally inundated and swamp forest. We were able to collect some information on the ecology and past and present hunting of both these species. The slender-snouted crocodile was also reported to be in the area, particularly in small forested rivers, but none were seen. We discovered two dwarf crocodile nests during our surveys in the swamp forests surrounding the Likouala aux Herbs River - one, found on 29 May, appeared as though its eggs (13 total) would hatch soon; the other, found on 1 June, had recently hatched.

We spent several days visiting bushmeat markets in the regional capital of Impfondo, situated on Ubangui River (which forms the boundary between Congo and the Democratic Republic of Congo (DRC)). Impfondo is connected to Epena by a paved road (ca. 70 km) and has an active commercial trade in dwarf crocodiles. During 2.5 days at Impfondo's Bakanzi market we saw (and measured) 22 dwarf crocodiles - all adults. The sex ratio appears to be male-biased (15 males: 7 females). During our visit (dry season), most of the crocodiles were reported to be transported across the Ubangui from forests in the neighboring DRC. During the dry season, swamp forests remain difficult to access on foot and are non-navigable by boat as they are reported to be during the high water season when hunters can enter in small pirogues. Extensive wet season hunting of dwarf crocodiles was reported from the upper reaches of the Likouala, particularly in the town of Mokengi. People we interviewed agreed that many more crocodiles could be found in the market during the wet season.

The crocodiles we observed in the main Impfondo market were destined for local consumption, but a significant number of crocodiles were also reported to be sent from the Impfondo area to Brazzaville, by riverboat (mostly during the wet season when the river is high enough for large boats), and by plane.

In the Congo, the dwarf crocodile appears to be a swamp forest habitat specialist, and in some areas is hunted heavily for the bushmeat trade. Dwarf crocodiles are highly prized as bushmeat because they are small and non-aggressive, which facilitates capture and transport, and allows animals to be kept alive for periods of days or weeks, insuring that the meat will arrive fresh at the market even when no refrigeration is available. Data on the sale of bushmeat in northern Congo found that, per kilogram, the price crocodile meat was slightly higher than the average for 21 species compared (Eaton 2002). However, price per kilogram appears correlated to the size of the whole animal and not entirely based on preference. Comparing the infrequently hunted dwarf crocodile with the commonly hunted blue duiker in northern Congo, it is of interest to note that the former, with an average weight of 7.3 kg, was sold for



Price sold per kg (in FCFA) against the log wt of 21 bushmeat species (selected species highlighted)

approximately 450 francs/kg while the latter (averaging 4.8 kg) sold for only 360 francs/kg. From this, we might conclude that either crocodile meat is preferred to blue duikers or that uncommon species might command a higher market price.

Crocodile hunting techniques

This summary of dwarf crocodile hunting techniques is from the Congo, based on information in Agnagna *et al.* 1996 and interviews we conducted. It seems likely that many of these same methods are used in Gabon as well, but because of the availability of ice, crocodiles that are drown in fishing nets may also be sold in markets in Gabon. The first two methods appear to be the commonly used.

1. Hooking out of burrows. Mainly used during the dry season. When a crocodile is located in a burrow this technique is used to pull it out. A sharp hook (usually fashioned from a bent steel reinforcement rod) is attached to the end of a pole or a more flexible liana and introduced into an occupied burrow. The hook is moved in and out both to confirm that a crocodile is present, and to hook it.
2. Baited hook. This is the principal technique used during the wet season. The hunter identifies a pool or flooded area frequented by a crocodile (usually based on tracks or other sign, or by banging a paddle on the side of the canoe and hearing a crocodile respond). A large fish hook is baited with decomposing fish or a frog and left at the edge of the water and tied to a nearby tree with a length of rope. Crocodiles swallow the hook and are captured when the hunter returns.

3. Hunters attract crocodiles by imitating adult/juvenile distress calls, or by making a bubbling noise by blowing into a bamboo tube with the tip underwater. Crocodiles that approach are captured with a fish spear, a forked stick, a net, or grabbed with the bare hands.
4. Hunting at night from a canoe with a flashlight and a multipronged fish spear.
5. Finding incidentally in forest pools and grabbing with bare hands.
6. Blocking up burrows with leaves/mud and pulling out dead crocodiles after they have drowned.

7. Soaking a cloth with gas and push it into a dry burrow with a stick, causing the crocodile to abandon the burrow.
8. Using a spear to stab and kill the animal while it is in the burrow.

Dynamics of the crocodile trade in the Lac Tele Community Reserve-Impfondo region

All three species of African crocodiles are known to occur in the LTCR area in Congo. Because the region is heavily dominated by swamp and seasonally-inundated forest, the area is particularly suitable for the African dwarf crocodile. In May-June 2003, we spent approximately two weeks in the LTCR collected collecting information on the status, ecology and hunting of crocodiles in the LTCR, as well as in the nearby town of Impfondo, situated to the east of the LTCR on the Ubangui River.

This preliminary study has shown that crocodiles are widely hunted throughout the region. In the LTCR, crocodiles are hunted throughout the year using a variety of techniques. During the annual low water period, crocodiles are relatively easy to locate in their underground burrows, and are pulled out using a long section of liana with a hook attached to the end. The hunter probes likely holes with the hook until he locates an occupied burrow. Once extracted crocodiles are tied up and carried out of the forest alive. Hunting of crocodiles increases during the wet season when fishing is less productive, and when flooding provides easier access to the forest in pirogues, which also greatly facilitates the transport of captured crocodiles. Based on information from a previous WCS study by Basile Efoakondza in 1993, the early dry season (Dec-April), when water levels are falling but still high enough to permit access into the forest by pirogue, is the most favorable time of the year for hunting dwarf crocodiles.

