

**A management program for  
*Crocodylus porosus*  
and  
*Crocodylus johnstoni*  
in the Northern Territory  
of Australia**

**PARKS AND WILDLIFE COMMISSION OF THE NORTHERN  
TERRITORY**

Approved by the Administrator of the Northern Territory of Australia in pursuance of Section 75(3) of the *Territory Parks and Wildlife Conservation Act 1998*, on 31/3/00.

Declared by the Minister for the Environment to be an approved management program for the purposes of the Commonwealth *Wildlife Protection (Regulation of Exports and Imports) Act 1982* on 20/1/99.

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# 1. TITLE AND INTRODUCTION

## 1.1 Species concerned

Class: Reptilia

Order: Crocodylia

Family: Crocodylidae

Species: *Crocodylus johnstoni* Krefft, 1873 (Australian Freshwater Crocodile, Freshwater Crocodile, Johnston's River Crocodile, Fish Crocodile, Freshie); and, *Crocodylus porosus* Schneider, 1801 (Saltwater Crocodile, Estuarine Crocodile, Salty).

A taxonomic synopsis of both species is provided by Cogger *et al.* (1983).

## 1.2 Agency responsible

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## 1.3 Introduction

This management program has been developed in accordance with the requirements of the *Territory Parks and Wildlife Conservation Act 1998* and the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. Its aim is to enhance the current and long-term conservation of wild crocodiles and their habitats through a commercial ranching program and other sustainable use initiatives. This program is a continuation of previous management programs covering both species of crocodile.

Between 1984 and 1989, crocodile management in the Northern Territory was approached on an experimental and trial basis, within geographically restricted areas. This approach involved continual monitoring, assessment and refinement of the various elements of those programs. As predicted, the following occurred:

- the size of the wild population was not compromised by the harvest program;
- the program enhanced the value of crocodile conservation in the eyes of the community;
- a small but tightly controlled, promising export industry was established;
- an effective administration was established for the industry; and
- a responsible means of realising a commercial value from wild crocodiles was developed.

From 1990 onwards management has been continually refined and industry has grown

out of the sustainable utilisation of the resource, while maintaining the same continued levels of monitoring and assessment.

The long-term objective of all previous programs was to establish a commercial value for crocodiles and use it to make crocodiles and their habitats assets to landowners, rather than liabilities. The present program encompasses a range of strategies through which that objective can be achieved.

## **2. AIMS AND OBJECTIVES**

This management program is directed at the long-term conservation of crocodiles and their habitats throughout the Northern Territory. Crocodile conservation on private lands will ultimately depend on the maintenance of suitable wetland habitats in the face of competing forms of land use. Management that provides for direct commercial gain by landowners, from such habitats, will facilitate achieving these objectives.

The management program seeks to:

1. Maintain viable wild populations of crocodiles and conserve the wetland habitats upon which they depend;
2. Enhance public safety by maintaining an active public awareness campaign and by removing problem crocodiles;
3. Develop, monitor and regulate the sustainable utilisation of crocodiles throughout the Northern Territory;
4. Allow for the expansion of the crocodile industry commensurate with the capacity of the wild populations to sustain harvests.

## **3. MANAGEMENT MEASURES**

### **3.1 Legislation and international obligations**

#### **3.1.1 Northern Territory**

*Crocodylus johnstoni* and *C. porosus* are defined as protected wildlife under section 26 of the *Territory Parks and Wildlife Conservation Act 1998*. Section 29 of the Act prohibits the taking or destruction of protected wildlife without a permit issued by the Director of Parks and Wildlife or his/her delegate. It is also an offence to possess or trade in live or dead crocodiles, crocodile eggs or parts of crocodiles (sections 31-33 inclusive). The maximum penalty for breaches of these provisions is a \$2000 fine and/or 6 months imprisonment, with additional fines of up to \$100 per animal or part thereof involved.

