CROCODILES

Proceedings of the
16th Working Meeting of the Crocodile specialist Group
of the Species Survival Commission of
IUCN – The World Conservation Union
convened at
Gainesville, Florida, 7 – 10 October 2002

(Unedited and Unreviewed)

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Cover: American alligator, *Alligator mississippiensis* - photograph by C. C. Lockwood©. Courtesy of <www.cclockwood.htm>www.cclockwood.com.

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THE CROCODILE SPECIALIST GROUP

The Crocodile Specialist Group (CSG) is a worldwide network of biologist, wildlife managers, government officials, independent researchers, non-governmental organization representatives, farmers, traders, tanners, manufacturers and private companies actively involved in the conservation of crocodilians (Crocodiles, Alligators, Caiman and Gharials). The Group operates under the auspices of the Species Survival Commission of IUCN. The CSG provides a network of experts to assess conservation priorities, develop plans for research and conservation conduct surveys, estimate populations, provide technical information and training, and to draft conservation programs and policy. CSG also assists monitoring international trade and identifying products. The Group is headed by the chairman, Professor Harry Messel, and maintains offices in Gainesville, FL, USA. Working meetings of the CSG are held every two years.

FOREWORD

Once again CSG members from all over the world have come together in a spirit of friendship and cooperation to share their expertise, knowledge and vision for the global conservation of crocodilians. Our vision and policies for this important effort continue to evolve and adapt to changing circumstances. This meeting presented results of an initiative begun at the 14th Working Meeting in Singapore 1998 to look more closely at the economic imperatives driving crocodilian trade and the linkages- or lack of linkages- to conservation. By recruiting new expertise from resource economists, and with the cooperation of the commercial sector of our membership, we have gained new insights into how these factors affect each other, and new ideas on how we can more effectively channel economic benefits and incentives toward conservation of crocodilians and their habitats. Many papers in these Proceedings reflect this developing view.

At the same time, we remain deeply concerned about continuing endangered status, and in some cases, continuing declines, of a small group of species for which commercial incentives are either inappropriate or not working. The good news is that for many of these species, including Chinese alligator, Siamese crocodile, Philippine crocodile and Tomistoma, there are new and active national programs addressing their needs. We continue to be deeply grateful for the efforts of our partners in China, the Philippines, and among international NGO's like Wildlife Conservation Society and Fauna and Flora International, who are spearheading these efforts. As always, it is by the individual efforts of CSG members operating in their day to day work, that crocodilians are saved. The CSG continues to promote and enhance these efforts by mobilizing international concern to support members' activities. The activities of dedicated task forces on Siamese crocodiles, Philippine crocodiles and a new task force on Tomistoma, provide a focus for these efforts. By meeting together every two years, we affirm the importance of our work, refresh our energy for the task and renew valuable professional and personal connections. My thanks again to the organizers, sponsors and the participants at this working meeting.

Harry Messel, Chairman, CSG

SUMMARY OF THE MEETING

Between 7 and 10 October 2002, over 270 CSG members and supporters convened in Gainesville, Florida, USA, for a very successful working meeting. The meeting was hosted by United States Geological Survey – Biological Resources Division, Florida Wildlife Coop Unit, and Florida Caribbean Science Center, Florida Fish and Wildlife Conservation Commission. Florida Museum of Natural History, University of Florida, and Florida Wildlife Federation.

The organizing committee comprised of H. Franklin Percival (USGS, Chairman), Ken Rice (USGS, program), Kristina Sorenson (USGS/UF, volunteer coordination), Harry Dutton (FWC registration management and treasurer), Allan Woodward (FWC, program), Dwayne Carbonneau (FWC, social), Steve Sieigler (FWC, audio-visual coordination), Pat Linehan (FWC, program and social), Perran Ross (FLMNH, CSG liaison), Manley Fuller (FWF, Fiscal Services), John Thorbjarnarson (WCS, program).

Crocodile Specialist Group and the meeting hosts and committee are very grateful to the many donors and sponsors listed below for their support of the meeting. We particularly appreciate the support of Phil Steel and Jake Puglia for providing the initial seed support beyond their normal CSG donation and to Gene and Dennis Pella for their support of the hospitality room. The University of Florida supported sign language translation enabling the participation of a hearing impaired crocodile enthusiast. The Gainesville Sheraton Hotel, overlooking Biven's Arm Lake and its wild alligators provided a comfortable setting, facilities and amenable and flexible staff for the meeting.

The meeting was opened with a welcome address from Vic Heller, Assistant Executive Director FWC and Russ Hall representing USGS. The first session on market driven conservation presented an overview of the complexities of the relationship between conservation and commercial use by John Hutton and then critical evaluations from several perspectives by John Thorbjarnarson, James MacGregor and Tommy Hines. The afternoon was occupied by reports on alligator conservation and management throughout the USA, one of the success stories of sustainable crocodilian use. Sessions on the following days included wild crocodilian harvest programs; presentations on current conservation action on the Chinese alligator, Siamese crocodile, Philippine crocodile, Orinoco crocodile and Cuban crocodile; advances in crocodilian physiology, techniques; disease and health in both captive and wild populations; Human-crocodile interactions and crocodilian DNA studies. Two workshops were conducted on Wednesday afternoon, one on Latin American issues and the other following up on the opening session on trade issues.

This meeting introduced several innovations to the working meeting format. Participants received a printed collection of abstracts of the presentations on registration and each session concluded with drawing for a door prize, to encourage a good audience for the later papers of each session. A highly popular feature was the meeting hospitality suite, a dedicated room where participants could gather after hours to socialize, converse, discuss issues, and partake of the beverages generously donated by CSG members Gene and Dennis Pella and beer brewed by Harry Dutton. As has become customary at CSG working meetings, the social and personal interactions during the meeting provided a rich medium for friendship and professional connections. An opening cocktail welcome set the standard for good food and copious refreshments. The evening poster session was enriched by the presentation of snacks and drinks, ensuring nearly 100% turnout and spirited discussion of the many projects presented. A

dedicated group of cigar smokers inaugurated the Harry Messel cigar Olympics, activating hotel smoke alarms and requiring industrial scale ash disposal.

A high point of the social agenda was the evening barbecue banquet. Served under canvas at the rustic Austin Carey Research forest, and dramatically backlit by a circle of pick-up truck headlights, participants reveled to local traditional music and enjoyed barbecued pork, shrimp, Alligator in several forms and a dramatic strawberry dessert in a setting of rural-chic and great camaraderie. At the banquet the Castillo prize for crocodilian conservation, a handsome silver pitcher, was presented to John Thorbjarnarson in recognition of his multiple and long term efforts in global crocodilian conservation.

The CSG Working Meetings are the primary international meeting dedicated to crocodilian conservation and have become the forum where current events, recent discoveries and new directions are presented. Each meeting has its special highlights, but participants were effusive in their praise for the 16th Meeting for the venue and facilities, excellence of presentations and a very rich and productive social organization.

ACKNOWLEDGMENTS

The Chairman, Steering Committee and all members express their thanks to the meeting organizers and sponsors.

Sponsors of the 16th Working meeting

- United States Geological Survey –Biological Resources Division
- Institute of Food and Agricultural Science (IFAS) Office of the Vice president for Academic Affairs, University of Florida
- Florida Alligator Marketing and Education Council (FAME)
- Louisiana Fur and Alligator Council
- Alachua County Tourist Development Council with the Alachua County Board of Commissioners
- Jake Puglia, Alligator Adventure at Barefoot Landing, North Myrtle Beach SC.
- Phil Steel, Crystal River Alligator Farm, FL
- Center for Natural Resources, University of Florida
- Florida Museum of Natural History, Office of the Director and Natural History Department
- Department of Wildlife Ecology and Conservation, University of Florida
- Genie and Joe Tillman, Lake Placid, FL
- Gene and Denis Pella, Sebring FL
- Robert Young, Alligator Bob's
- Allen Register, Gatorama, Palmdale FL
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- Zackary Casey and Penny Mathews, Pelts and Skins Inc. Kenner, LA

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[1] The total number of alligator skins in trade each year during the period 1870-1902 may have exceeded 110,000 (R. Elsey, pers. com.).

[2] The taxonomy of the caiman is subject to considerable debate. For the purposes of this paper the term 'caiman' includes all variations of *Caiman crocodilus* including what is sometimes known as *Caiman yacare*.

[3] 14 species and 2 sub species of the 21 species recognised

[4] A country that takes a 'reservation' against the listing of a species in CITES is not bound by that listing decision.

[5] In some cases reservations have played a positive role in conservation and the evolution of CITES (Kievit, 2000).

[6] It was decided that the removal of eggs or young animals from the wild for subsequent rearing in captivity should be termed "ranching" and should not benefit from the trade possibilities provided by 'bred in captivity' exemptions.

[7] In the market, alligator and crocodile skins are known as "classics". Classic skins and caiman skins are usually considered separately.

[8] Notably by TRAFFIC-USA which consistently and successfully focused attention on the illegal and unregulated crocodilian trade during the 1980s.

[9] With species of low value or which are difficult to breed in captivity.

[10] An alleged illegal shipment of Nile crocodile skins into Zimbabwe proved to have legal permits.

Legal Trade Snaps Back: Using the Experience of Crocodilians to Draw Lessons on Regulation of the Wildlife Trade

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ABSTRACT: Using international trade in crocodilian hides as a case study, this paper addresses two competing hypotheses:

a. That legal trade in wildlife can be used to displace illegal trade.
b. That legal trade in wildlife will inevitably encourage illegal trade.

We document that the modern crocodilian trade has seen the replacement of skins from unregulated exploitation with skins from sustainable resource management. Today, at least 30 countries may use wild harvests, ranching or captive breeding to produce crocodilian products from 12 species to supply international trade – but only on the understanding that these programmes do not threaten the future of any species in the wild. As a result, the eleven most commercially valuable species are the species *least* threatened with extinction.

We conclude that conservation incentives can and have been generated by markets; the economic importance of the resource has led directly to stronger institutional arrangements specifically for conservation and sustainable management, and; illegal international trade, which flourished before CITES encouraged legal trade, has been all but eradicated.

INTRODUCTION

Regulation of the international trade in wildlife is undertaken at several different levels. The most well-known regulatory body is the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), which is a multilateral institution. But regional groupings such as the European Community also impose their own regulations, as do individual states. In all cases these regulations, and their enforcement, can evoke strong passions.

Competing explanations are put forward for cases where regulation appears to fail. Is it because insufficient resources are being devoted to enforcement? Or is it because regulation barely touches the real causes of the species' decline? Widely different prognoses are offered of proposals to change regulations. Will tightening trade restrictions save a species, or actually exacerbate its conservation status? Will a partial loosening of existing regulations lead to a massive increase in the illegal trade, or cut the ground from beneath the illegal trade?

Underlying these disputes there may be differences about the goal of regulation. Is the aim simply to conserve wild species? Or are there objections to any trade in (some) wild species, whatever its impact on their conservation? In addition, is there an obligation to consider the equity implications of trade regulations, particularly in developing countries?

Within CITES and domestic regulatory contexts, the question of whether legal trade stimulates illegal trade has persistently emerged. It appears clear that the existence of an unregulated trade has in many circumstances provided the distribution network and the market to enable a flourishing illegal trade. Some have moved from this observation to the proposition that allowing a regulated trade will promote illegal trade. As divergent answers to this question provide central conceptual planks of various opposing arguments within CITES, and substantial conservation and livelihood impacts ride on the answer, answering this question is a high priority.

Using international trade in crocodilian hides as a case study, this paper addresses two competing hypotheses:

c. That legal trade in wildlife can be used to displace illegal trade.
d. That legal trade in wildlife will inevitably encourage illegal trade.

Both hypotheses have their adherents, and in most discussions of wildlife trade the relationship between legal trade and illegal trade will eventually become an issue. For example, the tension between the two competing hypotheses was neatly captured 25 years ago in debate on the conservation and trade in crocodilians:

> "Crocodile farmers have claimed that hides from captive stock, with their steady supply, and uniform size and quality, will replace wild hides in the international market. On the other hand some conservationists fear that the farmed hides will stimulate, but fail to satisfy, increased demands for crocodilian products." (Anon 1976)

This paper:

- briefly addresses the two assumptions, highlighting some of their characteristics.
- presents a case study of the crocodilians, and
- attempts to draw conclusions which may be of relevance to the way we deal with wildlife trade in general.

THE COMPETING HYPOTHESES

Legal trade displacing illegal trade

The idea that legal trade might be a useful tool to displace illegal trade is one commonly advocated by economists who promote market solutions to conservation problems. They seek to link the economic consumptive use of wild resources to incentives for sustainable harvesting. Discussion is usually couched in terms of property rights, the capture of economic rents, discount rates and institutions. For example, with respect to the African elephant it is claimed that:

> "It is not the mere existence of rents from ivory harvesting but who captures these rents which often determines the incentives for over-exploitation." (Barbier et al. 1990)

An alternative but related argument suggests that in some circumstances legal trade from species produced in captivity can directly substitute for illegal or unsustainable trade originating from wild harvests, as follows:

> "Where a wild population is being over-exploited for trade, it is possible that an alternative supply from captive sources could divert some of the trade and reduce pressure on the wild population…increasing the supply so that the market becomes saturated and the price is driven downwards." (Luxmoore & Swanson 1992)

It can be argued that model has been supported by the Articles of CITES where the commercial trade in Appendix I species is allowed provided the products come from captive breeding or artificial propagation of the species [Article VII (4)], but not if they come from sustainable harvesting from the wild.

Legal trade leading to illegal trade

Even if legal trade poses no direct threat to the survival of a species, it is widely recognised, including by the proponents of market solutions, that legal trade may provide increased opportunities for illegal trade. This situation has been well articulated as follows:

> "[g]iving wildlife commercial value is a double-edged sword. Poachers like wildlife with commercial value too." (Michael Sutton 1992, quoted by Keller)

Illegal trade is rightly regarded as both difficult to control and more likely to lead to unsustainable harvesting than legal trade, and there are plenty of examples where illegal trade has flourished under the cover of legal trade. In the past, this was certainly a challenge with crocodilians:

> "Laundering", poaching, and difficulties in identifying species and countries of origin are problems that perpetuate the [illegal] crocodilian trade and make it difficult to monitor" (Roeper 1983).

However, an entirely reasonable concern has often been recast as an immutable assertion that legal trade inevitably leads to illegal trade and that this will, in turn, enhance rates of resource depletion. Support for this argument is based on acceptance of the following assumptions:

1. Any market will result in over-exploitation as the inevitable result of human greed combined with the opportunity for short term financial gain.
2. Legal trade will stimulate demand which it is then unable to meet, leading to an escalation in price thus adding to the incentive for illegal harvesting and trade.
3. Attempts to counter or mitigate the threat to species resulting from trade will be ineffective. The force of markets, once unleashed, is so great that enforcement can never meet the challenge.

In the words of two adherents to this axiom:

- "[I]t is in the nature of individual economic decision making to seek to maximise individual financial return even if it is at the cost of reducing the resource base being used". (Favre 1993)
- "Legal production tends to stimulate and perpetuate the markets for such products, thus *increasing*, or at least maintaining, the poaching pressure on wild populations." (Hoyt 1994)
- "When luxury products from wildlife are legally traded in international commerce, the economic incentives for killing such animals are overwhelming." (Hoyt 1994)

Over the years, the notion that legal trade will inevitably lead to unsustainable, uncontrollable, illegal trade has been at the heart of a great deal of the opposition to proposals to transfer species from Appendix I to Appendix II of CITES. Thus:

> "WWF believes that resuming a legal trade in horn carries many risks. The move would perpetuate a demand that has caused the catastrophic fall in rhino numbers over the last 30 years." (WWF 1992)

> "The history of trade in this species clearly indicates that illegal trade in sea turtle products flourishes under the cover of legal trade…. Any legal trade, particularly on a continuing basis, is likely to generate even more demand for illegal products." (IFAW 2000)

In the CITES context, even the discussion of legal trade is sometimes held to be dangerous. Serious consideration of legal trade is said to send the 'wrong signals' to would-be poachers and illegal traders, encouraging their activities:

> "What will happen if the proposals (for elephants) are accepted? Poaching will resume. Indeed the very existence of the proposals has led to increased poaching." (Greenpeace June 1997)

EXPLOITATION AND TRADE IN CROCODILIANS

Of the 23 crocodiles, alligators and caiman species (collectively known as "crocodilians") generally recognised in more then 90 countries, 15 or more have commercially valuable hides and have experienced remarkably similar histories of utilisation, conservation and management, regardless of the countries in which they occur (Ross, 1998). From the 1800s onward, crocodilian skins became commercially valuable in some countries. In the US, for example, trading firms in New York were handling more than 60,000 American alligator *Alligator mississippiensis* skins a year in the late part of the 19th Century (Fuchs et al. 1989)[1]. The demand for many species appears to have increased exponentially after World War II. Thus, in the late 1940s it is reported that 120,000 Nile crocodile *Crocodylus niloticus* skins were being exported annually from Madagascar to tanneries in France (Games, Ramandimbison and Lippai, 1997) while in the mid-1950s, nearly 60,000 Nile crocodile skins were exported from East Africa every year (Fuchs et al., op cit).