In the southern sections of the LTCR, crocodiles are hunted primarily during the early wet season (August) and are kept alive until the level of the Likouala aux Herbes River rises enough to allow commercial boat traffic (usually in September). Crocodiles are then sold to traders on the boats and taken downriver to Brazzaville by way of the Sangha and Congo Rivers.

Crocodile hunting appears to be a regular activity of certain individuals in nearly all the villages in the LTCR, but some communities are renown for their dedication to crocodile hunting. In the northern LTCR one such village is Mokengui, where hunters take crocodiles from the northern parts of the reserve as well as the extensive swamp forests further north. Captured crocodiles are transported down the Likouala aux Herbes River to a paved road in the village of Matoko, where they are sold. Traders will then transport the crocodiles into the town of Impfondo on public transport or a military truck. Just to the east of the LTCR, hunters will transport crocodiles by pirogue down the Tanga River to the village of Botola, along the same road into Impfondo.

There is also considerable commerce across the Ubangui River from the DRC into Impfondo, including crocodiles. Crocodiles that arrive in Impfondo, either from the east (DRC) or the west (Likouala region) are either sold for local consumption, or transported alive (and occasionally smoked) south to Brazzaville. During the high water period large riverboats can ply the waters of the Ubangui and will transport crocodiles, stopping at other villages along the way and thus providing traders with the opportunity to purchase more crocodiles. Crocodiles are also transported from Impfondo to Brazzaville on a regular commercial flight, tied up and bundled into the cargo compartment with the rest of the travelers' luggage. Crocodiles are also flown out on occasion on military transports (P. Elkan, pers. comm.).

In Impfondo, crocodiles are sold in the Bakanzi morning meat and fish market with other bushmeat. Crocodiles are brought in alive before being dismembered and sold in Fcfa 500 ($US 1) piles. And adult male dwarf crocodile (12-15 kg) can be purchased whole by market sellers for Fcfa 8000-10,000 ($US 13-17).

In 1993, WCS sponsored an evaluation of the crocodile trade between Impfondo and Brazzaville. The results were presented in two interim and one final report by Basile Efoakondza and are summarized here. Some of the information in these reports appears to be incorrect (particularly regarding the sexes of crocodiles), and the surveys were not conducted in a systematic fashion, but much of the information from these reports is illuminating.

The information was gathered during five round-trip boat voyages from Brazzaville to Impfondo. Crocodiles were measured and the owners interviewed as they entered the boat. The author points out that the monitoring was not exhaustive, as animals would enter both day and night, frequently come aboard in numbers too great for one person to deal with, and many of the owners would not let him collect information. The author also spent time collecting information on crocodiles in the main market in Impfondo, and on one of his trips also traveled to Epena. Overall, the report concludes that some 2000 crocodiles a year are shipped down the Ubangui to markets in Brazzaville.

Travel Time. Boats normally took about 10 days to travel upstream and 7 days downstream. Travel times were longer in the dry season when boat navigation was difficult (or impossible at the height of the low water period).

Species Composition. A total of 730 crocodiles were registered coming aboard the boats, of these 721 (98.8%) were dwarf crocodiles and only 9 were slender-snouted crocodiles.

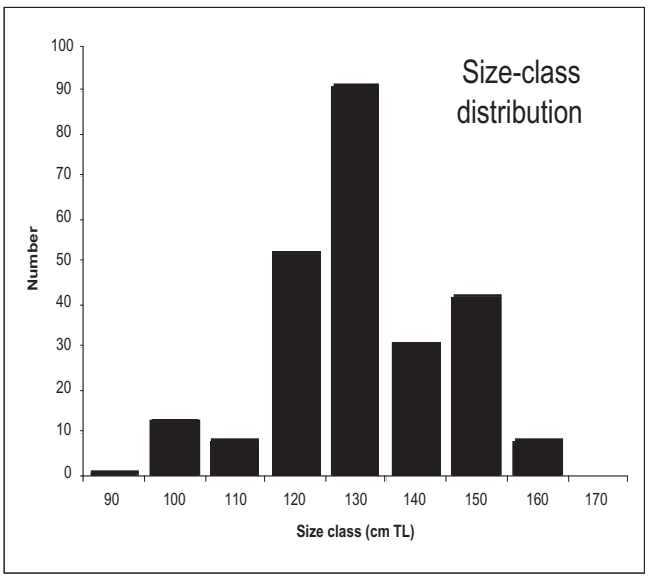
Source of animals. Crocodiles were brought aboard the boat at nearly all the villages downstream of Impfondo, between Impfondo and Mossaka (situated near the mouth of the Likouala River (Table).

Animals that were sold in the Impfondo market originated in both the Republic of Congo (Likouala area) and entered Impfondo along the Epena Road, or in the Democratic Republic of Congo and were traded across the Ubangui River. In one sample of 51 animals collected over 9 days in November 1993, 43 (84.3%) came from the DRC.

Sex Ratio. Although the reports presented information on the sexes of crocodiles measured, we considered these data to be unreliable, based primarily on the fact that animals recorded as females almost certainly were males based on their size (≥140 cm TL).

Village	Crocodiles
Balloye	21
Boleke	4
Botala	2
Botounou	2
Bouboulou	4
Bouboulou Zaire	4
Lango	2
Likiendze	3
Liranga	10
Longo	22
Loukolela	2
Malembe	2
Moboukou	1
Molembe	4
Mombendzele	14
Mossaka	5
Ngombe	9

Size-class distribution. The size-class distribution of 246 crocodiles that were measured by Efoakondza is presented here as a graph. These data show that hunting is clearly aimed at adult animals, principally crocodiles over 120 cm TL. The largest crocodiles in the sample were 160 cm (including one crocodile sexed as a female but almost certainly a male), and the smallest was a 90 cm TL male. The size-class distribution shows a peak in the 130-140 cm TL interval, which likely represents large adult females and young adult males. The secondary peak from 150-160 cm TL is probably comprised entirely of adult males.