Permits to possess and/or trade in crocodiles may be issued by the Director of Parks and Wildlife or a delegate in accordance with section 33 of the *Territory Parks and Wildlife Conservation Act 1998*. The Director may apply terms, conditions or limitations to the permit, and it is this section that is used to regulate crocodile farming.

Consignment of crocodiles or parts thereof between the Northern Territory and other States and Territories within the Commonwealth can only be undertaken with a permit issued under section 34 of the Act. Such legislative provisions are common to all States and Territories of Australia.

Enforcement of the *Territory Parks and Wildlife Conservation Act 1998* is undertaken primarily by Conservation Officers appointed under the Act and officers of the Northern Territory Police Force.

### **3.1.2 Commonwealth**

*C. porosus* and *C. johnstoni* are included in Schedule 2 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*, which is administered by Environment Australia. Export of crocodiles or crocodile products from Australia requires that the specimens are bred in captivity or taken in accordance with a section 10 approved management program for wild taken specimens. Export permits are issued under section 29 of the Act.

Enforcement of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* is carried out by officers of the Australian Customs Service and the Australian Federal Police.

### **3.1.3 International**

The endemic *C. johnstoni* and the Australian population of *C. porosus* are both included in Appendix II (unqualified) of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Appendix II unqualified listing allows for legal trade in crocodile products derived from eggs or non-hatchling crocodiles harvested from the wild under an approved management program. Australia is a party to CITES, and the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* enables its obligations under the Convention to be discharged.

## **3.2 Permits**

Capture, possession, killing and trading in crocodiles and their parts is controlled by permits issued under the overall authority of section 43 of the *Territory Parks and Wildlife Conservation Act 1998*. However, section 122 of the Act provides for Aboriginal people to harvest crocodiles and their eggs for traditional purposes, including hunting, food gathering (otherwise than for purposes of sale), ceremonial and religious purposes.

### **3.2.1 Permits to take**

The removal of any stock from the wild (animals or eggs) is subject to permit in accordance with sections 29 or 30 of the *Territory Parks and Wildlife Conservation Act 1998*, and requires the provision of details of the extent and location of the harvest.

### **3.2.2 Permits to keep and trade**

Individuals or companies are issued with a permit to keep and trade crocodiles and/or their parts in accordance with sections 31, 32, 33 and 34 of the *Territory Parks and Wildlife Conservation Act 1998*.

Individuals or companies involved in commercial trade of parts are issued annually with a permit to trade in parts of a protected animal under section 31.

### **3.2.3 Export permits**

Consignment of ranched and captive bred crocodiles or their parts from the Northern Territory to other Australian States and Territories is subject to a permit issued under section 34.

The export of crocodiles or their parts from Australia requires an additional permit from Environment Australia, under section 29 of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*. For each consignment, details of the animals involved and the destination are provided to Environment Australia.

## **3.3 Harvest scope and management**

The role of the harvest in this management program is to provide a means by which landowners can gain financially from crocodiles on their lands, thus providing a direct incentive for them to regard crocodile habitats as productive lands, worth conserving. The harvest of crocodiles now includes an egg harvest, the most important harvest in terms of numbers taken, and the direct take of juvenile and adult crocodiles from the wild. The juvenile and adult harvest commenced in 1997 on a trial basis and the use of those crocodiles was limited to the production and sale of primarily skins, but also meat where appropriate health standards are met.

## **3.4 Harvest areas**

The selection of harvest areas will be determined by the interest and commitment of the relevant landholders, the availability of the local resource, and its capacity to sustain regular harvests. Harvest levels will be determined from long-term monitoring data available to the Parks and Wildlife Commission, and/or by surveys of crocodile populations in proposed harvest areas.

## **3.5 Harvest supervision**

The removal of all crocodiles and crocodile eggs from the wild will be subject to 'Permits

to Take' issued in accordance with the permit provisions of the *Territory Parks and Wildlife Conservation Act 1998* (see section 3.2.1 of this management program). Persons involved in collecting eggs and/or crocodiles are required to provide returns to the Commission with full details of all stock removed from the wild.