By the 1960s almost all wild populations of commercially important species were being exploited for trade to some degree and conventional wisdom holds that, as recently as the early 1970s, over 2 million crocodilian skins were to be found in trade. The vast majority, perhaps as many as 1.8 million, were from the South American caiman *Caiman crocodilus*[2] originating in a wide range of countries including Bolivia, Brazil,

[1] The total number of alligator skins in trade each year during the period 1870-1902 may have exceeded 110,000 (R. Elsey, pers. com.).
[2] The taxonomy of the caiman is subject to considerable debate. For the purposes of this paper the term 'caiman' includes all variations of *Caiman crocodilus* including what is sometimes known as *Caiman yacare*.

Colombia, Paraguay and Venezuela, with the balance made up of alligators from the USA and crocodiles from many other parts of the world (e.g. Brazaitis, 1989).

Table 1 – List of countries with crocodilian production programs indicating mode of use. Wild harvest is direct harvest of adults from the wild. Ranching is collection of eggs from the wild that are raised in captivity, captive breeding is the production of eggs from adults held in captivity

Country	Species	Mode of use
United States	*A. mississippiensis*	Ranching, wild harvest and captive breeding
Mexico	*C. moreletii*	Captive breeding, ranching under development
Honduras	*C. acutus*	Captive breeding
Nicaragua	*Caiman crocodilus*	Wild harvest
Cuba	*C. rhombifer*	Captive breeding
Colombia	*Caiman crocodilus*	Captive breeding
Venezuela	*Caiman crocodilus*	Wild harvest and ranching
Guyana	*Caiman crocodilus*	Wild harvest
Brazil	*Caiman crocodilus*	Captive breeding, Ranching under development
Bolivia	*Caiman crocodilus*	Wild harvest
Paraguay	*Caiman crocodilus*	Wild harvest
Argentina	*Caiman latirostris*	Ranching
South Africa	*C. niloticus*	Captive breeding, ranching
Mozambique	*C. niloticus*	Ranching
Botswana	*C. niloticus*	Ranching
Malawi	*C. niloticus*	Ranching
Zimbabwe	*C. niloticus*	Ranching, captive breeding
Zambia	*C. niloticus*	Ranching
Uganda	*C. niloticus*	Ranching
Kenya	*C. niloticus*	Ranching, captive breeding
Tanzania	*C. niloticus*	Wild harvest, ranching
Ethiopia	*C. niloticus*	Ranching
Madagascar	*C. niloticus*	Ranching, captive breeding
Thailand	*C. siamensis*	Captive breeding
China	*Alligator sinensis*	Captive breeding
	C. porosus	Captive breeding
Cambodia	*C. siamensis*	Captive breeding
Indonesia	*C. porosus*	Captive breeding, wild harvest
	C. novaeguineae	Wild harvest
Malaysia	*C. porosus*	Captive breeding
Singapore	*C. porosus*	Captive breeding
Papua New Guinea	*C. porosus*	Ranching, wild harvest
	C. novaeguineae	Ranching, wild harvest
Australia	*C. porosus*	Ranching, captive breeding
	C. johnsoni	Ranching, captive breeding

There is strong anecdotal evidence that by the 1970s many wild crocodilian densities had fallen dramatically, sometimes to levels where populations were in danger of becoming extinct (e.g Cott 1961: p215). Not unnaturally, conservationists concerned about this situation tended to advocate an end to harvesting and trade. It is thus not surprising that when CITES was introduced in 1975 all crocodilian species were listed on the Appendices, most[3] on Appendix I where commercial trade is completely prohibited.

There were, however, conservationists who saw the curtailing of trade only as a short term management tool. Due to their influences, the late 1970s saw the growth of a nascent movement away from "prohibition for ever" towards the development of programmes in which wild crocodilians could be harvested on a sustainable basis to generate ongoing economic and conservation benefits. This happened in several countries with diverse economic, social and cultural settings, notably Australia, the United States of America, Papua New Guinea,

[3] 14 species and 2 sub species of the 21 species recognised

Venezuela and Zimbabwe, where the impetus for sustainable use often came from quite different directions (Webb, Manolis and Whitehead 1987).

CITES AND CROCODILIANS

Because almost all exploitation feeds international trade, the harvesting of crocodilians has been particularly amenable to influence from CITES. On the face of it, the Appendix I listings in place when the Convention came into force meant that legal trade in many traditionally important crocodilian species was technically impossible. In practice, however, trade often did continue through several different mechanisms. Firstly, in the 1970s a number of important producer and consumer nations were not Parties to CITES (including Zimbabwe, France and Italy) and continued to trade. Secondly, when joining in the 1970s and 1980s many new Parties lodged 'reservations'[4] against crocodilian species allowing them to maintain their harvesting and industry programmes (including, for example, Botswana, Zambia, Zimbabwe, France, Italy and Japan). Thirdly, CITES allowed specimens from Appendix I listed species that were bred in captivity for commercial purposes to be traded legally as if they were in Appendix II. In addition to legal trade through these mechanisms, a combination of continuing high demand for crocodilian hide, inappropriate regulation and poor national controls meant that considerable trade continued on an illegal basis.

During the 1980s the possibility for legal trade between non-members was restricted as the majority of traditional producer and consumer countries joined the Convention. In addition, even though it is perfectly legal to trade Appendix I crocodile skins under a reservation, member countries came under pressure to withdraw their reservations when it was argued that these allowed trade in skins taken illegally in their country of origin[5]. On the other hand, new possibilities for legal trade were created when, from 1981, it became possible to transfer some crocodilian populations from Appendix I to Appendix II if certain precautionary measures were adopted, including systems of production based on "ranching"[6] or governed by strict quotas.

By 1989, as CITES began to close down illegal and unregulated sources of crocodilian skins, the number of skins in trade was reduced from an estimated high of 1.5 million a year to a low of about 500,000. During the 1980s an increasing number of countries reintroduced exploitation and turned their attention to ways in which their crocodilian populations could be transferred from Appendix I to Appendix II to allow legal, well regulated trade to continue or recommence. Others focused on captive breeding that could benefit from the exemptions afforded to Appendix-I species under such programmes. As a result, the number of crocodilian skins in trade began to rise again until it reached a new peak of almost 1.4 million skins in 2000 (Figure 1). Trade before the 1980s was dominated by skins harvested from the wild. After the 1980s the vast majority originated from ranching and captive breeding. It is thought that about 300,000 classic[7] crocodile and alligator skins entered trade each year in the early 1970s (Ashley & David 1985), almost all originating from animals harvested in the wild. By 1983, under the influence of CITES, this number had fallen to 43,000 and the number of skins from the wild has hardly changed since then. In 1999 it is reported that 390,000 skins entered trade, but the increase reflects the bias of CITES towards ranching and captive breeding which together supplied 336,000 skins (Table 2). Over the same period the number of wild caiman skins in trade dramatically decreased from 1.4 million to 34,000 while the number of skins produced by captive breeding (principally in Colombia) increased from zero to over 770,000 (Table 2) (McGregor 2001 in prep).

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[5] In some cases reservations have played a positive role in conservation and the evolution of CITES (Kievit, 2000).
[6] It was decided that the removal of eggs or young animals from the wild for subsequent rearing in captivity should be termed "ranching" and should not benefit from the trade possibilities provided by 'bred in captivity' exemptions.
7 In the market, alligator and crocodile skins are known as "classics". Classic skins and caiman skins are usually considered separately.

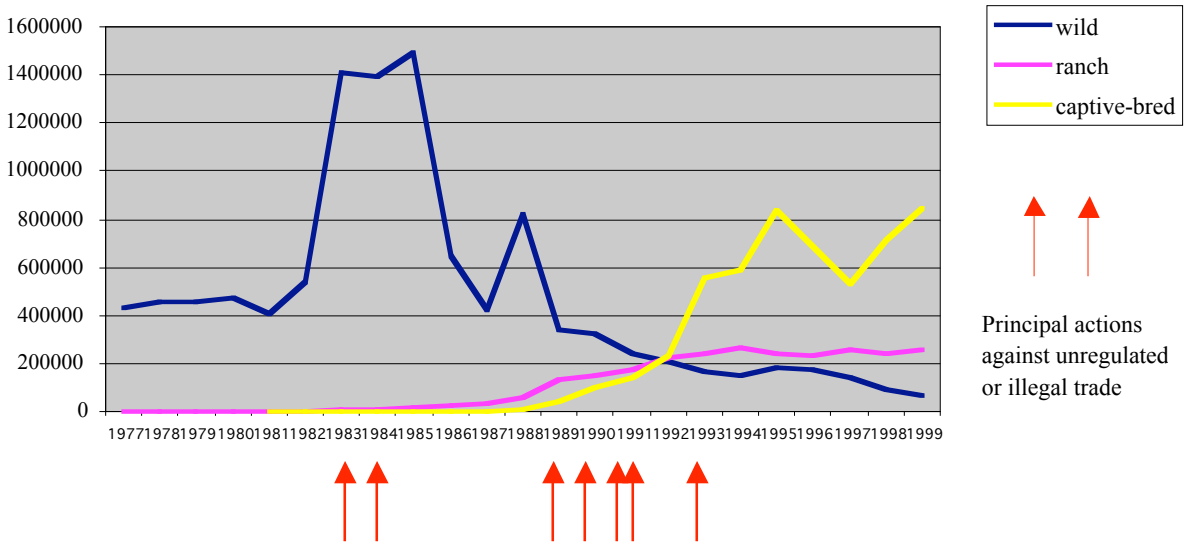

Figure 1 – Changes in the number of crocodilian skins harvested directly from the wild, ranched and captive-bred on farms during the period 1977 until 1999.

Table 2 – Classic and caiman Skins in global trade by method of production during the period 1977–1999 (from McGregor, 2001)

	CLASSICS				CAIMAN			TOTAL
	Captive-bred	**Ranch**	**Wild**	**TOTAL**	**Captive-bred**	**Wild**	**Total**	**TOTAL**
1977	0	1258	38831	**40089**	0	388322	388322	**422013**
1978	0	175	71045	**71220**	0	388322	388322	**451794**
1979	0	991	67902	**68893**	0	388322	388322	**458954**
1980	0	1039	81869	**82908**	0	388322	388322	**514429**
1981	403	3193	66306	**69902**	0	338265	338265	**435219**
1982	2	3339	39839	**43180**	0	223300	223300	**288319**
1983	73	6523	63557	**70153**	0	1349426	1349426	**1439978**
1984	222	11975	56105	**68302**	0	1333281	1333281	**1402293**
1985	640	18473	64653	**83766**	0	1428145	1428145	**1513120**
1986	786	22884	64302	**87972**	0	585080	585080	**681363**
1987	3422	36104	71752	**111278**	0	353012	353012	**469608**
1988	5614	58380	70333	**134327**	0	752933	752933	**896201**
1989	10885	126405	74799	**212089**	31168	265749	296917	**515914**
1990	10284	146569	82298	**239151**	91386	242083	333469	**477345**
1991	11121	173953	64960	**250034**	129521	172704	302225	**483848**
1992	22707	213926	56695	**293328**	208669	151117	359786	**548067**
1993	39719	234298	51487	**325504**	516002	112992	628994	**890520**
1994	49856	264421	52618	**366895**	536762	95668	632430	**944830**
1995	56864	237337	58287	**352488**	781313	120937	902250	**1178181**
1996	33413	236041	56545	**325999**	652528	113691	766219	**979147**
1997	46249	257248	74955	**378452**	483631	64408	548039	**806393**
1998	44219	244506	58455	**347180**	670469	34424	704893	**1040036**
1999	73105	262898	54642	**390645**	771456			**393793**

All crocodilian production programmes, especially ranching and captive breeding, involve the investment of significant manpower and financial resources. As a result of the dramatic growth of ranching and captive

breeding since the 1980s an important new constituency has been created amongst governments, NGOs and the private sector whose interests are compromised by illegal trade. We believe that the creation of this constituency was pivotal to the headway that the Parties to CITES began to make against large-scale illegal trade during the 1980s (Anon, 1998) and which appears to have been eliminated during the 1990s. The constituency found a home, coordination and a unified voice in the Crocodile Specialist Group (CSG) of the IUCN Species Survival Commission. From about 1980 this group exerted a strong influence on the evolution of the various CITES mechanisms dealing with crocodilians as well as on the way that the Secretariat and Parties responded to unregulated and illegal trade.

The following examples illustrate the measures through which illegal trade was addressed by the Parties to CITES:

(i) In the early 1980s, a number of important importing countries (notably France, Italy and Japan) were widely criticised[8] for importing Appendix I crocodilian skins under a number of reservations. France and Italy were pressured by the European Community to drop their various reservations in 1984 and Japan dropped its reservation on *Crocodylus porosus* in 1989.

(ii) Although it did not hold any reservations on crocodilian species, Indonesia was implicated in the illegal trade of its indigenous crocodiles (and other wildlife species) during the late 1980s. In 1994, after almost a decade of deliberation, the CITES Standing Committee recommended that trade with Indonesia be suspended. The recommendation was not followed through because Indonesia, working with the IUCN/SSC Crocodile Specialist Group, successfully addressed the problem over a five year period of intensive management in which illegal trade was largely eradicated in favour of a well-regulated legal trade.

(iii) In 1983 there was a great deal of concern that Bolivia was responsible for laundering caiman skins from Brazil. Concerns in this regard continued until 1985 when the CITES Standing Committee recommended that trade be suspended – as a result of which Bolivia voluntarily withdrew from all international trade in wildlife.

(iv) In 1983 it was reported that Japan had imported 45 tonnes of caiman skins from Paraguay, and it was considered likely that these were illegal in origin. A few years later, in 1990, Paraguay re-surfaced again amid concerns that 35,000 caiman skins from Brazil had been laundered through that country. As a result of this, and similar problems, the CITES Secretariat suspended cooperation with Paraguay and shortly afterward a number of reforms were introduced which were considered to have resolved the problems.

(v) In 1990, 6,000 illegal caiman skins destined for Italy were seized in Belgium. Concerns about the role of Italy in the illegal trade of caiman skins were reinforced when evidence emerged that at least a further 9,000 illegal skins reached Italy that year. By 1992 the problem had become so serious that the CITES Standing Committee recommended that trade be suspended with Italy. Once again, this most drastic of compliance actions on the part of CITES resulted in a resolution of the situation, and the closure of yet another loophole for illegal trade.

(vi) Italy was not considered the only 'leaky cauldron' as far as the illegal trade in caiman was concerned, both Thailand and Singapore also had their problems. In 1988 it was reported that Thailand imported an estimated 750,000 illegal caiman skins because it had not passed legislation allowing it to enforce its obligations under CITES. In 1990, after further problems, the CITES Secretariat distributed an official notification warning Parties about the consequences of trade with Thailand. In 1991, when it was clear that no progress had been made, the CITES Standing Committee recommended that Parties should adopt stricter domestic measures to suspend trade with Thailand. Once again this mechanism had the desired effect. Domestic legislation was enacted and the illegal trade was eradicated.

(vii) In the early 1990s a great deal of concern was expressed by several South American Parties to CITES about the import of caiman skins under reservation by Singapore. It was suggested that many of these skins might have been taken illegally from Brazil and laundered through a range of intermediary countries, notably Aruba administered by the Netherlands. After a period of negotiation, characterised by a great deal of

[8] Notably by TRAFFIC-USA which consistently and successfully focused attention on the illegal and unregulated crocodilian trade during the 1980s.

recrimination, Singapore decided to drop its reservation on caiman in 1992, closing one of the last of the 'traditional' routes for caiman from 'grey' sources to enter international trade.

(viii) In 1990 concerns were raised that some crocodile ranching operations in Africa were laundering wild skins in order to maintain their economic viability when experiencing declining prices coupled with high investment and production costs (Hutton 1992). These fears have receded, not as a result of enforcement, but because a number of the countries most affected have worked within CITES to reintroduce sustainable cropping from the wild. At the same time they have moved away from ranching. Together these developments have removed many of the incentives for illegal trade.

(ix) In 1992, shortly after Singapore dropped its reservation, the first concerns were raised that wild caiman skins were being exported through captive breeding units (farms) in Colombia. For some years the 'preferred' conservation strategy for crocodilians, and many other species, was "captive breeding". However, it was feared that captive breeding provided incentives for the laundering of illegally-taken wild skins in some circumstances[9]. A decade later, these concerns continue in some circles (D. Ashley, pers.comm.), but no concrete evidence of any wrongdoing has ever come to light.

(x) In response to concerns about the possibility that an illegal trade in crocodilian skins could resurface, the Parties to CITES responded by introducing a universal system for the tagging of crocodilian skins at the points of origin and re-export. First introduced in 1992, this system was refined on two subsequent occasions to take into account the experiences of the various implementing countries. At the time of writing, all crocodilian skins and parts of skins, have to be recorded and tagged in compliance with Resolution Conf. 11.12. This system is considered to have been so successful that the CITES 'TIGERS' database on illegal trade, established in 1997, contained only one report of illegal commercial trade between 1995 and 2000, and on inspection this was found to be in error[10].

WHICH HYPOTHESIS?