Mortality. In the interim reports, with information from two voyages, the mortality rate of crocodiles on boats was estimated to be 5-6%. However, the final mortality rate was much higher - 17.8%, with a total of 130 dead crocodiles found. Dead crocodiles were butchered and sold on the boat or smoked presumably so they could continue the voyage and be sold in Brazzaville .

Prices. Crocodiles coming from the Epena region were reported to be sold for an average of about C CFA 2,000 in the town of Botala (on the Likouala-aux-Herbes near Epena). The same animal would sell for approximately C FCA 4000 in Impfondo and C CFA 6000-10,000 in Brazzaville.

Efoakondza estimated that approximately 2000 crocodiles per year were transported from Impfondo to Brazzaville during 13 voyages. Crocodiles rarely make it to Brazzaville aboard the boats. Buyers from Brazzaville markets usually meet the riverboats in Maloukou, at the upstream end of the Stanley Pool, in order to buy crocodiles at a lower price. We learned from our interviews that crocodiles were sold prior to entering Brazzaville in order to avoid government wildlife authorities searching boats for illegally transported animals.

Gabon

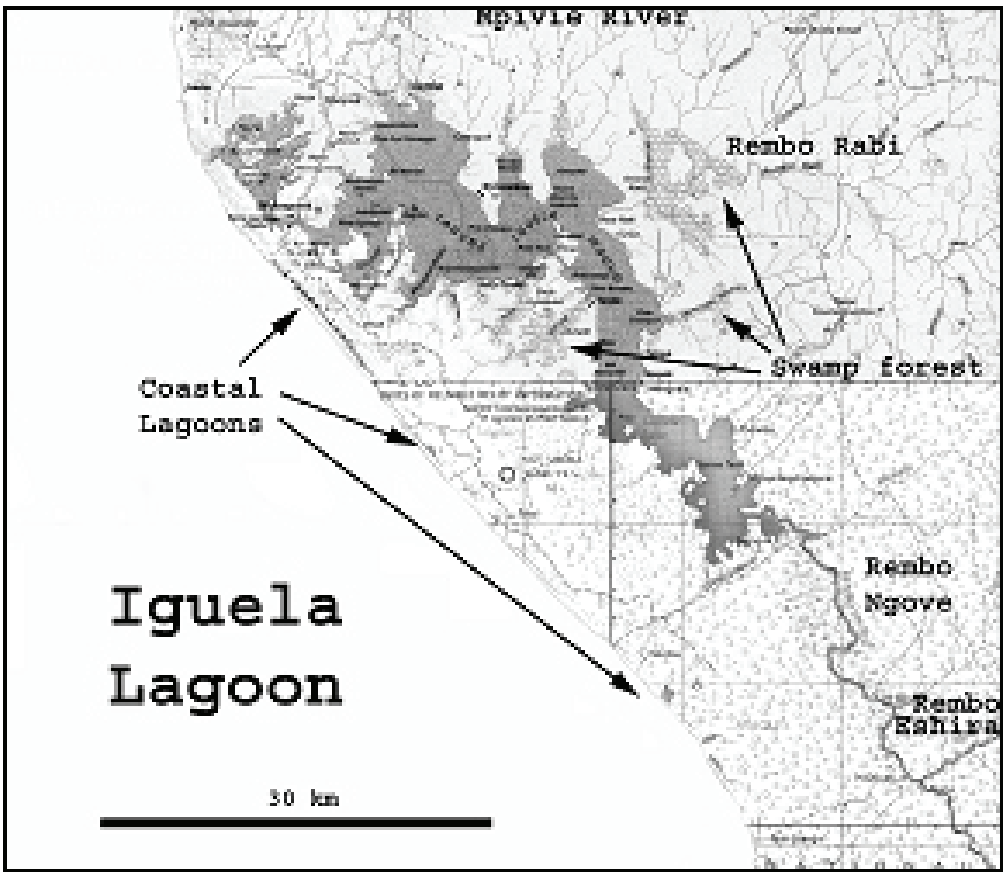
In Gabon we were based at the Iguela Lodge, adjacent to the Loango National Park, and situated on the Ngove Lagoon. Over the next two weeks we carried out day and night surveys of the Mpivie River, a portion of the southern shore of the Nkomi Lagoon, sections of the northwestern Ngove Lagoon, rivers flowing into the Ngove (the Ngove, Rabi, and Yombe), as well as a series of coastal lagoons stretching along 48 km of shoreline. On four of these outings we were accompanied by staff from the Gabonese Fish and Wildlife Department to familiarize them with survey procedures. We are able to conduct nocturnal surveys in a variety of wetlands, and were impressed with the diversity of habitats and the overall high density of all three species. Our last two days were spent collecting information on crocodile bushmeat trade in Port Gentil.

Nile crocodiles, because they nest in sandy soils, were restricted primarily to the northwestern sector of the Iguela Lagoon (adjacent to an extensive network of paleobeaches), and the many small coast wetlands that form behind the uninhabited beach of the Petit Loango NP. In these areas Nile crocodiles were widespread, but usually at relatively low densities. Based on reports (eg Behra 1987) and several interviews we conducted during our visit, the hunting of Nile crocodiles by Africans and Europeans for the skin trade was widespread during the decades of the 1960s through 1980s. Commercial hunting of the Nile and slender-snouted crocodile largely ended with the implementation of CITES restrictions and the subsequent collapse of trade in wild crocodile skins. Behra (1987) found no Nile crocodiles in his surveys of the Sette Cama region and Fernan Vaz lagoon and reported organized and widespread commercial hunting up to a few years prior. The observation of many Nile crocodiles (but few adults) during our surveys, conducted nearly 20 years after Behra's, suggests that this species is in the process of making a slow recovery. In some of the coastal lagoons we found Nile crocodiles present in brackish waters (up to 17 ppt). Tracks suggest that crocodiles move overland between lagoons and will enter the ocean as well.