### **3.6 Harvest strategies**

Earlier management programs made provision for harvesting of eggs and/or hatchlings, as well as the capture of juveniles and adults for raising in captivity. The majority of the past harvest has been confined to egg collection, limiting potential management to breeding areas. The previous management program also made provision for trial harvests of juvenile and adult crocodiles directly from the wild. The quota for juvenile and adult crocodiles taken directly from the wild in the previous management program was 900 individuals (500 juveniles and 400 adults). The quota in this management program is increased to 1,100 individuals (500 juveniles and 600 adults) (see Appendix). This management program allows for one or more of the following strategies to be incorporated into a management regime for any selected area.

### **3.7 *Crocodylus johnstoni***

Current export market demand for skins or parts of *C. johnstoni* is low, and harvests are expected to be minimal. Despite this, harvest limits will remain the same to allow for any long-term market developments or changes in demand for the products.

#### **3.7.1 Egg harvest**

Eggs may be collected under permit during the nesting period from July to November and incubated under artificial conditions.

#### **3.7.2 Hatchling harvest**

When eggs hatch in November or December, hatchlings (animals less than 0.25 metres total length) may be collected under permit.

#### **3.7.3 Juvenile harvest**

Juveniles (0.25 to 1.5 metres total length) may be harvested under permit. In areas where sexual maturity is reached below 1.5 metres, the upper size limit for juveniles will be set accordingly.

#### **3.7.4 Adult harvest**

Adults (greater than 1.5 metres total length) may be harvested under permit. In areas where sexual maturity is reached below 1.5 metres, the lower size limit for adults will be set accordingly.

### **3.8 *Crocodylus porosus***

During the life of this program, trial harvests of juvenile and adult *C. porosus* will continue. Harvest quotas will be determined at a local level on the basis of surveys of population



densities in river systems, and pre- and post-harvest monitoring surveys will be used to assess the short and long term impacts of the harvests.

### **3.8.1 Egg harvest**

Eggs will be collected under permit during the nesting period from October to June and incubated under artificial conditions.

### **3.8.2 Hatchling harvest**

When eggs hatch, hatchlings (less than 0.4 metres total length) may be collected under permit.

### **3.8.3 Juvenile harvest**

Juveniles (0.4 to 2.2 metres total length) will be harvested under permit.

### **3.8.4 Adult harvest**

Adults (greater than 2.2 metres total length) will be harvested under permit.

## **3.9 Management of problem crocodiles**

Problem crocodiles are broadly defined as those individuals that occur within settled areas or areas of recreational use, where public safety is a prime consideration, and those that attack stock in pastoral areas. In some areas such as Darwin Harbour and the Katherine River near Katherine, any crocodile, regardless of species or size, constitutes a problem animal. All animals removed as problem crocodiles are considered part of the total annual harvest of adult and juvenile crocodiles (see Appendix).

Some of the aims of problem crocodile management in remote and pastoral areas may be met through the trial harvest program. The upstream spread of *C. porosus* into totally freshwater areas dominated by *C. johnstoni*, and used extensively for public recreation, may pose a risk to public safety. Removal of *C. porosus* found in such areas may be incorporated into the harvest regime for particular areas or river systems.

## **4. MONITORING AND ASSESSMENT**

The principal purpose of monitoring the wild population is to provide an objective means through which any serious general decline, due to any cause, can be detected in sufficient time to effect remedial action. The monitoring programs proposed will meet that objective. In addition, they allow rates of change in population size and structure to be quantified and assessed, thereby providing an objective basis for adjusting harvest levels.

Spotlight and helicopter counts over selected river systems within the Northern Territory are the standard methods of monitoring for both species. With *C. porosus*, the monitoring program for the Northern Territory population as a whole involves helicopter counts in a

large number of tidal rivers around the Northern Territory coastline. Corrections for seasonal biases in the monitoring program are now possible (Webb *et al.* 1989). Spotlight surveys are carried out in selected river systems and provide more detailed information, including population size structure. Results of monitoring programs are presented in the Background Information section of this management program. During the life of this plan, the methodology of the monitoring program will be reviewed and refined further.