Within 20 years the crocodilian trade has seen the replacement of skins from unregulated exploitation with skins from sustainable resource management. Today, at least 30 countries may use wild harvests, ranching or captive breeding to produce crocodilian products from 12 species to supply international trade – but only on the understanding that these programmes do not threaten the future of any species in the wild. As a result, the eleven most commercially valuable species are the species *least* threatened with extinction (Ross, 1998).

In the case of crocodilians, it seems clear that:

1. Conservation incentives can and have been generated by markets;
2. The economic importance of the resource has led directly to stronger institutional arrangements specifically for conservation and sustainable management.
3. Illegal international trade, which flourished before CITES encouraged legal trade, has been all but eradicated.

We can therefore reject the hypothesis that legal trade inevitably leads to illegal trade and adopt the hypothesis that legal trade can displace illegal trade.

THE WIDER LESSONS

The experience of crocodilians demonstrates at least that a regulated trade does not inevitably stimulate an illegal trade. The legal, regulated trade can be seen to have effectively displaced the illegal trade over a period of several decades.

However, this lack of impact does not represent a general rule. The question then becomes: under what circumstances does a regulated trade not stimulate illegal trade? While comprehensive answers to this question remain elusive, some interesting suggestions emerge from the study of crocodilians.

First, legal trade may be likely to suppress illegal trade when the legitimate trade creates a powerful constituency for whom illegal trade is against their economic interests. This certainly appears to have been an important factor in the case of crocodilian skins. As the skin trade both became an important source of revenue

[9] With species of low value or which are difficult to breed in captivity.
[10] An alleged illegal shipment of Nile crocodile skins into Zimbabwe proved to have legal permits.

in range countries, and represented an increasingly large investment of management effort as well as research and development resources, this was reflected in the level of political will and resources made available to counter the illegal trade.

Second, structural characteristics of trade in some commodities may lend themselves to relatively low cost enforcement. In the case of crocodilians, for instance, the very small number of tanneries through which any high value products are required to pass make for relatively easy control of the vast bulk of the trade.

Third, the crocodilian example emphasises that the availability of effective enforcement measures such as trade suspensions is likely to be a vital component in decreasing the illegal trade.

CONCLUSION

Over the last 10 – 15 years there has been a marked change in the narrative associated with international conservation. From strategies of strict protectionism, which have been coined 'fortress conservation', new approaches have developed which shift the balance from prohibition to positive incentives for conservation. These approaches, including community-based conservation, are based on the post-modernist belief that markets need not be a threat to wild species, rather they can and should be manipulated to deliver effective conservation on the ground.

While the conservation of crocodilians has clearly required and adopted a range of methodologies, including strict protection, the sustainable use approach is particularly tried, tested and well known worldwide. As a result, the experience of the crocodilians is one of the central pillars supporting that belief, in general and in detail, within the international community which ranges from organisations such as the OECD, through the Parties which make up CITES and the CBD to important NGOs and academics who have often bought into this narrative only with some reluctance. At the moment this new narrative faces a challenge from several directions, including a number of influential conservation biologists and international donors who are sceptical of the market and of community involvement in conservation and advocate for a return to more traditional preservationist approaches.

As a result, we can expect the programmes that the CSG has encouraged for the conservation of crocodilians to be under close scrutiny over the next decade. It is time, therefore, for crocodile specialists worldwide to redirect their attention to the many programmes that have been started over the last 20 years or so to make sure they are still the effective conservation tools that they were originally designed to be. Wherever there may be problems, the CSG must redouble its efforts to overcome these. Anything else is surely unthinkable?

ACKNOWLEDGEMENTS

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Commercial Consumptive Use of Crocodilians: a Conservation Panacea or Pitfall?

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ABSTRACT: Commercial consumptive use (CCU) has been widely touted as a conservation panacea for crocodilians. However, it was actually worldwide efforts to protect crocodilians and limit commercial trade of skins and skin products that led to the remarkable recovery of species such as the American alligator, and certain populations of the Nile and Saltwater crocodiles. In areas where adequate habitat remained it was these increased protective measures that made CCU programs feasible. The role of CCU can be viewed as a supplementary tool for sustaining population recovery by providing economic incentives for nations and/or local people to conserve these otherwise unsavory animals. However, the effectiveness of these economic incentives has rarely been addressed. Today, in fact there is no good evidence that CCU incentives are strong enough to influence land-use decisions concerning wetlands habitats used by crocodilians. Ranching is widely recognized as having the potential for generating income for local communities or landowners, however, worldwide trends suggest that ranching programs tend to evolve into closed-cycle farming programs (Zimbabwe and Papua New Guinea). The CSG has recognized that these farming programs usually have no conservation role, but for certain highly endangered species farming can have potentially disastrous consequences by generating economic incentives to collect and sell the last remaining wild individuals to farmers (Cambodia). CCU programs can be successful moneymaking operations but there is a need to evaluate the role of these programs in terms of conservation.

International Trade in Crocodilian Skins: Review and Analysis of the Trade and Industry Dynamics for Market-based Conservation[11]

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ABSTRACT:

- This study analyses the global trade in crocodilian skins in order to understand the scope and potential for the development of market-based approaches to conservation concerns in this industry.
- The premise of market-driven conservation, employed as a complement or a substitute to formal regulation, is that voluntary regulation may be used to alter or "tweak" incentives to industry stakeholders in order to create conditions that favour conservation.
- A comprehension of incentives facing the skin trade, its industry and its stakeholders lies at the core of an economics approach to conservation
- A number of crocodilian conservation programs have seen some success in harnessing the potential of the market to deliver conservation outcomes.
- The challenge is whether these successes can be extended to the industry as a whole and hence, to all crocodilian populations.

The lack of systematic analysis of global trade in crocodilian skins has been an obstacle to assessing the potential for market-driven conservation, as information fundamental to this approach, such as the transmission of price signals between producers and consumers, has been unreliable or incomplete. This study represents an initial effort to address this challenge and identify the factors that will affect the development and success or failure of market-based approaches to conservation of crocodilian populations.

INDUSTRY FUNDAMENTALS AND CURRENT TRENDS

Trade in crocodilian skins includes crocodile, alligator and caiman, and forms part of the overall trade in exotic leathers supplying fashion accessories to a variety of market segments worldwide. In the fashion industry, the crocodilian segment is typically associated with sophisticated or luxury tastes along with superior product quality upheld by small family-run firms with "traditional" values. In fact, the industry has undergone significant change in the past 15-20 years, particularly in the structure of supply. Regulation and marketplace changes, including market liberalisation and globalisation, technological advances, environmentalism, and fashion trends, have led skin supply to move from unregulated exploitation of wild specimens to increased reliance on ranching and captive breeding.[see Figure 1]

Since the promulgation of CITES, the proportion of skins supply from wild harvests has diminished dramatically, from over 99% in 1983 to only 6% in 1999. At the same time, overall volumes of trade have risen. Demand for crocodilian products has remained robust and, at the high end of the market, apparently resilient to economic climate and fashion trends. Meanwhile, trade in lower-cost caiman products, particularly in Asia, has grown rapidly. The development of ranching and captive breeding has lowered skin supply costs thanks to economies of scale, and introduced commoditisation and increased certainty of supply. [see Figure 2 for historical value trends in the industry]

[11] Presentation at the 16th Meeting of the Crocodile Specialist Group, Gainesville, Florida

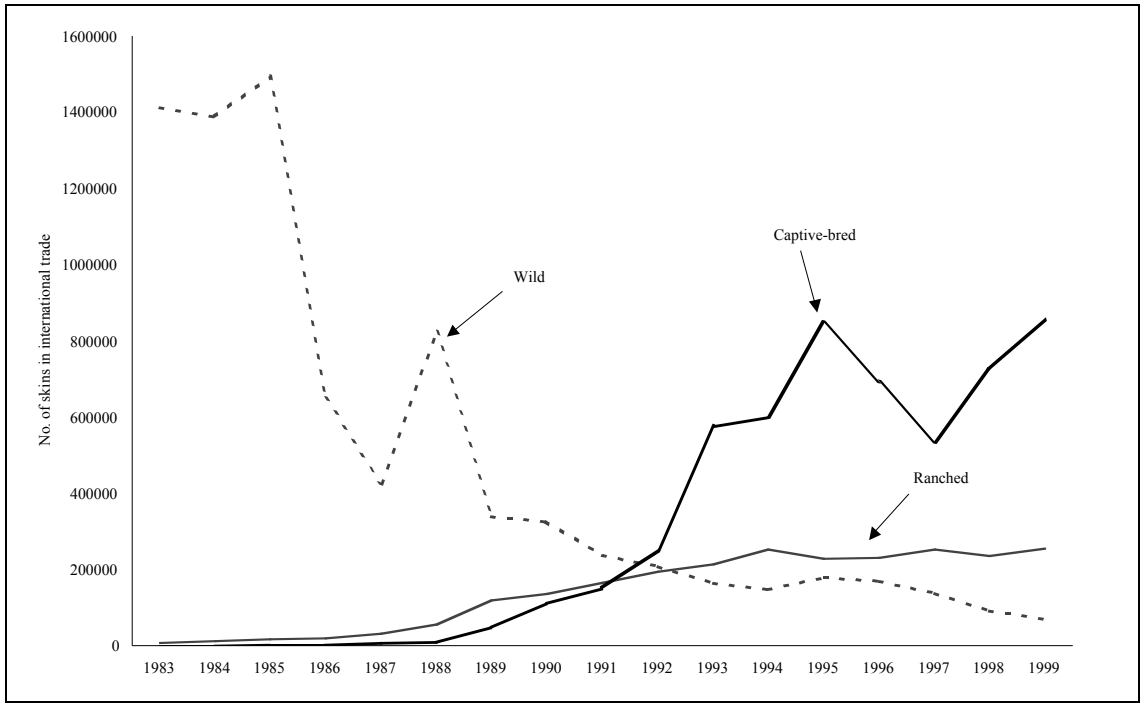

Figure 1. Estimated trade in Crocodilian skin by method of production (including caiman production), 1983–99.

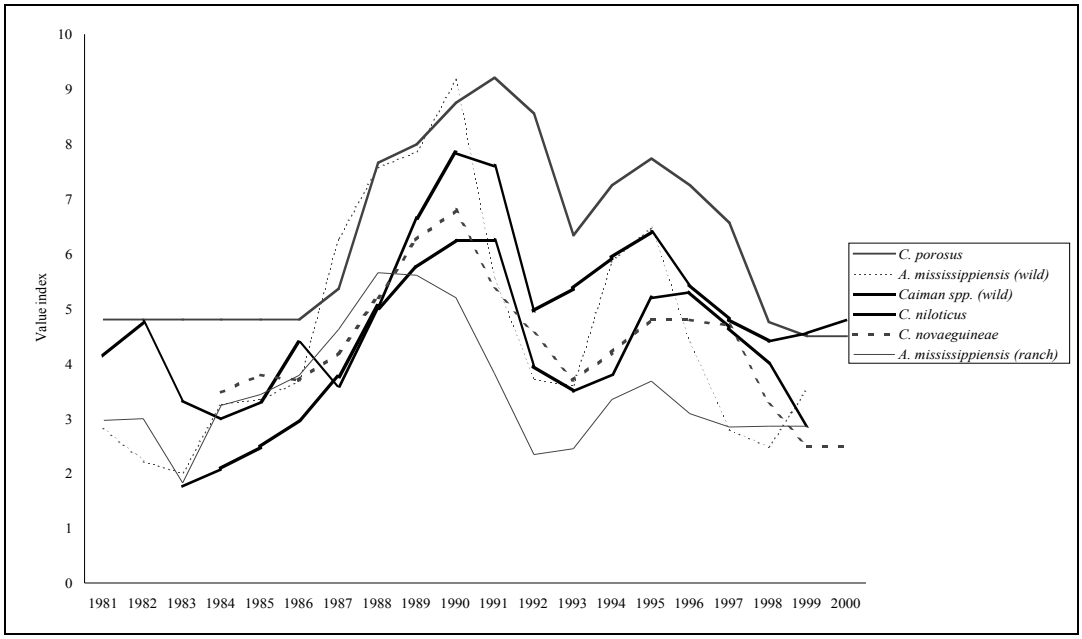

Figure 2. Value indexes for Crocodilian species' skins, 1984–2000.

The structure of the industry remains imperfect, however, in ways that delimit and shape the extent to which changes in retail value and volume of skin demand affect upstream values and incentives. The industry is hourglass-shaped, with numerous producers, manufacturers and retailers, but fewer tanneries [see Figure 3].

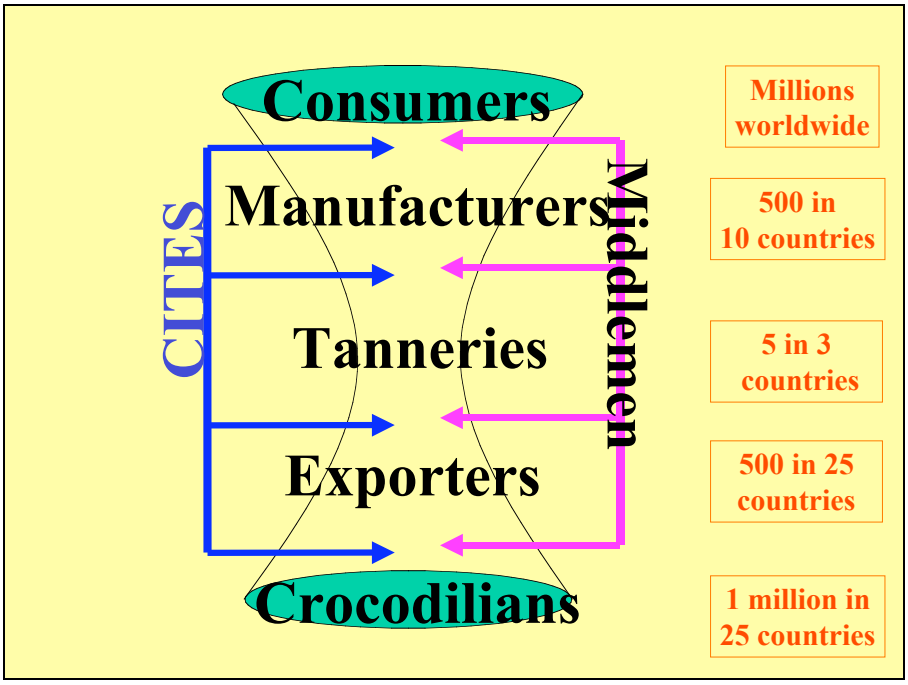

Figure 3. Representative structure of the Crocodilian skin industry (indicating numbers of stakeholders)

Hence tanneries are potentially a bottleneck in the supply chain as well as a potential location of economic power within the industry, although there is no evidence of collusion *per se*. The storability of skins from the tannery on to the manufacturer and retailer introduces the possibility of asset speculation by delaying production and supply decisions at each of these levels. While speculation is a standard entrepreneurial activity, it impacts on the industry's flow of incentives from customer to crocodilian. Other characteristics of the industry, such as the subjective and unregulated tool of "grading" to signify the quality of a skin, appear to operate to the benefit of stakeholders with power and prestige.

MARKET SEGMENTATION AND TRANSMISSION OF PRICE SIGNALS

The effect of the growth of ranching and captive breeding combined with the existing industry structure has been to differentiate market segments with respect to core economic characteristics and the relationship between retail and producer prices [see Table 1].

Table 1. Typical Disbursement of Value in the Crocodilian Skin Industry

Industry Sector	Percentage of Retail Value	Large Item, e.g.: Handbag (USD)
Retail	100%	3,000
Manufacture	42%	1,250
Tanning	17%	500
Export	8%	250
Production	6%	200

In the smaller skins segment, which tends to be captive-bred caiman and ranched alligator, a strong relationship exists between retail price and the price received by landholders and producers of skins. This owes to a combination of lower speculative potential, high and possibly very high demand, practical barriers to managing supply of large numbers of units, and acknowledgement of the minimal gains from doing so.

By contrast, in the market for larger skins, which command higher prices and are primarily "classic" crocodile skins along with wild-harvested caiman, asset speculation appears to be a significant factor in determining both the supply and value of skins. Rent dissipation is not absolute, however; even in this segment,

there is evidence that consumer preferences at the retail level filter through the industry and affect the incentives facing landholders over resource utilisation.

PATHWAYS TO MARKET-BASED CONSERVATION

Scope. The dynamics of price signal transmission from the retail market up to the landholder and producer open the possibility of designing mechanisms that use market-driven methods for conservation. They also point to challenges that such mechanisms will need to address if they are to be successful. Although the markets for skins from wild and non-wild harvests are increasingly distinct, their prices still move in tandem. If these markets became more distinct, with fewer cross-price effects, it would encourage greater stability in the value of wild-harvested skins and enable conservation-oriented supply management innovations at producer level. Additionally, the constriction of the market at the tannery level, by diverting excess profits away from those segments in a position to re-invest in the wild resource, may limit the effectiveness of some market-based conservation measures, unless these also tackle the causes of this consolidative tendency in the first place.