The African slender-snouted crocodile appears to be locally common in medium-sized rivers both in areas of forest (Mpivie River, Rembo Eshira) as well as areas where rivers are bordered by marsh (Rembo Ngove). Dwarf crocodiles are common in the Iguela area and are found principally in the extensive swamp forests that borders the Iguela Lagoon and some of its tributary rivers (Rembo Rabi). Dwarf crocodiles may also enter cool forest rivers (water

temperature <25˚ C) at night, and were also observed at night along the margins of the Iguela Lagoon where it was bordered by swamp forest. In the latter case they appear to spend the day in burrows or buried in mud in the swamp forest and then forage along the lagoon edge at night.

Hunting crocodiles for bushmeat is relatively uncommon in the Iguela lagoon region, if only as a result of the very low human population density. However, there appears to be significant hunting in some areas adjacent the park, particularly around the southern edge of the Nkomi Lagoon and the Rembo Nkomi (A. Downer, pers. comm.), where larger villages are situated. Crocodiles in these areas are taken for local consumption, or sold in markets in Omboue or Port Gentil. Unlike Congo, where crocodiles are kept alive until butchered in the markets, crocodiles enter the Omboue and Port Gentil markets dead and are kept on ice, which, unlike in Congo, is readily available in Gabon. Our preliminary observations also suggest that while dwarf crocodiles comprise the majority of crocodile bushmeat in Gabon, slender-snouted crocodiles are more commonly seen in markets than in Congo. Over a one-day period we saw 15 dwarf crocodiles and 4 slender-snouted crocodiles in the Marche La Ville, the largest of four markets in Port Gentil reported to sell crocodiles. The sale of meat from the larger slender-snouted crocodile may also be result of the availability of ice, as it allows large crocodiles to be transported to markets dead then butchered and sold over a period of several days, a process that would be difficult in Congo.



Dynamics of the crocodile trade in the central coastal region of Gabon

Omboue Market, Nkomi (Fernan Vaz) Lagoon

While the village of Omboue is the largest population center in the region around Iguela, it may not be a large importer of hunted crocodiles to its market. From discussions with project staff and local residents, villagers from settlements such as Saint Anne, Asseywe, and Ndougou, as well as from Omboue, may hunt large numbers of crocodiles for export to Port Gentil markets. We were told of a ferry that travels once per week, stopping at each of these villages, to Port Gentil and which is used to export crocodiles and other bushmeat. Crocodile hunting, in this region at least, appears to be more opportunistic than deliberate. Most of the residents we spoke with about crocodiles said that crocodiles are killed when found entangled in fishing nets, rather than the specific target of hunting. Crocodile hunting certainly occurs in this region, but fishing appears to be the principle economic activity. The village chief of Idjembo stated that crocodile skin hunting by Europeans was widespread 30+ years ago and that people currently

living on the Mpivie River have killed all the large crocodiles (*C. cataphractus*). The chief's lack of knowledge of crocodiles (ie stated that no crocodiles live in Iguela lagoon as it is too salty) indicated that they are not heavily hunted by this village. More time spent in village markets and talking to villagers is needed to better understand the importance of crocodiles in the local diet and in local and regional economies.

Omboue market was visited briefly only twice. An afternoon visit on 8 June found the market almost deserted with a small amount of smoked fish and some agricultural products for sale. A late morning (9:50) visit on 23 June found 3 softshell turtles (2000-4000 FCFA/ea.) and one piece of smoked turtle (likely *Trionyx* sp.). A woman with a sack full of monkeys in wheelbarrow was seen outside the market (number, species, and destination unknown), and the head of a dwarf crocodile was found floating in the water near the town's port.

Port Gentil

There are several markets in Gabon's second largest city, with the Marché de la Ville seemingly the largest and most important for the bushmeat trade. The Marché de la Ville, located near the city's main port, appears to receive shipments of agricultural products on a daily basis but was said to be supplied with bushmeat only on Mondays and Thursdays. Vendors indicated that bushmeat arrives in pirogues returning from the Ogooué River delta. The Marché de la Ville contains numerous ice chests distributed throughout the market which, along with an ice factory located in Port Gentil, allows vendors to store and sell bushmeat throughout the week rather than only on Mondays and Thursdays. It is very likely that boats leaving Port Gentil are supplied with chests or coolers full of ice to facilitate the transport of bushmeat from large distances. This situation is fairly unique, as the distance for exporting fresh bushmeat elsewhere in central Africa is often limited by the maximum travel time which prevents spoilage of the meat (with the exception of live crocodiles). In addition, without ice vendors must either smoke the meat or sell fresh game within a day or two of it being killed. One very noticeable difference in hunting between northern Republic of Congo and Gabon is that crocodiles (especially dwarf crocodiles) are nearly always captured and transported live in Congo and nearly always killed in Gabon. The availability of ice, and therefore the ability to transport larger distances, in Gabon appears to be the most obvious explanation for the differences in hunting technique.

We were present at the Marché de la Ville on Monday (23 June, 2003) and recorded the arrival of a substantial amount of wild game (see below). Boats on Mondays and Thursdays were said to arrive in the morning and evening, but we observed several wheelbarrows full of bushmeat being brought into the market at midday. We assumed these animals were transported from the port. One man, claiming to be the hunter, was carrying 13 headless dwarf crocodiles in a wheelbarrow and informed us he had transported a total of 22 from the swamp forests surrounding the Ogooué River.