In addition to regular monitoring by Commission staff, wild harvests will be subject to strict record keeping. These data will provide an objective means for assessing the extent to which measured fluctuations in the wild population have been influenced by harvest regimes.

## **5. MANAGEMENT STRATEGIES**

### **5.1 Harvest limit determination**

Harvest limits for each category and each species are outlined in the Appendix. They may be revised by the Director of Parks and Wildlife, after consideration of the following:

1. Current trends in population size and structure;
2. Seasonal effects on breeding, recruitment and survivorship;
3. Management objectives for specific areas;
4. Proportion of total habitat subject to harvesting;
5. Review of previous harvests;
6. Review of past and current research results; and,
7. Other information considered relevant by the Director of Parks and Wildlife.

Within specific areas of land subject to harvesting, local sustainable harvest levels will be determined after similar considerations.

Should monitoring results indicate that the management aims and objectives (section 2) are not being met, several feedback mechanisms are available for implementation. For example:

- In areas where populations are too high, or where they are increasing faster than desired (e.g. in recreation areas), harvest levels can be increased.
- In areas where populations are decreasing or increasing more slowly than is desired, harvesting can be reduced or stopped for a specified period of time or the harvest strategy changed.
- The selection of one or more of these options will be made by the Director of Parks and Wildlife on the basis of the extent and nature of the increase

or decrease, and its likely effects on the management aims and objectives.

## **6. REPORTS**

The Parks and Wildlife Commission will provide annual reports to Environment Australia detailing all aspects of the wild harvests, stocks on crocodile farms and the performance of farms in husbandry and production. The results of the monitoring programs will be provided to Environment Australia at the expiry of this management program.

## **7. COMPLIANCE**

### **7.1 Industry regulation**

#### **7.1.1 Farms and ranches**

The value of some animals removed from the wild can be increased by maintaining them in captivity. In the case of eggs, hatchlings and smaller juveniles, they can be incubated and/or grown to a larger size for skin and flesh production. Adults can be used for captive breeding. The commercial production of crocodile skins by the farms already established in the Northern Territory has been greatly enhanced by supplementing ranches with stock derived from captive breeding.

Decisions on the number, type and location of crocodile farms and ranches will be based on the capacity of the wild resource to sustain the necessary levels of harvest. Other proximate factors that will be taken into account are:

1. The type of farm proposed (captive breeding/raising or educational display);
2. Suitability of proponent.

The performance of crocodile farms and ranches will be monitored by the Department of Primary Industry and Fisheries (DPIF) to:

1. Ensure acceptable levels of welfare, husbandry and production efficiency are maintained; and
2. Identify and assist with technical difficulties that may arise from time to time.

Permits to take crocodiles from the wild are subject to annual renewal, and permits to keep crocodiles in captivity are subject to five year renewal and

compliance with the provisions of the *Territory Parks and Wildlife Conservation Act 1998*.

### **7.1.2 Records and returns**

Responsibility for the records and returns for all individuals and companies is with DPIF, as outlined in Section 7.1.1. DPIF will audit records on an annual basis.

### **7.1.3 Live crocodiles**

Stocks of each species held by individuals and companies will be categorised as either hatchlings, raising stock or breeding stock. Monthly stock returns to DPIF will detail current stocks in these categories, including acquisitions and disposals.

### **7.1.4 Skin and flesh shipments**

Details of skins exported in any one shipment are recorded on NT EXPORT PERMITS, including details of skin tag numbers and the consignee. Skin shipment records are submitted to DPIF each month.

Skin shipments exported overseas are inspected by a DPIF officer and packed into cartons to which orange approved-product carton tape is fixed. The tape displays the CITES permit number for the shipment and is signed and dated by the DPIF officer.

Skin shipments shipped domestically are sealed in cartons that are marked to show that the enclosed product is a farmed product. Producers can either use pre-marked cartons or can seal standard cartons with specially marked blue tape displaying the name of the producer and the date of shipment.