Approaches. Given these industry characteristics, a variety of market-friendly methods for conservation are worth considering:

- Supply management: including producer cooperatives, restricting supply to range states
- Resource rent management: redistributive mechanisms to enhance landholders' returns and the translation of demand signals into conservation outcomes, including differentiating those skins that embrace conservation values and subsidization of wild populations by all skins;
- Demand management: including options such as 'certification'.

Issues and concerns. The scope for successful implementation of these measures should be assessed in tandem with formal regulation approaches, and with a sharp eye for exogenous factors and unintended outcomes. For instance, exchange rates play a key role in shaping incentives: evidence from Venezuela and Zimbabwe shows that local currency values rather than international prices are the key indicator for producer and landholder decisions over harvest. Furthermore, the growth of captive breeding might in the future divert production away from the traditional range states, limiting the scope for domestic cross-subsidization of wild populations for conservation, and increasing the imperative for international regulatory interventions. In addition, a closer understanding is required of the complementary and substitution effects between crocodilian skins and other exotics leathers.

Finally, the quality and availability of data within this industry remain short of what is needed to design sophisticated interventions. Further research is needed both at the aggregate, market level and on subtle but important factors such as the effect of changing economic conditions on size, grade and other characteristics of harvest. These and other data must be collected and widely disseminated to support the development and improve the effectiveness of new conservation methods.

Key Issue: Is captive breeding an ambiguous development for conservation?

The main impact on the industry of captive-bred skins: ensuring certainty of supply – hence, diminishing uncertainty/ risk and increasing economic efficiency of trade. Some likely economic impacts are identified:

- *increased price competition* as economies of scale and technology are realised by larger producers. Unit costs decrease and prices might fall
- *horizontal integration*: concentration of production and economic power among selected large-scale producers
- industry supply becomes more certain and stable as disruptive factors such as climate are erased from the production equation, technology is more important
- *comparison*: domestication increases specialisation and homogenisation of supply units, increasing the potential for comparison between the products of different producers – possibly increasing production efficiency and inevitably generating further price competition
- *vertical integration*: any reduction in the number of industry stakeholders in certain sectors will expedite communication between producers and downstream stakeholders.

Potential long-term losers:

- *smaller suppliers of captive-bred skins* to the industry fold as competition favours larger producers
- *suppliers of wild-harvested skins* to the industry *could* suffer a contiguous downward spiral in value. Synchronous fluctuations in value forewarn of cross-price effects: if supply-led effects of captive-bred skins affects its *own* market value in the short-term, this could affect the value for *all* crocodilian skins
- *livelihoods* of those stewards of wild crocodilian resources
- *intermediaries* will be needed less, because fewer transactions will be executed between fewer industry stakeholders.
- *range states* without access to the technology to take full advantage of specialisation and economies of scale.
- *ill*egal trade market consolidation would reduce enforcement costs and possibly raise standards in a sector with fewer stakeholders.

CONCLUSION: INCENTIVES AND OPTIONS FOR CONSERVATION

All too often, conservation relies overly on transfers of international existence value via donor agencies and the goodwill of landholders. Increased emphasis on market-driven conservation fosters the potential to achieve many conservation outcomes by harnessing the power of the market. In this, the crocodilian skin industry is no exception. As this study shows, the specific characteristics of the industry set up particular challenges and incentives, which must be properly understood if market-based conservation efforts are to be successful. Substantial and specific further research is needed into the economics of the industry. Nevertheless, some important preliminary findings may be offered as of now.

Redistributive mechanisms: a prerequisite for success

The crocodilian skin trade as presently organized displays many consolidative features that direct excess profits to specific segments, rather than distributing them all along the value chain. This means that particular stakeholders retain economic power and privilege in the industry. Because these stakeholders are typically not the ones closest to the resource, it is therefore unreasonable to expect that excess profits will automatically lead to re-investment in the wild resource. From a conservation standpoint, therefore, market-based initiatives must be redistributive: i.e. they must be specifically designed to ensure that rents accrue to the resource (through the landholder) rather than being appropriated elsewhere in the industry.

The imperative of redistribution makes the design of effective mechanisms more complex, but it is a necessary consequence of the structure of the industry. The challenge is by no means insurmountable, and further research into industry economics will be of great benefit. A series of simple mechanisms and market interventions could potentially increase rents flowing to the resource and create conspicuous incentives for market-driven utilisation. At the same time, tackling the underlying causes of the consolidative tendency in the industry could prove beneficial in the long term to all wild crocodilian resources.

A value wedge

An attractive overall approach for conservation is to drive a value wedge between those skins that embrace conservation principles and those that are the result of industrial processes. This need not be a fundamental change to the industry, but rather a recognition that the industry needs a new kind of insurance for guaranteed future supply of skins, i.e. conserving *in situ* populations.

The industry context and the imperative of redistribution shape some of the options for specific interventions to establish such a wedge. Fine-tuning interventions will require crucial research along several directions, including:

- own-price effect within species
- cross-price effect including other exotics
- consumer willingness to pay for conservation
- the relative benefit of private and cooperative intermediaries over time

- more sophisticated consumer classification.

In addition, a more complex understanding is required of the economics of landholders and producers, and the discrepancies between local and international incentives for sustainability of the wild resource. The case studies of Venezuela and Zimbabwe suggest several key issues. For one, international value fluctuations are not the most salient indicator of producer incentives. Rather, local currency value is the key indicator. Hence, the demonstration of conspicuous economic incentives for conservation is contingent on exchange rates. Secondly, inflation does not seem to be an important factor in determining wild-harvest effort. Decisions are made in the short term, and discount rates appear to be high. Finally, when economic or regulatory conditions change, so does resource use, often in ways that are very subtle but have important effects on the prospects for sustainability. To understand these effects requires going beyond the volume of skins and into more specific data, including skin size, species, finish, cut, and geography. By combining these dimensions with domestic and international economic data, it should be possible to construct robust indicators and dynamic tools for decision-makers.

Options for implementation

Management of supply. Because it is imperative to direct conservation incentives to the landholder and producer level, management of supply offers the most direct routes for new conservation mechanisms.

- *Producer cooperatives*. Range states with wild-harvested and ranched skins adopt producer cooperative techniques to manage supply. The premise is that restrictions in supply to the market of "large" skins will even the power differentials and allow landholders to appropriate a great proportion of the rents from the *in situ* resource, including the ability to re-invest. "Small" skins may not benefit from such mechanisms, however, because the small-skin segment is demand-led.
- *Private intermediaries*. An industry stakeholder plays the role of a producer cooperative by negotiating the sale of skins to tanneries for maximum profit, and hence maximum returns to landholders. The intermediary must be appropriately incentivised.
- *Auctions*. The use of auctions to sell skins pushes the market to reveal the true current price of skins. Particular types of auction (sealed-bid; Vickrey) mitigate against collusion among buyers.
- *Restrict supply to range states*. From a total economic value perspective, it may make sense to reward those countries that have a comparative advantage in the supply of wild crocodilian populations and habitat. One way to do this would be to restrict skin supply to range states. However, the complexity of determining the total economic value of *in situ* populations and their habitat call for caution.
- *Cross-subsidization*. In theory, levies could be enforced on each specimen or unit in trade. The funds generated could then be disbursed to those *in situ* populations who would benefit the most. In practice, however, this is a huge undertaking that requires new institutional arrangements and complex coordination. Moreover, it is not a long-term solution as it does not rely on market-based incentives to conserve the wild resource.

The understanding of the international crocodilian skin industry is presently at an intermediate stage. Assessing the industry as a global, interconnected system as opposed to a collection of local industries is a relatively new undertaking. The opaqueness of the industry, and the bottlenecks that reside principally at the tannery level, have been obstacles to information flow and to economic analysis. These obstacles are now coming down, and initial analysis strongly suggests that although the crocodilian skin industry possesses many particularities, it is likely to be amenable to new research and to new methods of industrial organization and regulation just as other wildlife-based industries have been. This study has aimed to capture the overall traits of the industry and identify key directions for such research.

The development of market-based mechanisms to support conservation of the wild resource is highly desirable and, in light of analytic progress and examples from other industries, highly promising. At the same time, any such mechanisms will have to confront head-on the consolidative, or non-redistributive, tendencies inherent in the present industry structure. They must clearly assist in directing rents toward the producer and landholder and producing incentives for effective reinvestment of these rents into the resource. At root, this will

require not only a technical, but also a strategic understanding of the incentives and challenges landholders and producers in a globalising economy.

Ecuador Ranching Project
Why Did it Fail?

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In 1992, Mr. Pablo Evans who was interested in ranching black caiman in Ecuador contacted me. He was willing to finance surveys in the Amazon Region of Ecuador to determine if population levels were at a level to justify down-listing black caiman, *Melanosuchus niger*, to Appendix II of the CITES Treaty to allow ranching.

The Beginning

In the beginning, the prospects for success appeared favorable. The businessman/prospective rancher was willing to make a substantial investment in surveys and was committed to supporting a biologically sound approach. He familiarized himself with current crocodilian literature and sought the assistance of the Crocodile Specialist Group (CSG). Furthermore, the prospective rancher traveled to various parts of the world to familiarize himself with current husbandry methods. He was also familiar with the Ecuadorian political structure and encouraged government support. In addition, there was strong support from the CSG as well as volunteer efforts from other biologists interested in the success of the project.

Biological Assessment

The original proposal submitted to Mr. Evans and the Government of Ecuador to evaluate the feasibility of ranching black caiman provided the impetus for the first surveys in 1992. The proposal contained the following three objectives; 1) to determine the population status and distribution of black caiman within the Amazon region of Ecuador, 2) To generate information and recommendations concerning the management of black caiman in the wild, including a long term monitoring system, 3) to provide Mr. Pablo Evans with recommendations regarding the feasibility of ranching and/farming black caiman in Ecuador.

Study areas for the initial survey consisted of lagoons, backwaters, and disjunct oxbows associated with the Rio Napo (from Coca to Rocafuerte), and up the Rio Largarto Cocha. Then, in August 1994 we conducted an additional survey along the Rio Curaray, which is one of three remote river systems between the Rio Pastaza and the Napo. Routes were located in the lagoons, oxbows and the actual river from Amarunchocha to the Peruvrian border.

In general, the surveys indicated that there were viable populations of black caiman in the region. Crocodilians were observed along all 12 survey routes (totaling 240km) in the area of the Rio Napo and black caiman were observed on all routes except one. Densities ranged from 0 to14.72 black caiman/km with an average of 4.65 animals/km (Hines and Rice 1992). Thirteen lagoons and 8 river routes were surveyed (totaling160km) along the Curaray. Black caiman occurred in 12 of 13 lagoons and were most abundant in 6. The highest count was 12.43 animals/km with a mean density of black caiman on all surveys on the Curaray of 4.34/km (Hines and Wilkinson 1995).

Conclusions and early recommendations: Following is a synopsis of the recommendations made in the first report (Hines and Rice 1992): 1) Population data from other researchers should be combined with data from this project to provide a more complete picture of population status. 2) Address the effects of annual variation on surveys and train Ecuadorian biologist to perform surveys. 3) Identify and quantify available habitat 4) survey the extensive region south of the Napo. In addition, recommendations were made to implement research on reproduction, mortality and growth, improvement of monitoring, and interspecific competition of *Melanosuchus niger* and *Caiman crocodylus*. It was also recommended that simultaneous with the field research that the practical aspects of captive rearing of black caiman should begin, and that the role of indigenous people in a ranching program should be identified to assure that conservation benefits of the ranching program be maximized.

The second report (Hines and Wilkinson 1995) concluded that viable populations in similar densities to those found in the Napo region occurred along the Curaray. But, for a more complete understanding of caiman status in the region, surveys of the Conanaco and Nashino should be conducted.

Project Funding

The Rio Napo survey, and the subsequent replications of the original surveys were totally funded by Pablo Evans. The Rio Curaray surveys were funded by Evans with some help from the Ecuadorian government. After the first survey effort, it became apparent that the cost of operating in the remote regions of the Amazon region of Ecuador was very high. In addition, we had proposed additional research to compliment the survey effort and to provide a sound base for a long term management program. In February of 1993, I asked the CITES Animals Committee for support and financial assistance to continue the project. We were not able to get funds from this source and very limited assistance from any other source. One workshop was held in Ecuador with the objective of fostering interest in the caiman project within the country and attracting outside funds for continuing the project. None of these efforts generated any funds.

Down Listing

By 1994 the decision to ask for a change in listing from Appendix I to Appendix II Ranched was made. The basis for the decision included the following; we were proposing a ranching program which had little chance of serious impact on population levels. Population densities appeared to be comparable with other known viable crocodilian populations in the world. We were confident that Mr. Evans was a responsible user and would follow the guidelines provided by the CSG. We had not quantified habitat to the extent that was originally proposed. But, significant areas had been surveyed and large areas within the same region were identical habitat, and we were confident similar populations occurred in those. Mr. Evans was willing to fund additional surveys and research if he could generate some cash flow from the caiman project.

Ranching Efforts

After the down listing in 1994, Mr. Evans attempted collection of hatchlings and some contacts were made with indigenous people to buy hatchlings from them. Rearing tanks were constructed, in Coca, upstream from where most of the available caiman were collected. A total of 300 hatchlings were collected and placed in rearing tanks over a three-year period, and 185 animals remained in those tanks in 2002.

Outcome

By 1997, it became apparent that Mr. Evans was having some difficulty in securing enough hatchlings to adequately stock his rearing tanks. He had invested a large sum of money and the number of hatchlings he was obtaining was inadequate. His prospects for a profitable operation appeared to be diminishing, and to date it appears the project was a failure. The major objective of this paper is to examine the facts regarding this effort and find a possible explanation for the failure. Some of the reasons are endemic to Ecuador, but some can be used as a case study for other such projects.

Factors Influencing the Success of the Project

The direction presented in the first report (Hines and Rice 1992) provides a sound basis for a crocodilian management program. However, it is instructive to compare the actions recommended with those actually taken. Further, the possible effects of the action, or lack of it, on the eventual outcome of the project are examined. Those recommendations and their outcome follow.

1. <u>All available population data should be combined:</u> Population data from Ecuador from all sources were summarized, and reported densities were comparable to the population levels we observed. Furthermore, the nightlight counts we reported were comparable to other viable crocodilian populations in other parts of the world.

2. <u>Investigate the effects of annual variation on counts and replicate existing surveys</u>: Some of the surveys were replicated, but there was never any serious investigation of the effects of the dramatic water level fluctuation on survey results. The fact that these investigations did not take place did not contribute to

the failure of the project but an understanding of the effects of these variables on surveys should have been a part of a long term management program.

3. Quantify available habitat in the Amazon Region of Ecuador: The available habitat was never systematically quantified. We became familiar with the relatively large area of the Amazon region and made a judgment as to the quantity of habitat. Even though it was apparent that we were dealing with viable populations of caiman, it was important that we know the amount of available habitat. It was not that we were anticipating a harvest that would jeopardize caiman populations. But, if we had specifically quantified the available habitat, we would have been in a better position to evaluate Mr. Evan's chances of obtaining adequate numbers of hatchlings.

4. Survey other river systems: A major survey was conducted along the Curaray in the large area south of the Napo. These data provided important insights into caiman populations in this region, and there is little reason to believe that the river systems to north of the Curaray harbored populations of black caiman any different than those we observed elsewhere. But, the other systems should have been surveyed to better understand the extent of the caiman population and the potential collection area.

5. Continued research effort: Because funding was limited, none of the research priorities proposed in the first report were implemented. This did not contribute to the failure of the project. However, over the long term, it was important that these research projects be conducted to assure a solid biological basis for future management actions.

In addition to the previously mention factors, there were other considerations which, in retrospect, were very important to the success of the project. They fall into five broad categories:

1. Access to habitat
2. Logistics
3. Relationships with indigenous people
4. Economics
5. Infrastructure

Access to habitat: There were three factors which influenced access to habitat where hatchlings occurred. Large areas in the Amazon region were designated as National Parks or Natural Resource areas where the legality of collections was unclear. These land management categories are unclear in the law, and the application of the law concerning these lands is unclear. Other areas are controlled by indigenous groups, and in some cases, there are overlapping claims of authority by the government and Indian groups. In other cases, areas are remote and simply difficult to access.

Logistics: Closely related to the access problem is the logistics of collecting and moving hatchlings to the rearing tanks. In many cases, the source of hatchlings is in excess of 100 miles by canoe from the rearing station. In other cases, it would require air travel into a site and canoe trips of many miles to collect animals. If the rancher attempted to collect the hatchlings, both the problem of access and the logistical problems associated with distance and remoteness make the collections very expensive and perhaps impractical.

Relationships with indigenous people: In the first report, it was pointed out that the role of the Indian groups in the region should be large. The motivation, in the beginning, was to maximize the conservation benefits. But, it became apparent that without considerable help from the people in the area, it was impossible to be successful. If there had been a more concentrated effort to become involved in the political and social structure of the region, and if the local people had been convinced that it would be profitable for them to collect hatchlings, the access and logistical problems would have been lessened. Then, the chances of success would have been increased considerably.