Visiting the port on a Tuesday (24 June, 2003), we saw a number of large pirogue-like boats, many with multiple outboard engines. The boats' appearance suggested they would be able to either cross the bay or follow the coast from the Ogooué Delta. Presumably, these boats would arrive without an established schedule, leaving unclear why the Marché de la Ville receives bushmeat only twice per week. One possible explanation is the ferryboat 'Fernan Vaz', which was also seen at the port on Tuesday loading people and supplies for departure. We assumed this to be the ferry mentioned above, traveling once per week from Assaywe, Ndoiugou, Saint Anne and Omboue to Port Gentil. We were unable to verify if this boat arrived on Monday, nor if this or another ferry also arrives on Thursdays.

The port area, situated very close to the Marché de la Ville, also has a market that sells agricultural products, manufactured goods, and bushmeat. We were told that the Port Market receives pirogues (i.e. bushmeat) only on Fridays, but were unable to determine from where. No bushmeat was seen at the port during our visit.

Many of the restaurants in Port Gentil serve bushmeat on their regular menus. One restaurant near the Marché de la Ville (Cafe du Wharf) had an entire page of its menu dedicated to dishes prepared with bushmeat, including crocodile, red river hog, porcupine and antelope. A restaurant owner of European nationality was seen in the Marché de la Ville purchasing a red river hog for his business.

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Evaluation of Wild Populations and Habitats of American Crocodile (*Crocodylus acutus*) in Venezuela

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Abstract

The American crocodile (*Crocodylus acutus*) in Venezuela is considered an endangered species included in Appendix I of CITES. Government is developing a Conservation Program, which includes population surveys in natural habitats and ranching for reintroduction. Abundance and size structure of wild populations, and a characterization of occupied and potential habitats were carried out, in order to choose better reintroduction areas. A total of 23 locations within the historical distribution area of the species were visited, observing a total of 292 crocodiles. Size structure was: 99 hatchlings, 257 juveniles, 72 small-sized adults, 44 adults, and 29 large adults. The highest abundance was located at the Tocuyo River. The favorable environmental conditions considered for habitat characterization was the presence of stable populations, mangrove or marginal forests, potential nesting sandy beaches, affluence or predominance of freshwater, and legal protection. As negative factors, the presence of tourist activity, housing, agriculture and industrial activities, navigation, fishery, and proximity to roads were identified. Statistical tests indicated that the better marine-coast area for reintroduction was Turiamo Bay. Among freshwater environments, the most favorable were the Tocuyo and Tucurere Rivers, and the reservoirs of Játira and Burro Negro.

Resumen

El Caimán de la Costa (*Crocodylus acutus*) es una especie amenazada, incluida en el Apéndice I de CITES. El Gobierno venezolano ha desarrollado un Programa de Conservación, realizando censos poblacionales de la especie en su hábitat natura y cría en cautiverio para reintroducción. En el presente trabajo se evaluaron las poblaciones naturales en términos de su abundancia y estructura de tamaños, y los hábitats naturales de la especie, con la finalidad de proponer zonas de liberación y reintroducción. Se visitaron 23 localidades del área de distribución histórica de la especie donde se observaron 291 caimanes sin incluir los individuos pertenecientes a la clase I (99 en total). La clase II está representada por 157 ejemplares, la clase III por 71 caimanes, la clase IV por 44 individuos y la clase V por 19 ejemplares. La mayor cantidad de individuos se localizó en el Río Tocuyo (Edo. Falcón). Entre las condiciones ambientales favorables para el establecimiento de poblaciones estables de la especie se citan la presencia de manglares o vegetación marginal boscosa, playas arenosas para la anidación potencial, afluencia o predominancia de aguas dulces, protección a través de figuras legales, y presencia actual de la especie. Como factores negativos, se identifican la presencia de actividad turística, viviendas, actividades agrícola e industrial, navegación, pesca y cercanía a vías de acceso. De acuerdo a resultados estadisticos, el area marino-costera mas favorable fue Bahia de Turiamo. Entre los ambientes de agua dulce, los mas favorables fueron los Rios Tocuyo y Tucurere, asi como los embalses de Játira y Burro Negro.

Introduction

The American Crocodile (*Crocodylus acutus*) is geographically distributed within the south coast of Florida (USA), all the Great Caribbean Sea, and coasts of the Pacific Ocean from Mexico and Central America, Colombia and Peru (Fig. 1). The historical area of distribution in Venezuela includes the whole marine coast. Seijas (1984, 1986a, 1990), Arteaga (1997) and Arteaga and Sánchez (1996) recorded the presence of this species in several coastal and freshwater locations.

This species is currently included in Appendix I of CITES in Venezuela. The Ministry of Environment and Natural Resources (MARN) of Venezuela started in 1993 the National Program for Conservation of the American Crocodile (Velasco *et al.* 2000), with the collection and ranching of hatchlings from Turiamo Bay (Aragua State) and Fundo Agropecuario Masaguaral (Guárico Stete), to be released after one year of raising at the Cuare Wildlife Refuge (Falcón State) (Velasco and Lander 1998). One of the objectives of this Program is the identification of other favorable locations for reintroduction of the ranched individuals, within the historical area of distribution of this species.