Economics: With the advantage of hindsight, it has become apparent as a resource manager I viewed the problems we faced from a different perspective than did Mr. Evans as an entrepreneur. My motivation was to build a biological sound management program that was profitable to Mr. Evans. He had a similar goal, but he was investing with the idea that there was a strong probability of a return on his money. When the probability for returns appeared to decrease dramatically, he wisely invested his money in more profitable ventures. I still

wanted to look for ways to make the project work. Had I fully grasped the significance of these two points of view, I might have advised him to approach the project in much more conservative manner and wait for more outside funding.

The lack of funding from sources other than Mr. Evan's was one of the major causes of declining commitment at the end of the project. Evan's invested large sums of money up front to finance surveys. This reduced the amount he was willing to invest in searching for the right approach to make the program work in Ecuador later on. His up front investment was the limit of what he was willing to gamble on the prospects of success.

Infrastructure: The Ecuadorian government provided assistance by issuing permits and preparing the proposal to change the listing to Appendix II. They also participated in the one workshop. However, there were numerous changes in government personnel during the life of the project, and their commitment lacked continuity. Also, it is probable that the caiman resource could only support one or two operations. These one or two ranchers would potentially represent a very small political power base, and would have some difficulty attracting serious attention from a government strapped for resources.

The importance of having Ecuadorian biologists working on the project was understood in the beginning. We had contact with some young graduates in biology and Evan's even supported one coming to FL to get some training in survey techniques. In the final analysis, funding was the key issue and Evan's simply could not support the entire program.

Conclusion

The major mistakes made on the ground were an inadequate assessment of the quantity of habitat, failure to grasp the difficulties of access and logistics in regard to collection of hatchlings, and failure to develop close relationships with indigenous people to provide hatchlings. However, the larger problem was a lack of funding. Many of the difficulties might have been addressed if outside funding could have been used to perform the initial surveys. Crocodilian ranching enterprises typically operate on a relatively narrow margin. Consequently, it appears impractical to ask a prospective rancher to fund expensive surveys in remote regions with the prospect of generating enough income from the ranching enterprise to cover his initial expenses. Some governmental commitment in funds and overall support is necessary. The only other alternative is to have strong financial support from the international community. In Ecuador, we had a strong commitment from the prospective user. But a commitment from professionals in the country who have some knowledge of wildlife management, and a governmental infrastructure is equally important

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Florida's Alligator Management Program: an Update 1987 to 2001

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ABSTRACT: Florida's Alligator Management Program has developed around the premise that the economic value derived from consumptive use of Florida's alligator (*Alligator mississippiensis)* resource can provide economic incentives to conserve alligators and preserve their wetland habitat. The expansion of management programs and growth of an industry dependent on the alligator resource has provided a constituency group to serve as advocates for wetland conservation. The major objectives of the program are to implement sustained alligator harvest programs while optimizing the economic, aesthetic, and ecological values of alligators as a renewable natural resource. By emphasizing these values, not only are there incentives for conservation of the alligator, but also the wetland ecosystems they inhabit. The intent of this paper is to provide the current status of this unique and comprehensive management program relative to the last update provided to Crocodile Specialist Group members in 1996 (David et al. 1996).

INTRODUCTION

Alligators have been an important component of Florida's wetland systems for thousands of years, and have also been commercial used in Florida as early as the late 1800's. Because harvesting of alligators went unregulated through the early 1900's, concerns about population declines in easily accessible areas stimulated establishment of a four-foot minimum size limit (the first statewide alligator regulation) by the former Florida Game and Fresh Water Fish Commission in 1943 (now part of the Florida Fish and Wildlife Conservation Commission, and hereinafter referred to as the "Commission"). Alligator populations continued to decline despite regulatory efforts through the late 1950's and early 1960's. As a consequence, the alligator harvest season in Florida was closed in 1962. Wide spread illegal exploitation continued, however, due to an inability to affectively enforce state laws, culminating in American alligators being included on the first federal endangered species list in 1967. In 1970, strict federal regulations were imposed through an amendment to the Lacey Act that made it illegal to ship illegally taken alligators between states. Under this highly effective regulation, illegal trade came to an end, and alligator populations in areas where declines had been observed made impressive comebacks (Hines 1979).

Alligator population surveys conducted by Commission biologists in the mid 1970's indicated that most populations were increasing rapidly (Hines 1979, Wood et al. 1985). Concomitantly, the Commission was receiving 4,000 to 5,000 nuisance-alligator complaints annually. In 1977, the status of Florida's alligator population was reclassified from endangered to threatened by the U. S. Fish and Wildlife Service, following the population status evaluation conducted by the Commission's alligator research staff. This change in status allowed the Commission to initiate management of the nuisance-alligator problem through harvest, resulting in our current nuisance-alligator control program (Hines and Woodward 1980, and Woodward and Cook 2000). The American alligator is currently listed under the Endangered Species Act as threatened due to similarity of appearance (Neal 1985).

In 1980, the Commission's alligator research staff began focusing its efforts on the impact of alligator harvests on wild populations. As a result of these investigations and subsequent experimental alligator harvests on selected wetlands, the Commission created an Alligator Management Program, later to become the Alligator Management Section (AMS) within the Division of Wildlife's Bureau of Wildlife Resources.

The Commission's Alligator Management Program has developed around the premise that the economic value derived from consumptive use of Florida's alligator resource can provide economic incentives to conserve alligators and preserve their wetland habitat. The expansion of management programs and growth of an industry dependent on the alligator resource can provide a new constituency group to serve as advocates for

wetland conservation. The major objectives of the AMS are to implement sustained alligator harvest programs while optimizing the economic, aesthetic, and ecological values of alligators as a renewable natural resource. By emphasizing these values, the Commission hopes to provide incentives for conservation of not only the alligator, but also the wetland ecosystems they inhabit.

The following is a summary of the major program components of Florida's alligator management program. A suite of rules adopted, and frequently amended, by the Commission collectively governs each of the program's elements. Although complex, these rules ensure sustainable harvests of the resource and credibility and integrity of this Convention on International Trade in Endangered Species (CITES) based program. Current versions of Florida's alligator management rules can be viewed on the Internet at http://wildflorida.org/gators/ (click on the Data Center link).

PUBLIC WATERS ALLIGATOR HARVEST PROGRAM

Under this program, alligator populations are managed on designated waterbodies ranging in size from 1,000 to over 100,000 acres. These Alligator Harvest Management Units (AMUs) are established by Executive Order (a document signed by our Commission's Executive Director), and the Commission's Executive Director, or his designee, establishes annual harvest quotas via a signed memorandum. Figure 1 depicts the total annual harvest quotas established for all AMUs each year since the program's inception.

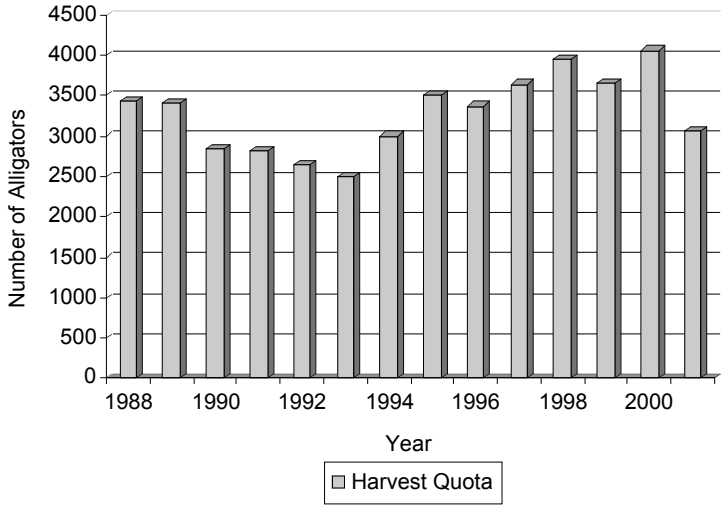

Figure 1. Total annual alligator harvest quotas established on Alligator Harvest Management Units in Florida from 1988 – 2001.

Biologists assigned to the AMS review and recommend AMUs for establishment annually. Procedures for two types of AMUs are used in this evaluation: (1) those for which a harvest quota is established by annual, intensive population monitoring (used on areas referred to as "variable-quota AMUs") and (2) those for which a harvest quota is established by either a one-time alligator habitat inventory or population survey (used on areas referred to as "static-quota AMUs"). Brunell et al. (2002) provides a complete and detailed account of the current protocol used to recommend new AMUs, calculate recommended harvest quotas for AMUs, identify AMUs to be closed to harvest, and determine when closed AMUs should be reopened. Figure 2 depicts the number of AMUs that have been established since the program's inception.

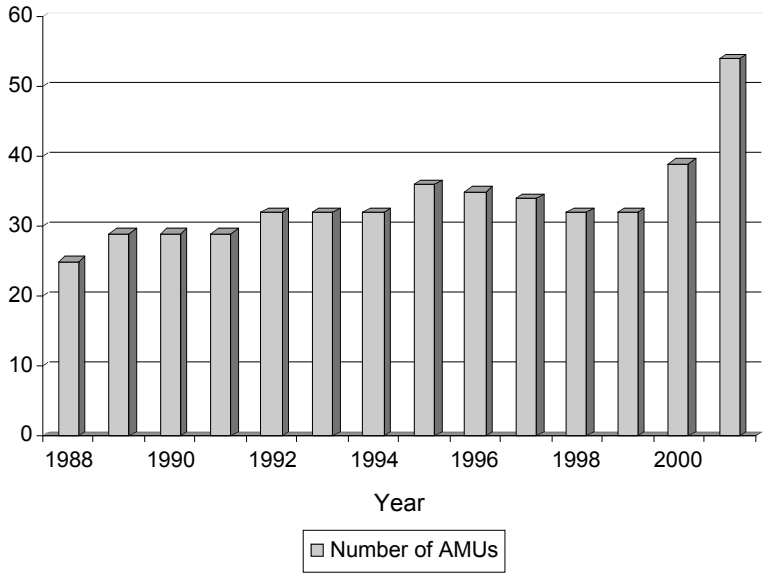

Figure 2. Total number of established Alligator Harvest Management Units in Florida from 1988 – 2001.

The Commission's public waters alligator harvest program continues to be an important component of the overall management strategy. It captures statewide, national, and international interest and provides an excellent opportunity to inform the public about the value of alligators and wetlands, while allowing participants to enjoy harvest benefits from this renewable natural resource. Table 1 summarizes the various participation and harvest trends in this program since its inception. Of particular note is the more than doubling of permits available starting in 2000. This was the direct result of Commission rule changes that decreased the number of tags issued with each permit from five to two, making the program truly recreational in nature as opposed to its former commercial roots. This has increased participation in the hunts and has generated additional revenues to support other recent changes in the other alligator management program elements. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 1. Public waters alligator harvest program summary, 1988-2001

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Applications Submitted	5,855	20,163	10,122	15,311	12,085	7,380	6,859	8,909	12,685	13,810	11,400	10,006	7,222	7,871
Permits Available	238	229	189	188	176	500	500	583	671	728	789	729	2,031	1,533
Permitted Applicants	230	222	177	186	143	405	464	565	652	709	723	673	1,706	1,524
Tags Issued	3,375	3,330	2,655	2,790	2,145	2,025	2,784	3,390	3,260	3,545	3,615	3,365	3,412	3,048
Alligators Harvested	2,988	3,031	2,502	2,408	1,491	1,571	2,302	2,985	2,900	2,829	2,260	2,340	2,547	2,267
Percent Harvested (%)	88	91	94	86	70	78	83	88	89	80	63	70	75	74
Avg. Carcass Length (ft.)	7.6	7.7	7.9	8.5	7.9	7.9	7.9	8.1	8.2	8.0	8.0	8.2	8.8	8.8

PRIVATE LANDS ALLIGATOR MANAGEMENT PROGRAM

Since a large percentage of Florida's wetlands are privately owned, conservation of alligator habitats on private lands is critical to the continued well-being of alligator populations in the state. The Commission has given landowners an incentive for maintaining these habitats by providing them an opportunity to manage and harvest alligators from their lands. To participate in the program, applicants must own or lease a parcel with a minimum of 1,000 acres of alligator habitat or with a minimum of 100 alligators greater than four-feet in length. A group of landowners or authorized lessees may apply jointly provided the aggregate adjoining properties meet the minimum alligator habitat acreage or population requirements.

Table 2. Estimated producer value and levels of wild alligator harvests in Florida during 1978-2001.

	No. Alligators Harvested							Hide Price			Meat Produced (lbs)				
Year	Nuisance	Public Waters	Private Lands	Total	Hides Tagged	Total Ft. Hides	Ave. Hide Length (ft.)	per linear ft.	per belly cm	Hide Value	Ave. per Alligator	Aggregate Total	Meat Price	Meat Value	Total Value
1978	1,871	0	0	1,871	1,556	11,005	7.07	$8.17	$1.40	$89,876		0		$0	$89,876
1979	1,679	0	0	1,679	0	0				$0		3,600	$4.00	$14,400	$14,400
1980	1,590	0	0	1,590	3,562	25,112	7.05	$11.47	$1.96	$287,939		36,900	$4.50	$166,050	$453,989
1981	1,871	350	0	2,221	2,732	19,179	7.02	$18.37	$3.14	$352,285		66,650	$5.00	$333,250	$685,535
1982	2,169	379	0	2,548	748	5,354	7.16	$22.42	$3.84	$120,060		60,900	$5.00	$304,500	$424,560
1983	1,871	277	0	2,148	2,261	16,045	7.10	$9.23	$1.58	$148,122		62,400	$5.00	$312,000	$460,122
1984	2,201	271	0	2,472	4,325	32,409	7.49	$18.24	$3.12	$591,101		83,500	$5.00	$417,500	$1,008,601
1985	3,023	1,052	39	4,114	2,689	20,219	7.52	$20.59	$3.53	$416,383		134,700	$5.00	$673,500	$1,089,883
1986	3,049	1,121	76	4,246	5,206	39,113	7.51	$22.72	$3.89	$888,548		135,000	$5.00	$675,000	$1,563,548
1987	3,853	1,016	0	4,869	5,320	39,847	7.49	$35.99	$6.16	$1,434,057		150,600	$5.00	$753,000	$2,187,057
1988	4,464	2,988	180	7,632	7,632	59,606	7.81	$45.15	$7.73	$2,691,207	31.1	237,125	$5.00	$1,185,625	$3,876,832
1989	4,263	3,031	577	7,871	7,871	60,685	7.71	$46.25	$7.92	$2,806,700	29.7	233,859	$5.00	$1,169,295	$3,975,995
1990	4,053	2,502	1,117	7,672	7,672	59,151	7.71	$58.04	$9.93	$3,433,131	29.7	227,946	$4.50	$1,025,759	$4,458,890
1991	4,228	2,408	1,600	8,236	8,236	65,311	7.93	$41.97	$7.18	$2,741,123	32.8	269,791	$4.50	$1,214,060	$3,955,183
1992	3,564	1,491	875	5,930	5,930	45,839	7.73	$23.91	$4.09	$1,096,008	30.0	177,780	$4.00	$711,118	$1,807,127
1993	4,019	1,571	1,523	7,113	7,113	55,410	7.79	$20.71	$3.55	$1,147,547	30.8	219,043	$4.00	$876,171	$2,023,718
1994	4,488	2,302	2,872	9,662	9,662	75,750	7.84	$35.30	$6.04	$2,673,978	31.5	304,216	$4.00	$1,216,864	$3,890,842
1995	4,752	2,985	4,210	11,947	11,947	94,262	7.89	$39.18	$6.71	$3,693,178	32.2	384,549	$4.50	$1,730,470	$5,423,649
1996	4,799	2,900	5,002	12,701	12,701	98,941	7.79	$32.00	$5.48	$3,166,105	30.8	391,124	$5.00	$1,955,618	$5,121,723
1997	5,138	2,829	3,667	11,634	11,634	89,349	7.68	$16.00	$2.74	$1,429,586	29.3	341,020	$4.50	$1,534,590	$2,964,175
1998	5,088	2,260	2,200	9,548	9,548	68,841	7.21	$16.89	$2.89	$1,162,726	23.5	224,814	$5.00	$1,124,068	$2,286,793
1999	5,022	2,340	3,037	10,399	10,399	75,913	7.30	$22.00	$3.77	$1,670,079	24.6	255,618	$5.00	$1,278,089	$2,948,169
2000	6,254	2,547	3,804	12,605	12,605	93,277	7.40	$27.25	$4.66	$2,541,798	25.8	324,818	$5.25	$1,705,295	$4,247,093
2001	7,204	2,259	4,164	13,627	13,627	100,022	7.34	$28.25	$4.84	$2,825,627	25.1	341,376	$4.50	$1,536,190	$4,361,817

Hides tagged may differ from alligators harvested in some years due to sales of confiscated skins, loss of damaged skins, and year of tagging.
Total Ft. Hides: Actual footage during 1977-87, calculated as (Total Hides * Ave. TL) after 1987.
Ave. Total Length: Based on actual length data from hide validations.
Hide Prices: Actual hide prices during 1977-87. Estimates of price for average size (7.5 ft.) alligator based on trapper and dealer interviews after 1987.
/belly cm.: Calculated from (price/lin. ft. / 5.842)
Hide Value: Actual price received during 1977-87. Calculated as (Total Ft. Hides * Hide Price) after 1987.
Meat Produced: Actual figures from 1977-1987; After 1987, yields were estimated from Woodward et al. (1992) formula (assumes meat yield of 30% of total weight).
Meat Price: Derived from verbal trapper reports.