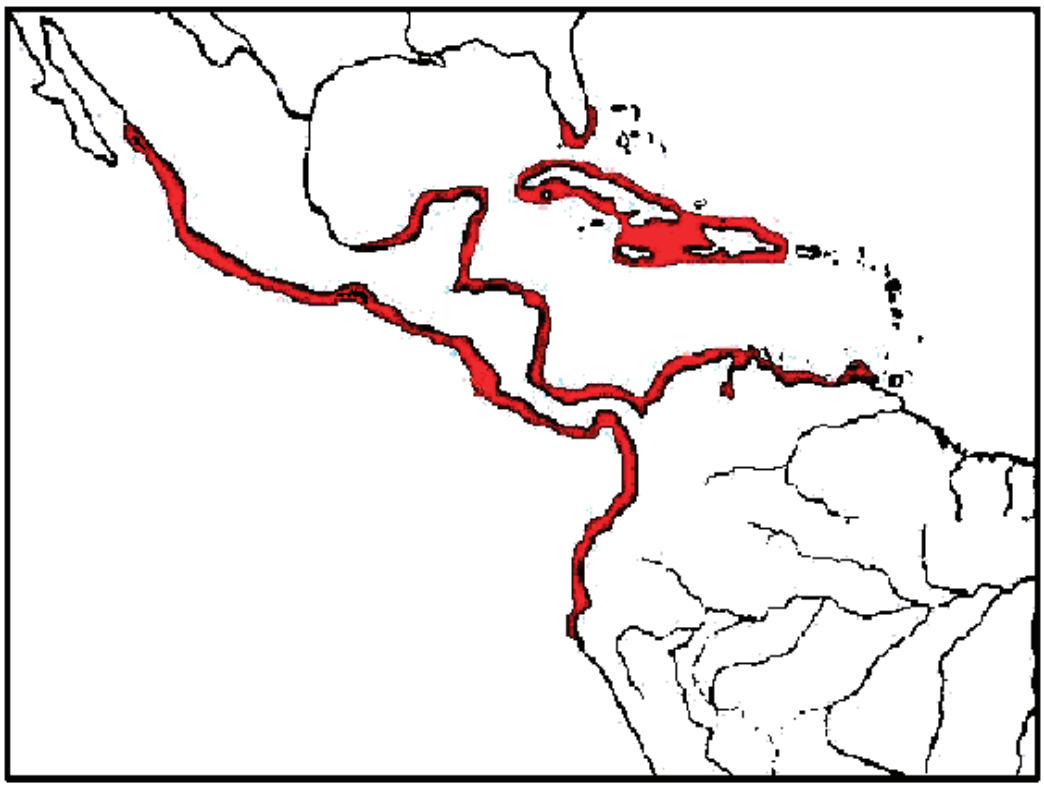

Figure 1. Distribution of the American Crocodile (*Crocodylus acutus*).

There are few works on habitat characterization for this species, since most publications are related with population status. Seijas and Chávez (1990) mentioned some factors affecting the presence of the American Crocodile in several Venezuelan locations, remarking the habitat destruction and presence of human population. Platt and Thorbjarnarson (1997) reported in Belice that the alterations of beaches were seriously affecting the nesting activities and that mangrove forests were the optimal areas for the species. Soberon (2000) in Cuba also pointed out the mangrove forests with freshwater lagoons, creeks and reservoirs, as the most suitable zones for the species.

The objective of the present work were to evaluate abundance and size structure of wild populations of the American Crocodile, and the general description of habitats within its historical distribution area in Venezuela, with the aim to propose new wild locations to release ranched individuals.

Area of Study

The field work was carried out during August to November of 2002, at several locations on or near the Caribbean coasts of the country (Fig. 2), including mangrove areas, coastal lagoons, river mouths, channels and reservoirs, selected to evaluate its properties as habitats for the species:

Central-Eastern Coast

Neverí River, Píritu Lagoon, Uchire Lagoon, Caño Sur and Caño Camaronera (Uchire Lagoon), Unare River, Tacarigua Lagoon and Río Chico Channels.

Western Coast

Turiamo Bay, Yaracuy River, Aroa River, Paují Creek, Las Pabas II Creek, Cumaripa Reservoir, Morrocoy National Park, Cuare Wildlife Refuge, Tacarigua Reservoir, Játira Reservoir, Tocuyo River, Tucurere River, Boca de Hueque, Los Olivitos Wildlife Refuge, Burro Negro Reservoir.

Each location was geographically referenced with GPS and cartographic charts. The data obtained were processed using a Geographic Information System (MAP-INFO).

Some of these selected locations could not be visited during the fieldwork, due to access problems: Píritu Lagoon,