Private lands participants may choose from several available harvest options, depending on the acreage of alligator habitat on their properties and/or alligator population information provided to the Commission. Private landowners may elect to harvest alligators, hatchlings, and eggs from their properties.

Participation in the private lands program has proliferated since 1988. Being a truly commercially oriented harvest program, property enrollment should be directly tied to the status of the alligator hide and meat markets. Despite chronically depressed alligator hide market conditions, this program has continued to expand. Table 3 summarizes the participation and harvest trends of this program since its inception. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 3. Private lands alligator management program summary, 1988-2001.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
# Participating Properties	7	21	35	104	73	63	84	114	124	144	112	142	143	152
Total Enrolled Acres (M)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.943	1.055	1.232
Tags Issued	225	700	1,276	2,099	1,592	1,999	3,619	5,055	6,191	6,436	5,234	5,035	6,633	7,663
Alligators Harvested	180	577	1,117	1,600	875	1,523	2,872	4,210	5,002	3,667	2,200	3,273	3,804	4,169
Percent Harvested (%)	80	82	88	76	55	76	79	83	81	57	42	65	57	54
Avg. Carcass Length (ft.)	N/A	7.7	7.1	7.8	7.6	7.7	7.6	7.6	7.3	7.1	6.8	6.9	7.1	7.2
Eggs Collected	567	1,038	2,701	4,078	1,968	998	6,944	14,225	14,544	18,663	8,148	14,996	13,755	16,576
Hatchlings Collected	72	160	160	51	0	0	0	0	0	0	0	0	0	0

NUISANCE ALLIGATOR CONTROL PROGRAM

This program is administered by the Commission's Division of Law Enforcement through contracts between the Commission and professional alligator trappers, and is designed to permit the harvest of alligators that are determined to be a threat to the welfare of the public, or their pets or property. Approximately 40 professional trappers are contracted to remove specific nuisance alligators. Members of the public call a Commission office to submit complaints regarding nuisance alligators, which are evaluated by Commission staff to determine if the alligator should be removed by a contracted nuisance-alligator trapper (Hines and Woodward 1980, Jennings et al. 1989, Woodward and Cook 2000). The program has helped to hold alligator attacks at a low level and has proved to be a quick and cost effective response to nuisance-alligator complaints (Woodward and Cook 2000). Therefore, the program has been viewed as a success and has remained virtually unchanged since its 1978 inception. Table 4 provides a summary of program trends since its inception. The gross value of the hides and meat produced under this program element are summarized in Table 2.

Table 4. Summary of Florida's Nuisance Alligator Harvests from 1978 to 2001

Year	Complaints Received	Permits Issued	Tags Issued	Alligators Harvested	Alligators Harvested/ Complaint	Meat Yield (lbs.)
1978	4,914	2,346	3,124	1,871	0.38	N/A
1979	4,639	2,486	3,321	1,679	0.36	3,617
1980	4,024	2,216	2,856	1,590	0.40	36,907
1981	4,931	2,622	3,318	1,871	0.38	58,656
1982	6,124	3,209	3,826	2,169	0.35	50,911
1983	5,955	3,003	3,550	1,871	0.31	53,528
1984	7,289	3,536	4,272	2,201	0.30	71,262
1985	6,432	6,187[c]	6,187	3,023	0.47	90,100
1986	6,018	5,458	5,458	3,049	0.51	95,568
1987	7,288	6,618	6,618	3,853	0.53	110,625[d]
1988	10,305	7,978	7.978	4,464	0.43	121,297[d]
1989	9,867	7,076	7,076	4,263	0.43	116,000[d]
1990	9,950	7,787	7,787	4,053	0.41	97,712[d]
1991	11,965	8,297	8,297	4,228	0.35	N/A
1992	10,480	7,880	7,880	3,564	0.34	82,735[d]
1993	12,089	9,032	9,032	4,019	0.33	96,858[d]

Year	Complaints Received	Permits Issued	Tags Issued	Alligators Harvested	Alligators Harvested/ Complaint	Meat Yield (lbs.)
1994	13,431	9,812	9,812	4,632	0.34	115,911[d]
1995	13,615	10,171	10,171	4,931	0.36	106,382
1996	13,220	10,123	10,123	4,799	0.36	109,952
1997	14,984	12,019	12,019	4,305	0.29	128,825
1998	15,616	12,866	12,866	5,149	0.33	113,344
1999	14,828	12,412	12,412	5,263	0.35	127,412
2000	14,954	12,343	12,343	6,254	0.42	158,737
2001	16,749	14,085		7,279	0.52	153,019

PUBLIC WATERS ALLIGATOR EGG AND HATCHLING COLLECTION PROGRAM

This program permits the collection of alligator eggs and hatchlings from public waters by licensed farmers who have met specific requirements established by Commission rule. However, the number of farms allowed to participate is restricted due to the limited availability of eggs and hatchlings in the wild. Restricted access effectively guarantees continued access to a finite source of eggs and hatchlings and avoids diluting the availability of "raw materials" to farmers who have made significant capital investment in rearing facilities.

AMS staff review and recommend alligator egg collection areas for establishment annually. Candidate areas are located based on staff familiarity with their region and suggestions provided by other personnel and the public. Commission biologists conduct aerial nest surveys by helicopter over each egg collection area during late June and early July and establish a collection quota of 50% of the non-depredated, non-flooded nests observed (Rice et al. 1999). Egg collections follow and are conducted under direct supervision of Commission biologists. Table 5 summarizes trends in egg collections under this program element since its inception.

Table 5. Public waters egg collection program summary, 1988-2001

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
No. of Collection Areas	3	5	7	7	14	14	14	14	14	14	14	18	17	19
Nest Quota	146	296	271	506	708	926	786	894	1,118	1,339	1,187	1,326	1,338	753
Eggs Retained	4,302	7,895	6,594	9,735	13,945	9,017	16,803	23,050	26,947	27,739	25,684	27,420	32,409	19,451

Hatchling collection quotas were established in 1987 based on the quantity and quality of alligator habitat in 65 of the state's 67 counties, and have remained unchanged. Quotas range from 50 to 400 hatchlings per county. Eligible farmers identify the total quota (number) of alligator hatchlings and the counties that they prefer on applications provided by the Commission. Hatchlings are permitted for collection from September 15 through November 30. Permitted farmers are allowed to collect hatchlings independently of Commission oversight, but are required to tag hatchlings immediately upon capture. Table 6 summarizes participation and collection trends under this program element since its inception.

Table 6. Public waters hatchling collection program summary, 1988-2001

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
# of Counties Permitted	63	57	62	20	6	11	17	21	22	21	23	27	38	50
Total Collection Quota	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200	10,200
Hatchlings Collected	4,172	4,959	4,820	1,944	330	1,437	535	1,605	1,439	1,822	1,947	1,662	2,793	3,080
% of Quota Collected	41	49	47	19	3	14	5	16	14	18	19	16	27	30

ALLIGATOR FARMING

Alligator farming in Florida has increasingly relied on wild egg and wild hatchling stock to support the continued growth of the industry, despite depressed alligator hide market conditions over the last several years. The number of licensed farms and the number of active farms producing hides increased through 1991, and has since remained relatively stable. Inventories have continued to be sustained at around 100,000 animals. Participation and production trends under this program element are summarized in Table 7.

SUMMARY

All of these programs allow the Commission to manage alligators on a sustained yield basis and recognize them as an ecologically, aesthetically, and economically valuable renewable natural resource. Revenues generated through user-fees provide funding for alligator management and research. Most importantly, the economic value of the species gives user groups a vested interest in the welfare of wild alligator populations. Therefore, beneficiaries become political advocates for wetland preservation, which ultimately conserves habitat not only for alligators, but for a wide variety of Florida's wildlife. The protection and recovery of the American Alligator is touted as a success story in U.S. wildlife conservation efforts, and now it is generally recognized by resource professionals that sustained use of alligators has the greatest conservation benefits.

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Table 7. Estimated producer value and levels of alligator harvest on Florida farms during 1977-2001.

				Est.	Ave. Hide Size		Hide Prices			Est.			
	Licensed	Active	Hides	Total Ft.	Length	Width	per linear	per belly	Hide	Meat Prod.	Meat	Meat	Total
Year	Farms	Farms	Produced	Hides	(ft)	(cm)	ft	cm	Value	(lbs)	Price	Value	Value
1977	4	0	0	0					$0			$0	$0
1978	4	3	335	2,345	7.00	43.8	$8.17	$1.40	$19,159			$0	$19,159
1979	4	2	220	1,430	6.50	40.6	$11.47	$1.96	$16,402			$0	$16,402
1980	4	1	89	534	6.00	37.5	$11.86	$2.03	$6,333	1,349	$4.50	$6,070	$12,403
1981	6	2	284	1,704	6.00	37.5	$18.37	$3.14	$31,302	4,304	$5.00	$21,521	$52,824
1982	10	2	244	1,464	6.00	37.5	$22.42	$3.84	$32,823	3,698	$5.00	$18,490	$51,313
1983	13	2	184	1,012	5.50	34.4	$9.24	$1.58	$9,351	2,054	$5.00	$10,269	$19,620
1984	19	4	738	4,059	5.50	34.4	$18.24	$3.12	$74,036	8,238	$5.00	$41,189	$115,225
1985	26	12	1,339	7,365	5.50	34.4	$20.59	$3.52	$151,635	27,962	$5.00	$139,810	$291,445
1986	30	14	3,921	21,566	5.50	34.4	$22.72	$3.89	$489,968	58,107	$5.00	$290,535	$780,503
1987	40	19	6,479	35,635	5.50	34.4	$31.52	$5.40	$1,123,199	69,997	$5.00	$349,985	$1,473,184
1988	48	20	7,529	41,410	5.50	34.4	$32.50	$5.56	$1,345,809	71,099	$5.00	$355,495	$1,701,304
1989	48	23	16,385	81,925	5.00	31.3	$35.56	$6.09	$2,913,253	128,379	$5.00	$641,895	$3,555,148
1990	58	24	20,007	100,035	5.00	31.3	$38.18	$6.54	$3,819,336	130,490	$4.50	$587,205	$4,406,541
1991	58	31	18,092	90,460	5.00	31.3	$32.56	$5.21	$2,945,604	135,342	$4.50	$609,039	$3,554,643
1992	56	32	33,219	166,095	5.00	31.3	$17.19	$2.75	$2,854,758	182,401	$4.00	$729,604	$3,584,362
1993	55	32	38,505	173,273	4.50	28.1	$13.56	$2.17	$2,350,008	184,953	$4.00	$739,813	$3,089,821
1994	48	32	37,113	167,009	4.50	28.1	$21.88	$3.50	$3,653,311	178,267	$4.00	$713,068	$4,366,379
1995	47	24	27,303	122,864	4.50	28.1	$25.94	$4.15	$3,186,772	131,146	$4.50	$590,157	$3,776,929
1996	56	24	23,308	111,878	4.80	30.0	$23.13	$3.70	$2,587,188	140,466	$5.50	$772,562	$3,359,750
1997	52	22	26,970	133,771	4.96	31.0	$18.75	$3.00	$2,508,210	182,390	$4.50	$820,756	$3,328,966
1998	58	28	30,789	147,787	4.80	30.0	$18.75	$3.00	$2,771,010	185,550	$5.00	$927,751	$3,698,761
1999	57	24	25,069	120,331	4.80	30.0	$18.75	$3.00	$2,256,210	151,079	$5.00	$755,393	$3,011,603
2000	59	23	27,417	140,375	5.12	32.0	$22.63	$3.62	$3,175,985	207,303	$5.25	$1,088,343	$4,264,329
2001	63	21	25,208	129,065	5.12	32.0	$23.44	$3.75	$3,024,960	190,601	$4.50	$857,704	$3,882,664

Active Farms: Farms that produced hides that were subsequently tagged with CITES tags.
Hides Produced: Number of hides that were tagged with CITES tags.
Total Ft. Hides: Calculated from [Hides Produced * Ave. Size (ft.)].
Ave. Size - Length: Average total length from interviews with farmers and dealers. Based on ave. belly width after 1995.
Ave. Size - Width: Converted from ave. length based on a conversion factor of 6.25 cm belly width per linear ft. After 1995, prices were based on reports from dealers.
Hide and Meat Prices: Ave. wholesale value based on interviews with farmers, dealers, and tanners.
Meat Produced: Derived from farm reports during 1985-92. Before 1985 and after 1992, derived from estimated weight of alligators (Woodward et al. 1992) and an assumed 30% meat yield.

Louisiana's Alligator Research and Management Program: an Update

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ABSTRACT: Louisiana's vast wildlife resources are managed and regulated by the state operated Louisiana Department of Wildlife and Fisheries. The headquarters for the alligator program is Rockefeller Wildlife Refuge, an 76,000 acre refuge located in coastal southwestern Louisiana, which primarily serves as a wintering area for waterfowl. Years of research at the refuge led to development of marsh management techniques for multi-species use; particularly waterfowl, alligators, furbearers, and fisheries organisms.

Extensive research on the biology of the alligator was undertaken years ago by refuge staff. Management practices developed and regulations enacted led to the recovery of the alligator from low populations of the early 1960's, and this is generally recognized as success in wildlife management.

Further research and legislation led to alligator programs based on sustained utilization, managing the alligator as a renewable resource. The objectives of this paper are to review Louisiana's alligator management program; and present updated research findings since the last presentation at a CSG meeting. Reports will be given on several ongoing research projects including evaluation of a wildfire on alligator nesting, studies on natural egg incubation temperatures/hatchling sex ratios, DNA studies, reproductive research, and other studies. Coastal Louisiana's alligator nest data, current farm inventories, and ranching results will be presented. Research being conducted on farm alligators released to the wild will be reviewed.

The Status of the American Alligator *(Alligator mississippiensis)* in Texas

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ABSTRACT: The decline in the population of American alligators, which began in the mid-1800's and continued through the early 1900's, was the result of excessive exploitation and degradation of wetland habitats. Texas provided complete protection for the alligator in 1969. State and federal protection measures remained in effect in Texas until 1983 when significant increases in alligator populations were observed throughout most of its range. Since 1984, statewide harvests of wild alligators have been allowed based on recommendations derived from aerial nest counts and night-count surveys. In 1986, Texas licensed the first alligator farmer and initiated the nuisance alligator program. In 1988, Texas began permitting the collection of eggs from the wild. Currently, alligators generate approximately $10,000,000 annually in Texas. Results from up to eighteen years of night counts, nest surveys, wild harvests on public and private lands, nuisance alligator complaints, egg collection from the wild, and alligator farming in Texas will be discussed.

Current Status and Management of the American Alligator (*Alligator mississippiensis*) in Arkansas, U.S.A.

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ABSTRACT: The American Alligator (*Alligator mississippiensis*) has long been a component of Arkansas' fauna. Precipitous population declines, due to habitat loss and unregulated hunting, prompted the Arkansas Game and Fish Commission (AGFC) to enact regulations to protect the alligator from take in 1961, six years prior to federal protection in 1967. Between 1972 and 1984 the AGFC released 2840 wild-caught Louisiana alligators within the presumed historic range. Arkansas' alligator population has since recovered to the point where "nuisance" alligator complaints are a common occurrence. To improve handling and coordination of nuisance alligator complaints the AGFC has recently adopted a nuisance alligator protocol. The AGFC administration called for an examination of the potential for an alligator sport hunt as a means to reduce nuisance alligator complaints. During May-June 2002 efforts were undertaken to initiate a 3-5 year alligator population survey. Results of this initial survey revealed that alligators were widespread in their distribution. However, the observed densities appear to be insufficient to sustain a sport hunt on a regional scale. Only two localities had densities in sufficient number to support a biologically sustainable harvest. Based on these preliminary data a sport hunt would not have an impact on the number of nuisance alligator complaints and the two should be addressed as separate management issues, i.e. a sport hunt will not supplant the need for an effective nuisance alligator control program.

The American Alligator (*Alligator mississippiensis*) has long been a component of Arkansas' natural heritage in the Coastal Plain and Mississippi Delta. Strangely though, few if any early settler's accounts speak to the presence of alligators in Arkansas. One of the earliest recorded accounts is from the *Arkansas Gazette,* May 1828, which reported the killing of an 11-foot specimen on the north side of the Arkansas River at Little Rock. Between 1860 and 1960 alligator populations throughout Arkansas and the southeast were severely depleted, primarily due to habitat loss and unregulated hunting. Alligator populations have since recovered in Arkansas through state and federal protection and restocking efforts. A combination of factors (i.e., increased alligator population, drought, limited habitat) has likely been the cause for a recent increase – within the past three years – in nuisance alligator complaints. The AGFC has recently adopted a nuisance alligator protocol in an effort to improve handling and coordination of nuisance alligator complaints. The increased volume of complaints resulted in a request from the AGFC administration for an examination of the potential for an alligator sport hunt as a means to reduce nuisance alligator complaints. The first step in assessing a sport hunt potential was to initiate an extensive alligator population survey. This paper will present information on the historic and current status and management of the American Alligator in Arkansas.

HISTORICAL PERSPECTIVE

Regulatory History

For over one hundred years extensive habitat loss through the draining of wetlands, coupled with the added pressures of direct take by hunters, caused alligator population numbers to reach an all time low in Arkansas by 1960. As a result the AGFC enacted a regulation to protect the alligator in 1961. Congress passed legislation in March of 1967 listing the alligator as an endangered species, thus protecting the animal from "take", six years before enactment of the Endangered Species Act of 1973. In January 1977 the alligator was downlisted to threatened status. In June 1987 it was delisted to recovered status and subject to a five-year monitoring program. At present, it is listed by the U.S. Fish and Wildlife Service (USFWS) as "Threatened due to Similarity of Appearance", as a means to ensure proper regulation of the legal trade in crocodilian products.

History of Restocking Efforts

By the mid-1960's Arkansas' alligator population was severely depleted. At that time the greatest populations persisted in the southwestern corner of the state. In 1973 it was estimated that 1,900 alligators occurred in approximately ~12 mi^2 of habitat in Hempstead, Lafayette, and Miller counties (Joanen 1974). The AGFC attempted an initial restocking effort in 1970 and 1971 utilizing native stocks taken from Grassy Lake, a privately owned 3,000 acre cypress swamp in western Hempstead County. At that time Grassy Lake harbored the largest native population of alligators in the state, as it does to date. However, this proved unsuccessful due to an inability to capture enough individuals of appropriate size class to supply the restocking effort. Shortly thereafter an agreement between the Louisiana Department of Fisheries and Wildlife and the AGFC was established to provide alligators for the restocking program. This agreement provided wild caught sub-adult alligators to restock areas within the presumed historic range, in the Mississippi Delta, Coastal Plain, and Arkansas River Valley (Fig. 1). Between 1972 and 1984 a total of 2,841 alligators were captured in Louisiana and released in Arkansas. Approximately 80% of restocked alligators were released on private lands, at the owner's request, in the belief that they would control nuisance animals such as beaver, rough fish, snapping turtles, and venomous snakes. Since 1984 no subsequent population survey or monitoring has been conducted to assess Arkansas' alligator population.

As a result of restocking efforts the current distribution of alligators in the northeastern corner of the state may be more extensive than at the time of European settlement. Two recent reports (summer 2002) of alligators from Greene County, Arkansas pushes the distribution even further north than mapped in Figure 1. The first report was of an individual that was poached from an aquaculture pond and subsequently eaten at a wedding party. The second report was of an individual captured in a commercial fishing net in a barrow ditch immediately adjacent to the St. Francis River in the southeastern corner of Greene County. Receipt of more specific locality data on these records is forthcoming.

On the basis of these reports, the possibility exists that records of the American Alligator may yet turn up in the St. Francis River floodplain of Missouri's bootheel. Recent reports of alligators in western Tennessee (A. Peterson, Pers. Comm.), from wetlands bounding the Mississippi River between Memphis and Reelfoot Lake National Wildlife Refuge, may likely be the result of dispersal from Arkansas' restocking efforts.

MANAGEMENT

Alligator – Human Conflicts

Arkansas' alligator population has increased as a result of state and federal protection and restocking efforts. They have re-colonized historically occupied areas and observations of large >6.5 feet in total length (ft TL) individuals are a common occurrence. However, the amount of prime alligator habitat has either decreased or remained at a constant level since it was listed as recovered 15 years ago. A finite amount of optimal habitat forces emigration of recruitment-aged individuals from source populations in search of suitable habitat, such as aquaculture ponds, agricultural drainage ditches and irrigation reservoirs, thereby greatly increasing the probability of encounters with humans. In 2000 a prolonged regional drought reached severe levels and it is believed that it forced many alligators to move from their home ranges in search of new habitat as water sources dried up. Over 100+ nuisance alligator complaints were received in 2000. Thus, a combination of factors, e.g., increased alligator population, constant or decreasing level of optimal habitat, and severe drought, has resulted in an increased number of alligator-human conflicts. Several of these alligator-human conflicts garnered statewide and national radio, television, or newspaper coverage. This exposure elicited many email messages and telephone calls from citizens wanting to know what the AGFC was going to do about this "perceived" overabundance of alligators. The flurry of public inquiry was the impetus for the AGFC administration to consider an alligator harvest (i.e., sport hunt) as a means of managing this "overabundance" of alligators. However, to answer the question of a "perceived" versus "real" overabundance of alligators can not be determined until a thorough population survey has been conducted.

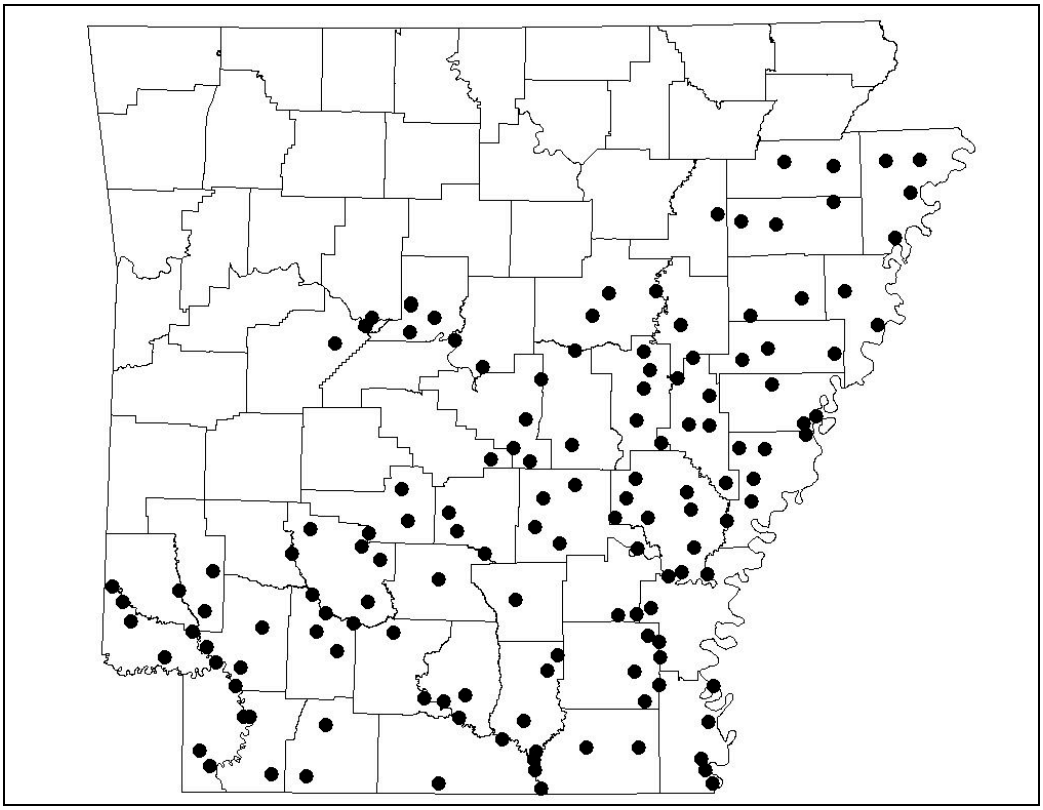

Figure 1. Distribution of the American Alligator in Arkansas, based on restocked and native populations. Localities are derived from various sources, [i.e., AGFC personnel, citizen reports, and Trauth et al., (in prep)].

Nuisance Alligator Protocol

Due to the increasing number of nuisance alligator complaints it became apparent that improved coordination and documentation of such complaints was needed. To address this problem the AGFC approved a Nuisance Alligator Protocol (NAP) in 2001. The format of this protocol was patterned after the agency's existing Nuisance Black Bear Protocol. Historically, various AGFC personnel (i.e., wildlife officers, district biologists) would receive and deal with nuisance alligator complaints without having the benefit of standardized documentation or coordination of complaints. This resulted in the capture and translocation of alligators without a system of recording and tracking these actions.

The NAP provides criteria for assessing the urgency of the complaint; procedures for receiving and recording complaints; data forms for translocated or destroyed alligators; and detailed capture and handling procedures. The Alligator Handling Procedures, which standardize agency approved capture and handling techniques for use by all AGFC personnel, provides uniformity of handling and safety procedures to increase the safety of both personnel and alligators. The NAP established a network of regional Nuisance Alligator Coordinators (NAC), who are responsible for receiving and coordinating all nuisance alligator complaints within their respective regions.

ALLIGATOR POPULATION SURVEY

In response to the growing number of nuisance alligator complaints, the AGFC administration requested an examination of the feasibility of an alligator sport hunt, as a means to reduce the number of complaints. Irwin (2001) proposed that a 3-5 year alligator population survey be conducted to provide the requisite data for review by the USFWS, before the AGFC could establish a regulated alligator hunt. To that end, a contract wildlife biologist, with alligator population survey experience was hired to train AGFC personnel proper survey technique and conduct an initial population survey in southern Arkansas. The following information is either summarized or modified from the population survey report by Wooding et al, (2002).

Survey Methods

At total of 28 localities in 12 counties were surveyed from 20 May – 26 June 2002. Alligators were surveyed using night-light counts (Chabreck 1966; Woodward and Marion 1978; Murphy and Coker 1983; Wood et al. 1985; Woodward and Moore 1993). Surveys were conducted by boat (n = 25), truck (n = 2), and ATV (n = 1) using a 200,000 candlepower spotlight. A variety of habitats were surveyed: large impoundments (n = 8); rivers, bayous, and creeks (n = 7); oxbows and brakes (n = 4); canals (n = 3); agricultural reservoirs (n = 2); river slough (n = 1); hardwood swamp (n = 1); and cypress swamp/lake (n = 1). The majority (n = 21) of survey localities were surveyed once and replicate surveys were conducted at (n = 7) localities. Length of survey routes was measured using handheld GPS units. Survey routes ranged from 0.6 - 18.1 miles in length, most (n = 18) were 3-9 miles in length. Length of survey routes was used to calculate the statistic (number of alligators observed per mile); this allows relative densities to be compared between localities. For replicated surveys, the mean ($\bar{x}$) number of alligators observed per mile was calculated. Data on variables such as water level (i.e., high, low, normal), water temperature, rainfall, presence of aquatic vegetation, wind, waves, visibility, and boat traffic were taken as these can influence counts, and can affect the interpretation of survey results. Alligator body length was estimated to the nearest foot in total length (ft TL), and was recorded to the nearest two- (2) foot size class if size could only be estimated with moderate accuracy. If the size of an individual could not be estimated with any degree of accuracy it was recorded in more general terms (e.g., "6+" size class) or classified as "size unknown", depending on the degree of observability. This provided data for assessing age class structure. Sighting proportions were estimated at 25%, based on the similarity of habitat and water temperature between, Arkansas and South Carolina (Murphy 1977).

Survey Results

A total of 251 alligators were observed on 24 of the 28 survey routes (Table 1, Note: the larger count number was used on replicate surveys). The mean number of alligators observed, using data from all repetitions, was 239.5 alligators. Assuming a 25% observability proportion (Murphy 1977), the surveyed routes would contain 958 alligators.

Two localities had significantly greater relative densities than all others did. Grassy Lake had 13.5 alligators/mile (n = 97; 7.2 miles) in a natural cypress swamp/lake and Moore Bayou had $\bar{x}$ = 9.2 alligators/mile ($\bar{x}$ = 32 individuals; $\bar{x}$ = 3.5 miles) in a backwater lake, created by a navigation dam on the Arkansas River. The third and fourth highest densities were observed in isolated wetlands in the Bayou Bartholomew watershed of Drew County – Tillar Farm (5.0 alligators/mile) and McClendon Reservoir (3.3 alligators/mile). The mean ($\bar{x}$ = 3) alligators per replicated survey for each locality, with survey distances of 0.6 and 0.9 miles respectively. While neither locality is considered to be a regionally significant population, these local populations are part of what is considered to be a metapopulation, which is dispersed throughout the brakes and reservoirs of the Bayou Bartholomew watershed.

The other 20 survey localities contained <2.5 alligators/mile; the majority of which (n = 12) contained ≤1 alligator/mile (Table 1). Low densities were found in large impoundments ($\bar{x}$ = 0.8 alligators/mile, SD = 0.6, n = 7), excluding Moore Bayou from the sample. Values were lower still in creek, river, and bayou habitat ($\bar{x}$ = 0.6 alligators/mile, SD = 0.7, n = 7). Whereas, oxbows ($\bar{x}$ ÷ = 1.75 alligators/mile, SD = 0.9, n = 4), and canals ($\bar{x}$ = 2.6 alligators/mile, SD = 1.5, n = 3) tended to support more alligators.

On replicated surveys the number of alligators increased at (n = 4) sites, remained the same at (n = 2), and decreased at (n = 1). Differences in counts appear to reflect normal variation, but reveal the value of conducting multiple surveys to produce a truer sample of the population. Multiple survey repetitions increases confidence when making comparisons of population densities between localities and over time. If trend data were sought, multiple repetitions of survey routes would enhance the ability to detect trends over shorter periods of time (Woodward 1996, Nickerson and Brunell 1997). Twenty-one out of the 28 surveyed areas is accessible to the public, all other localities (n = 7) were on private land. In terms of density (i.e., alligators/mile) four of the top five localities were on private land, and all but one of the privately owned localities was in the top 10.

Juvenile alligators were rarely observed during the surveys. In fact, only 14 alligators ≤ 2 ft TL were observed, of which 10 were at Grassy Lake. The majority (78%) of alligators observed were > 4 ft TL. Seven alligators were estimated to be ≥ 9 ft TL; the two largest individuals were 10-11 ft TL.

Habitat Assessment and Limiting Factors

Alligators were widely distributed throughout southern Arkansas, occurring in a variety of wetland habitats. However, their densities were relatively low compared to other populations in the southeast. The exceptions were the Grassy Lake and Moore Bayou localities where densities compared to the mid-range densities observed in Florida and Texas populations.

Localities with low densities had poor quality habitat and were void of aquatic vegetative cover. This was the case in the bayous and rivers, such as Bayou Meto and portions of the Arkansas River and canal. Densities observed in these habitats (0.6 alligators/mile) was comparable to low densities observed in riverine habitat in South Carolina (0.4-1.6 alligators/mile) (Murphy and Coker 1983); Mississippi (1.32 alligators/mile) (Duran, 2000); and North Carolina (≤0.1 alligators/mile) (O'Brien and Doerr 1986).

Alligators tend to reach their highest densities in lentic habitats, such as lakes and marshes. For example, alligator densities in premium lake habitat in Florida have exceeded 48 alligators/mile (Woodward and Moore 1990). However, low densities were observed in most impoundments during this survey (0.8 alligators/mile), even in lakeshore habitat with good stands of emergent aquatic vegetation. Portions of these lakes appeared to contain abundant suitable habitat, yet relatively few alligators were observed and populations seemed to be below carrying capacity, relative to the quality of available habitat. Conditions such as this were observed at Mercer Bayou, White Oak Lake, Lake Erling, Merrisach Lake, Coal Pile, and Arkansas Post. O'Brien and Doerr (1986) found similarly low densities in lake habitats in North Carolina (≤0.2 alligators/mile).

There appear to be several limiting factors that could influence alligator densities in Arkansas. Cold temperatures are certainly one such factor and limit the northern distribution of the American Alligator. After a hard winter in 2000-2001 the AGFC received many reports of dead alligators without any apparent signs of trauma. Alligators are severely cold-stressed when temperatures drop below 38° F for extended periods of time and can die of hypothermia (Brisbin et al. 1982). Smaller alligators are more susceptible to hypothermia because their body temperatures respond more quickly to temperature fluctuations. Large alligators are less susceptible due to their large surface to volume ratio (Smith and Adams 1978, Smith 1979). Cold stress can cause death by reducing blood supply to the brain and other vital organs and by severely reducing enzyme activity necessary for organ function. Further, chronic cold stress can suppress the immune system, thereby increasing susceptibility to disease. The greater susceptibility of smaller alligators to cold stress may be the reason why so few juvenile alligators were observed during this survey. Although our survey was not timed to see the maximum number of juvenile alligators, timing alone does not explain the low number observed. High relative mortality of the juvenile segment of the population could suppress recruitment rates into reproductive size classes. Further, cold stress and a sub-optimal thermal environment can adversely affect reproductive physiology. The endocrine system of the alligator is profoundly dependent on temperature. It is possible that the endocrine system of alligators in colder regions fails to function normally during years with extreme cold spells, and thus, may reduce egg viability or nesting frequency.

The northernmost alligator populations also have slower growth rates, increasing the age of sexual maturity. A study in North Carolina estimated that male alligators reach sexual maturity at 14-16 years of age and females at 18-19 years (Fuller 1981). Murphy and Coker (1983) estimated that male alligators in South Carolina do not reproduce until 20 years of age and 9 ft TL. In contrast, Florida alligators reach sexual maturity at 6-6.5 ft TL and 10-12 years of age (Woodward 1996). There are no data for growth rates of Arkansas alligators, but given the similarity in climate, growth rates may be as slow as those found in the Carolina's. A late age of sexual maturity normally decreases recruitment and a population's ability to recover from increased mortality.