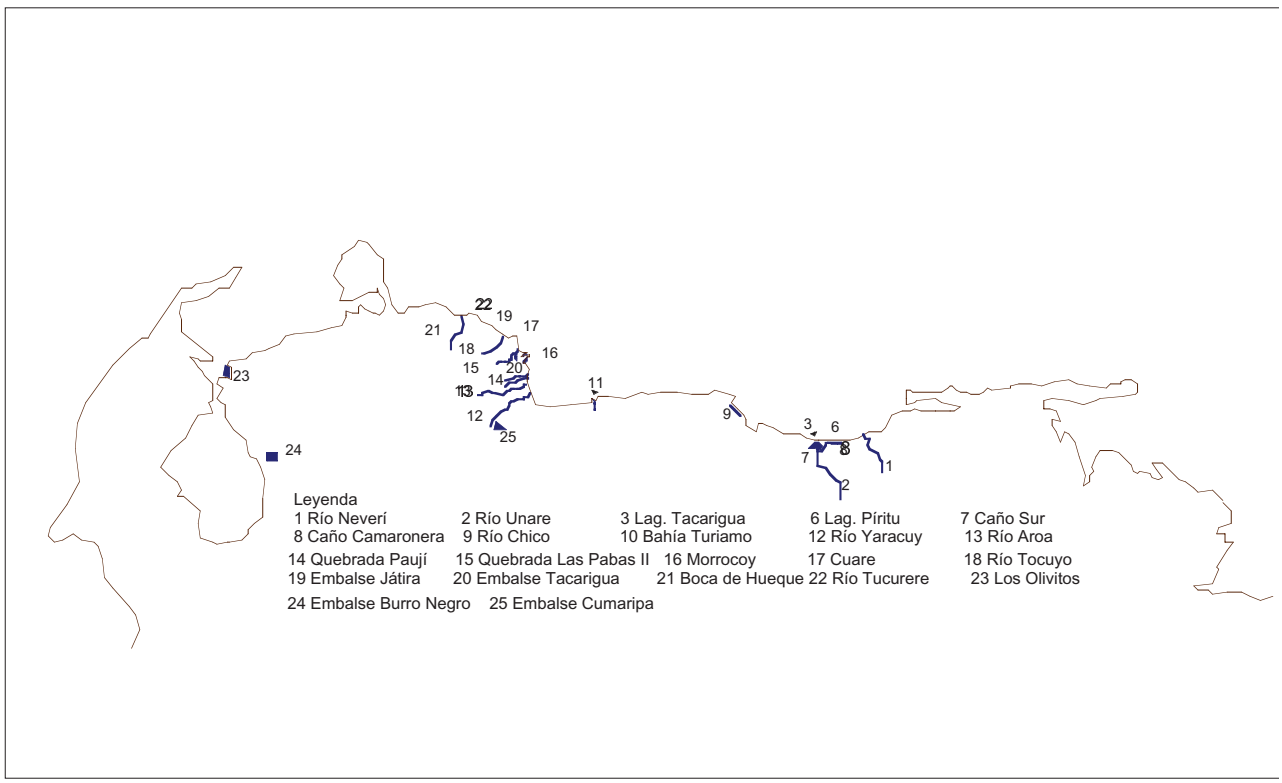

Figure 2. Surveyed locations on the Caribbean coast of Venezuela.

Uchire Lagoon, Boca de Hueque, Los Olivitos Wildlife Refuge and Cumaripa Reservoir, but their ecological characteristics and reports on the presence of the species allow to consider these locations within the present work.

Methods

The evaluation of population abundance was determined by night-light counts (Chabreck 1966; Woodward and Marion 1977). The size-class was observed using the categories of total length (TL) proposed by Seijas (1988) and Velasco and Lander (1998); Class I (<60 cm TL), Class II (60-120 cm TL), Class III (120-180 cm TL), Class IV (180-240 cm TL), and Class V (>240 cm TL).

The habitat description included the main ecological characteristics, and human population and its activities. On the basis of the requirements of the American Crocodile, subjective positive and negative features of the habitat were considered to obtain a better definition. The positive values related with favorable conditions of the habitat for this species: mangrove forest, dominant plant formation on the embankments, beaches for nesting, presence of freshwater, legal condition of the habitat (protected by law), and the presence of the species. The negative values included tourism, housing, agriculture, industry, navigation, fishery and proximity to roads. Both positive and negative factors were weighed to obtain a numerical basis for comparison of habitats, regarding the current or potential occupation by the species.

Results and Discussion

Abundance and Density

Table 1 shows the results of the 23 locations observed, with a total of 291 crocodiles surveyed (not including the Class I individuals). Linear densities were calculated on the basis number of surveyed individuals (Class I not included) and the length of the observer displacement in each habitat. The densities varied from 0.21 ind/km at Morrocoy National Park to 8.00 ind/km at Tocuyo River (Table 2). The total density recorded was 1.72 ind/km.

The results of abundance and density were compared with those reported by Seijas (1984, 1986a), Arteaga and Sánchez (1996), and Arteaga (1997) at the same locations (Table 2), to show the variation in time of the population status of the species. In general, the results of densities obtained in the present work are higher, but the difference should be related with several factors.

Table 1. Results of the surveys in number of individuals and size classes observed in the habitats.

Location	I	II	III	IV	V	Total	km Observed
Neverí River		2				2	2.5
Caño Sur		1	1			2	1
Caño Camaronera			1			1	1
Unare River		3				3	4
Tacarigua Lagoon		3	1	1		5	17
Río Chico Channels		4		1		5	12
Turiamo Bay	16	12	2	1		15	3
Yaracuy River		2	1			3	0.80
Aroa River	3	19				19	5
Paují Creek			1			1	1
Las Pabas II Creek				5		5	1.60
Morrocoy NP	19	2	3			5	24
Cuare WLR		3	4	1		8	26
Tacarigua Reservoir	7	16	4	3		23	25
Játira Reservoir	9	15	14	12	11	52	16
Tocuyo River	39	69	30	15	6	120	15
Tucurere River		1	2			3	2
Burro Negro Reservoir	6	8	7	5	2	22	12
Totals	99	157	71	44	19	291	

Table 2. Densities (ind/km) in the observed habitats and in previous reports.

Location	Present Work	Seijas (1984, 1986a)	Seijas (1990)	Arteaga (1986)	Arteaga (1987)
Neverí River	0.80	1.07			
Caño Sur	2.00				
Caño Camaronera	1.00				
Unare River	0.75				
Tacarigua Lagoon	0.29	0.94			2.28
Río Chico Channels	0.42	0.5			0.66
Turiamo Bay	5.00	3.67	5.30		
Yaracuy River	3.75	2.24	2.75	4.26	
Aroa River	3.80	1.31			0.71
Paují Creek	1.00				
Las Pabas II Creek	3.13				
Morrocoy NP	0.21	0.21			0.62
Cuare WLR	0.31				0.72
Tacarigua Reservoir	0.92	0.27	2.11		2.75
Játira Reservoir	3.25	0.83	3.50		3.22
Tocuyo River	8.00	1.03	0.76		0.20
Tucurere River	1.50				
Burro Negro Reservoir	1.83				

The Neveri River showed a reduction in abundance respect to previous reports. It can be related with the short displacement of the observers; almost all the surveyed animals were located near the mouth on the sea, and there are reports from farmers that more individuals have been sighted upstream. At the Tacarigua Lagoon National Park, the survey was accomplished during the daylight, so there was an underestimation of the population. Other locations revealed a slight increase in their populations, related with the hunting prohibition in these areas and the low level of human activities.

The general results indicate that all these populations are dominated by the smaller classes of size (hatchlings or juveniles). This fact is indicative that the populations are in a recovering moment, with a general trend to the increasing of size and abundance.

Habitat Description

Central-Eastern Coast

Río Neverí: (LN 10º 10' 15'' LW 64º 42' 26''), was observed from its mouth on the sea, crossing the city of Barcelona. The river showed high presence of floating plants, mangroves and sandy beaches, housing and human activity.

Piritu Lagoon: This shallow, coastal water body is separated from the sea by a sand bar with coconut palms, and was observed from the land. It is surrounded by mangrove and deciduous forest, mainly with clay soil. Strong fishery and fences inside the lagoon were noted. No crocodiles were surveyed.

Uchire Lagoon: This is another coastal lagoon, also with a sand bar surrounded by high-density housing, roads and fishery. It is surrounded by patches of mangrove, grasslands and bushes. Two freshwater creeks (Caño Sur and Caño Camaronera) and the Unare River are flowing into the lagoon.

Caño Sur: This is a effluent of the Unare River, with mangroves and sandy beaches on both banks. Strong fishery activity was observed.

Caño Camaronera: Close similar to Caño Sur, with presence of floating plants. A shrimp farm is using the water of this creek.

Unare River: It was observed from the sandy bar to the Unare Nuevo town. Mangroves, floating plants and sandy beaches were present. More than 80 houses on the banks with high human activity were observed.

Tacarigua Lagoon: This is the largest of the three coastal lagoons of this area, also separated by a sandy bar from the sea. The main vegetation is mangrove in the coast and forming islands, and deciduous forest. Several freshwater creeks are effluents of the lagoon, which are included in a National Park area with limitations in the fishery and navigation but high tourist activity. A daylight-count was performed at Caño Los Monjes and Patrocinio, at the west side of the lagoon, observing the south and north banks.

Río Chico Channels: These are several artificial channels located in the surroundings of the Tacarigua Lagoon. One of them is the Caño Copei, observed from the mouth on the sea. Generally, it is a very strongly intervened area for navigation and sport fishery, but conserving its natural mangrove vegetation in some zones.

Western Coast

Turiamo Bay: This is a wide bay opened to the Caribbean Sea, surrounded by mangrove, deciduous forest and sandy beaches. There is a small coastal lagoon and a freshwater creek (Caño San Miguel). Is a protected area, with a harbor that serves as base to the Venezuelan Navy.

Yaracuy River: This was observed from the mouth on the sea until the navigation was impracticable due to obstacles. There are abundant floating plants and sandy beaches, with strong industrial, agricultural and cattle raising activity.

Aroa River: Also observed running up from the mouth on the sea. It is surrounded by mangroves, bushes and grasslands, with sandy beaches on the banks. Intense human activity (navigation, fishery, housing) was observed.

Paují Creek: Mangrove, deciduous forest and grasslands are covering alternatively both banks, with sandy beaches.

Las Pabas II Creek: The same as Paují Creek.

Morrocoy National Park: The north and south coasts of this extensive protected area were observed. This is a highly intervened sector by tourism and sport fishery, and navigation of many boats. There are mangroves combined with deciduous forest and grasslands, alternated with sandy beaches, in the banks and small islands.

Cuare Wildlife Refuge: This is a small gulf surrounded by salty fields, beaches, grasslands and mangrove, in a RAMSAR protected wetland with several freshwater creeks in its banks. It is located very close to the city of Chichiriviche, other towns and tourism facilities, surrounded by several roads. There are also farming and fishery activities.

Tacarigua Reservoir: A freshwater reservoir located near the coast. The banks are surrounded by deciduous forest, alternated with sandy beaches. There is a plant for water treatment and low fishery activity or human occupation. This reservoir is linked to the Játira reservoir by a channel.

Játira Reservoir: With very similar characteristics of the Tacarigua reservoir but completely surrounded by sandy beaches, without any kind of fisheries.

Tocuyo River: Both margins with grasslands and forests, several sandy beaches; intensive agriculture and cattle raising activities.

Tucurere River: Is surrounded by mangrove and grasslands, with many sandy beaches. Few human activities were observed.

Los Olivitos Wildlife Refuge: A very wide protected area, formed by a wetland flooded with shallow marine water and surrounded by mangrove and grasslands, wit few human activities.

Burro Negro Reservoir: The freshwater reservoir is surrounded by deciduous forest, with beaches and floating vegetation, low human activity was observed.

Cumaripa Reservoir: The same conditions of the Burro Negro Reservoir.

Comparison of Habitats

To select the better areas for releasing ranched crocodilians, the positive and negative features of each habitat were weighed in a scale up to 9, adding one point for favorable characteristics and reducing one point for non-favorable ones. The lists of positive and negative environmental conditions present in each habitat are given in Tables 3 and 4, and are the basis to reach a subjective index of environmental quality in regard to the species requirements.

The ranged environmental quality values obtained for each location, were plotted against the observed density of crocodiles to apply the graphical Olmstead-Tuckey non-parametrical test (Fig. 3), divided in four areas by the respective median values of each axis. The test resulted significant for the degrees of freedom in the sample.

Accordingly to this result, the best locations to release ranched crocodilians are: the Tocuyo and Tucurere Rivers, the Jatira and Burro Negro Reservoirs, and the Turiamo Bay, all them located in the right upper quadrant of the graph reflecting high environmental quality and an appropriate density value registered during the present work.

Conclusions

A total population of 390 American Crocodilians was observed in 23 locations surveyed. The highest amount was found at the Tocuyo River, a natural freshwater environment. In freshwater reservoirs, the high population value was observed in the Játira reservoir, and the high amount in marine-coastal environment was located at Turiamo Bay.

The different surveyed populations of this species seem to be in a recovery phase, since the records in the present work were higher than previous reports, dominated by young individuals. This conclusion demands more continuous monitoring of the species in these habitats.

The habitat requirements for this species includes the presence of mangrove or forest on the banks, sandy beaches for