Alligators must find shelter from the cold to survive a harsh Arkansas winter. They may find shelter in an underground den, or alternatively, they may survive a cold spell submerged in deep water. Metabolism slows and the heart rate is reduced to a murmur during cold spells, and they can remain submerged for hours (Grigg and Gans 1993). However, they still have to surface to breathe, and ice can trap alligators under water where they drown. The danger of ice would be more of a factor for alligators wintering in open water than it would for alligators in dens where temperatures would be slightly warmer, and even in partially flooded dens, less likely to ice over. Winter den sites may be a critical component of the habitat for survival of Arkansas alligators.

Fluctuating water levels may also limit alligator densities in Arkansas. Winter floods could force alligators out of dens, perhaps exposing them to lethal cold. This would be especially detrimental if severe cold and ice occurred while dens were flooded. Conditions similar to this occurred during the winter months of 2000-2001, and there were numerous reports of dead alligators throughout the range in Arkansas in late winter and early spring of 2001 (K. Irwin, Pers. Obs.).

In a normal year drought would be more likely in summer than flooding. Summer droughts can strand alligator nests on dryer ground, increasing the probability of nest predation by raccoons, skunks, and opossums (Fleming et al. 1976). Further, drought conditions can lead to increased hatchling predation if the young are forced to travel over land to find water. Potential predators include raccoons, coyotes, opossums, otters, foxes, domestic dogs, great blue herons, red-shouldered hawks, etc. Late summer droughts could also increase cannibalism due to habitat constriction and resultant crowding, thereby increasing the chances of encounters between small and large alligators (Rootes and Chabreck 1993). Nest predation in Arkansas may be a significant cause of mortality even in areas with stable water levels. We observed raccoons, opossums, and skunks in abundance during the night-light surveys. These animals prey on the eggs of ground nesting species and it is possible that they pose a significant predation risk on alligator eggs.

In addition to mortality from cold, drought, and predation, humans kill alligators. Accidental mortality such as roadkills, or drowning in fishing nets or lines, is probably infrequent enough to be insignificant. Intentional killing is probably more widespread and potentially more significant. There have been a few cases in which alligators were killed for their meat. But it is more common for humans to kill alligators out of intolerance or because they view the alligator as a competitor for fish. Some may shoot alligators with a firearm or with bow and arrow because they offer an easy target. Numerous alligators were encountered during this survey that were extremely wary, which is often a sign that they have been harassed. Alligators were more abundant on private property than on public access property, and there could be a number of explanations for this, the one that seems most likely is that alligators on private property receive better protection from humans.

The combination of factors: extreme cold, floods, drought, predators, and human intolerance; may be responsible for the low density of animals observed during this survey. This, coupled with a limited quantity of optimal habitat, may explain the overall low density of alligators in Arkansas, in comparison to other southeastern states.

The abundance of alligators at Grassy Lake is the result of several factors: (1) the area contains fairly stable water levels, freeing the alligators from the extremes of flood and drought: (2) extensive amount of habitat (3,000 acres) can harbor a large number of individuals; (3) the habitat contains an interspersion of open water and cypress swamp, providing the habitat diversity needed for nesting, brood rearing, foraging, and denning; and (4) the property has been managed as a privately owned hunting club for 100 years, thus protecting the alligators from exploitation. In short, the area contains extensive, high quality habitat, and the alligators have been protected. The Grassy Lake population still has to contend with cold weather extremes but their abundance indicates that cold weather alone is not as important if the other limiting factors are minimized.

The reason for a high population density on Moore Bayou, relative to adjacent areas, is an enigma. Water levels are not as stable as they are on Grassy Lake, although the dam on the Arkansas Canal provides more stable water levels than occurred historically when the habitat was a free flowing bayou. The area is accessible to the public, is heavily fished, and thus, does not have the protection afforded at Grassy Lake. The puzzling thing is that the Arkansas Canal – Arkansas Post and Merrisach Lake survey localities contained similar habitat and conditions, yet had lower densities. Researchers from the University of Arkansas, Monticello, are currently engaged in alligator research on Moore Bayou, Arkansas Post, and Merrisach Lake, which may ultimately reveal the disparity in densities between these nearby localities.

Management Implications of the 2002 Survey Data

The impetus for this survey was an interest in assessing the possibility of establishing a sport hunt for alligators, in response to an increase in the number of nuisance alligator complaints. An alligator harvest of sufficient magnitude to significantly reduce the number of nuisance alligator complaints would result in a substantial population reduction, and would not be biologically sustainable. The possible establishment of an alligator sport hunt and control of nuisance alligators are viewed as two separate management issues.

The current AGFC nuisance alligator protocol for relocating problem alligators appears to be functioning well and there appears to be little reason to change it at this time. The program provides beneficial public relations for the agency and translocated alligators provide a source of stock for areas where more alligators are deemed desirable.

Nuisance alligator complaints usually occur in locations that are not conducive to regulated alligator harvests. They are typically at scattered locations and may occur in residential areas. These factors make it difficult to design a harvest program that would effectively resolve nuisance alligator problems without substantially reducing the number of alligators over a broad area. Based on our data there are too few alligators to support a system of licensed private trappers such as in Florida (Hines and Woodward 1980). It may be appropriate to issue a depredation permit to the landowner, similar to those issued for nuisance deer, as a practical solution to persistent nuisance alligators on aquaculture farms.

Alligators were practically extirpated from the state prior to the stocking program. This provides evidence that alligators in Arkansas are more vulnerable to exploitation than in areas like southern Louisiana and Florida, where in spite of unregulated commercial harvest alligators were able to persist in large numbers. Arkansas is at the northern periphery of the alligator's range, and due to limiting factors, recruitment rates do not appear to be as great as in more southern populations. Therefore, Arkansas alligator populations do not appear to have the capability to sustain the same levels of harvest that they can in more southerly states, where both productivity and quantity of habitat is greater.

Based on the densities derived from 2002 survey data, the number of alligators taken in a sustainable harvest would be minimal. More data is needed on alligator demographics in Arkansas before a rigorous harvest rate could be determined. However, an annual sustainable rate would probably be less than 2% of the harvestable-sized individuals (i.e., ≥4-ft TL). This estimate is based on the combination of sustainable harvest rates in other parts of the range and presumed lower reproductive rates and greater age of sexual maturity of the Arkansas population. The 2002 survey revealed only two localities that exhibited densities sufficient to support a harvest – Grassy Lake and Moore Bayou.

We will use the data from the Grassy Lake survey as an example for deriving a 2% harvest quota. The following data were recorded: total number of individuals (n = 97); harvestable-sized individuals (i.e., ≥ 4 ft TL) (n = 67); those ≤ 4 ft TL (n = 12); and unknown size class (n = 18). Therefore 67 + 12 = 79 known size class individuals; and 67 ÷ 79 = 85%, the proportion of harvestable size class individuals in the known size class sample. We then apply the 85% proportion to the unknown size class (n = 18) for a total of 15 individuals, giving us 67 + 15 = 82 harvestable size class individuals. If we assume a 25% observability proportion (Murphy 1977) of (n = 82), then the population contained 328 alligators ≥ 4 ft TL. Therefore, Grassy Lake could sustain a 2% annual harvest rate of 6-7 alligators ≥ 4-ft TL.

The use of sighting proportions to set harvest quotas should be applied with caution. There is an obvious risk of unsustainable harvests if sighting proportions overestimate population size. The safe approach to setting quotas is to use survey data without adjustments, but the drawback is that harvests will not be maximized. For example, the harvest quota for Grassy Lake with the safe approach would be 1-2 alligators/year, rather than the 6-7 alligators/year by using extrapolated survey results. If an alligator hunt were initiated in Arkansas, it would be best to set harvest quotas using the safe approach until further data can produce sighting proportions specific to the Arkansas population.

In conclusion, an alligator sport hunt would involve considerable planning and administration, and concomitant long term monitoring of the populations to insure that harvests are sustainable. Moreover, such a hunt will have little if any impact on the number of nuisance alligator complaints and the two should be addressed as separate management issues – an alligator sport hunt will not supplant the need for an effective nuisance alligator control program.

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Table 1. Arkansas alligator survey data for 20 May-26 June 2002.

Area	County	Habitat	Access	Miles Surveyed	# Alligators Observed	Alligators/Mile
Grassy Lake	Hempstead	Lake/Swamp	Private	7.2	97	13.5
Moore Bayou	Arkansas	Impoundment	Public	3.3, 3.7	35, 29	9.2[a]
Tillar Farm	Drew	Canal	Private	0.6, 0.6	3, 3	5.0[a]
McClendon Reservoir	Drew	Reservoir	Private	0.9, 0.9	3, 3	3.3[a]
Kuykendall Lake	Miller	Oxbow	Private	1.7	4	2.4
Kingfisher Lake	Yell	Impoundment	Public	1.8	4	2.2
Bois d Arc (Canals)	Hempstead	Canal	Public	1.9	4	2.1
McClendon, Oxbow	Drew	Oxbow	Private	3.6, 3.6	4, 11	2.1[a]
Willow Lake	Miller	Oxbow	Private	2.1	4	1.9
Beard Lake	Hempstead	Creek	Public	4.1, 3.9	5, 8	1.6[a]
Bois d Arc	Hempstead	Impoundment	Public	5.0	7	1.4
Merrisach Lake Plus	Arkansas	Impoundment/River Slough	Public	18.1	22	1.2
Coal Pile	Desha	River Slough	Public	4.0	4	1.0
Lake Bragg	Ouachita	Impoundment	Public	2.3	2	0.9
Rogers Reservoir	Arkansas	Reservoir	Private	5.3	4	0.8
Lake Millwood	Little River	Impoundment	Public	8.3	6	0.7
Mercer Bayou, Lower	Miller	Bayou	Public	5.7, 5.0	2, 5	0.7[a]
Miss. River Levee	Chichot	Canal	Private/Public	17.2	12	0.7
Bayou Bartholomew	Drew	Creek	Public	4.6	3	0.6
Little River	Little River	River	Public	5.3	3	0.6
Long Lake	Union	Oxbow	Public	1.8	1	0.6
Lake Erling	Lafayette	Impoundment	Public	7.4	4	0.5
Mercer Bayou, Upper	Miller	Bayou	Public	5.4, 5.0	0, 4	0.4[a]
White Oak, Upper	Ouachita	Impoundment	Public	7.1	1	0.1
Bayou Meto	Arkansas	Creek	Public	6.4	0	0.0
Champagnolle Creek	Union	Creek	Public	5.3	0	0.0
Lake Georgia Pacific	Ashley	Impoundment	Public	7.3	0	0.0
Seven Devils	Drew	Swamp	Public	5.7	0	0.0

[a] Average of the alligators/mile for the two surveys for these areas.

Everglades Alligator Production Differences between Marsh Interior and Marsh Canal Habitats at A.R.M. Loxahatchee National Wildlife Refuge

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ABSTRACT: Restoration planning is currently underway under the Comprehensive Everglades Restoration Plan (CERP). This plan includes the proposed removal of specific canal structures. Canals compartmentalize this wetland landscape. Effects of landscape decompartmentalization on American alligator (*Alligator mississippiensis*) populations largely are not understood. Recent research has revealed that: (1) adult alligator densities are higher in marsh canal habitats than in marsh interior habitats; (2) adult alligators appear to be bound to their home ranges within either canal or interior habitats; (3) adult body health condition may be better in canals than in the interior; (4) canal alligators appear to have a metabolic thermal advantage in some seasons.

Acquiring information about alligator production requires research in all Everglades habitats. Key variables that affect alligator production were analyzed during this study. Specifically, clutch and hatchling survival in canal and interior habitats at A.R.M. Loxahatchee National Wildlife Refuge were calculated during 2000 and 2001. Data was collected from 112 measured nests and associated clutches and 779 hatchling alligators. Individuals from 57 hatchling pods were recaptured during this study. No sampled clutches in the marsh interior experienced flooding at any level during 2000 (n = 35) and 2001 (n = 24). However, 10 of 13 (77%) and 30 of 30 (100%) clutches in marsh canal habitats experienced flooding during 2000 and 2001, respectively. Nests experienced higher depredation rates by raccoons (*Procyon lotor*) during 2001 (14 of 24 (58%) in interior and 1 of 29 (3%) in canal habitats) than during 2000 (4 of 33 (12%) in interior and 0 of 13 (0%) in canal habitats). The percentage of sampled clutches that were observed to successfully produce at least 1 hatchling was higher during 2000 (33 of 36 (92%) in interior and 5 of 13 (38%) in canal habitats) than during 2001 (20 of 35 (57%) in interior and 3 of 30 (10%) in canal habitats). Cormack-Jolly-Seber (CJS) survival probability estimates for 2000-generation hatchlings after the 1st 6 and 13 months of life were 44 and 20%, respectively. The estimated percentages of nests that produced hatchlings that survived for at least 3 months after hatch were lower in canal (38% and 10%) than in interior habitats (86% and 57%), during 2000 and 2001, respectively. The 95% confidence intervals for production per nest (values < 1 included) 3 months after hatch events averaged 7.85 alligators ± 1.49 and 4.01 alligators ± 1.51 in interior habitats during 2000 and 2001, respectively. For the same period of time, the 95% confidence intervals for production per nest (values < 1 included) averaged 2.68 alligators ± 2.51 and 0.69 alligators ± 0.88 in canal habitats during 2000 and 2001, respectively. The 95% confidence interval for production per nest (values < 1 included) 13 months after hatch events averaged 2.42 alligators ± 0.46 and 0.83 alligators ± 0.78 during 2000 in interior and canal habitats, respectively.

Marsh canal nests were subjected to a larger range of water levels during clutch incubation, and were thus more susceptible to clutch flooding pressures than nests in interior habitats. The greatest risk to canal nests at LOX NWR was shown to be flooding. Interior habitats offer higher elevations due to general marsh elevation and the presence of elevated tree islands. Marsh canal habitat at LOX NWR represents a population sink,

reproductively speaking. That is, due to low values of clutch fate and pod size in canal habitats and overall low mean hatchling survival at LOX NWR, canal habitats exhibited biologically insignificant production levels during 2000 and 2001. In Everglades areas lacking a multitude of elevated tree islands, flooding could be responsible for long-term population sustainability problems via clutch mortality. The building of spoil mounds on the interior side of marsh canal habitats to facilitate reproductive success could be considered as an alternative to the changing of current water management schedules. This alternative could significantly reduce flooding pressures on alligator nests in canal habitats at LOX NWR.

PROCEEDINGS

Everglades annual rainfall is seasonal with approximately 75 percent of the mean annual precipitation of 136 centimeters occurring from June through October. However, due to the constant human requirement for water, Everglades hydropatterns are managed according to many requirements. Alligators, though a keystone species, are not necessarily at the top of this requirement list. Subsequently, clutch failure rates have changed from low and predictable to high and variable in certain habitats (Kushlan and Jacobsen 1990). Marsh canals at LOX NWR may very well be one of these habitats. Everglades canals presently serve as alligator habitat in many areas, including LOX NWR. Adult alligator densities are higher in canal habitats than those in the natural marsh interior (Morea 1999).

Hydrologic restoration alternatives are now being developed and proposed in response to the many decades of adverse water management practices. Input of these results into ATLSS modeling will help predict and compare future effects of alternative hydrologic restoration scenarios on the alligator populations in Everglades habitats similar to those at LOX NWR. This information is key to addressing the significance of canal removal to alligator population ecology.

Alligator production may be estimated with the variables clutch fate (survival or failure of a clutch), pod size (the number of alligators to successfully hatch out of a nest), and mean hatchling survival. Knowledge of production, estimated as the number of alligators produced by each nest, is necessary when managing populations. Wildlife biologists and resource managers can use production estimates specific to habitat types to estimate the possible impacts of specific water management plans on these populations.

Canals may act as population sinks as defined by Hanski and Simberloff (1997) for this long-lived species in that canal populations sustain negative growth rates. In fact when considering the negligible production rates in canal habitats during this study at LOX NWR, rare and random immigrants from the interior may be the only recruits that survive to be adults in canals. Morea (2000) revealed that Everglades alligators are exclusively bound to their homeranges, whether these be in canal or interior habitats. Everglades alligators have relatively small home ranges (Morea 1999) and probable infrequent emigration from interior to canal habitats.

The survival of alligator embryos and hatchlings is directly associated with water levels that may flood the nest and kill embryos during a vulnerable incubation period (Hines *et al.* 1968). Effects of variable rainfall and water management practices can impact clutch fate in different habitats to different degrees. Other detrimental factors such as clutch depredation (Fleming *et al.* 1976; Deitz and Hines 1980) and cannibalism (Nichols *et al.* 1976) may increase or decrease according to environmental conditions.

Habitat-specific management and restoration requires an understanding of the degree to which the above-mentioned variables affect production in LOX NWR canal habitats where no elevated tree islands exist. This knowledge will provide a better perspective of population differences between habitats, as well as the uniqueness of LOX NWR populations to those of other areas in the Everglades.

OBJECTIVES

The objectives of this study were to estimate production values and differences in these values for Everglades alligators between years (2000 and 2001) and habitats (canal and interior). Included in these analyses were the necessary calculations and estimations of clutch fate (CF), pod size (PS), and mean hatchling survival (MHS).