The production and sale of flesh involves the completion of flesh production records. These are submitted to DPIF each month. Flesh can be sold in the form of whole, dressed carcasses, or parts of carcasses individually wrapped.

Flesh from more than one carcass may be packed in a carton, which is marked to indicate it is produced under an approved management program (see section 7.2).

### **7.1.5 Other parts**

Individuals or companies utilising parts derived from crocodiles taken in accordance with this program, are licensed and required, as a condition of permit, to: maintain detailed records; provide regular returns to DPIF; and, to mark such products with an approved product label. Products leaving the NT are packaged and sealed with approved PRODUCT CARTON TAPE.

## **7.2 Marking of stock, parts and derivatives**

Any part or derivative of *C. johnstoni* and *C. porosus* derived from animals taken under this program will be available for export in accordance with the provisions of the program.

### **7.2.1 Skins**

Non-reusable orange plastic tags which comply with the provisions of CITES Resolution Conf. 5.16 are attached to each skin entering trade, whether for export or domestic use. Each SKIN TAG is uniquely numbered and the number serves as an identification number for all subsequent record keeping related to the skin of that particular animal. The DPIF is responsible for issuing SKIN TAGS on a cost recovery basis.

### **7.2.2 Flesh**

Flesh is packed in cartons that are marked to show that the enclosed product is a farmed product. Producers can either use pre-marked cartons or can seal standard cartons using specially marked, green tape.

### **7.2.3 Other parts**

Uniquely numbered product labels are used to identify the origin of manufactured items. The labels are issued to processors for attachment to the items, and will serve to identify items as being legally manufactured and acquired under an approved management program. Large parts (e.g. skulls and hornback skins), minor parts and derivatives of animals exported under the program are marked and recorded as products derived from an approved management program.

## 8. APPENDIX

### HARVEST QUOTAS AND THEIR RATIONALE FOR THE OPERATION OF THE NORTHERN TERRITORY CROCODILE MANAGEMENT PROGRAM

During this management program, the total harvest throughout the Northern Territory will not exceed the limits listed below:

#### *Crocodylus johnstoni*

Viable eggs	4,000
Hatchlings	6,000
Juveniles	1,000
Adults	200

#### *Crocodylus porosus*

Viable eggs	17,500
Hatchlings	500
Juveniles	500
Adults	600

The quotas for *C. johnstoni* shown above remains unchanged from previous management program.

It is proposed to increase the quota for *C. porosus* eggs from 15,000 to 17,500 viable eggs and adults from 400 to 600 individuals, whilst maintaining the hatchling and juvenile quotas at the present amount. The rationales for individual quotas are outlined below. Details of the actual harvest taken in recent years and the current rate of increase of the crocodile populations are given in Section 9 (Background Information).

#### *Crocodylus porosus*

Current evidence suggests that the rate of increase of the total crocodile population has slowed over the last several years. Consequently, the justifications for the quotas listed below are conservatively based on a total population estimate of around 60,000 animals, the same estimate as in the previous management program.

#### **17,500 viable eggs.**

The removal of 17,500 viable eggs represents an increase of 2,500 viable eggs from the previous management program. The egg quota was set at 10,000 in 1989 and has increased by only 5,000 eggs in the last decade. In recent years up to 15,000 viable eggs have been harvested in normal years and this quota has not impeded growth of the population (see Background Information). Increasing the quota to 17,500 viable eggs will not necessarily result in more eggs being harvested from current harvest areas, but will allow new areas, particularly those on Aboriginal lands, to be harvested over the life of this program.

### **500 hatchlings (animals <0.4 m)**

This upper limit of 500 hatchlings represents a harvest of 0.8% of the estimated total population of 60,500 in 1995 and is 11.8% of the hatchling population (see Background Information). The population of crocodiles classed as hatchlings is estimated at 4,200 individuals or 7% of the total population, at the time that surveys are carried out. It should be noted that a high mortality of hatchlings has already occurred by this time, and thus the initial number of hatchlings is much higher than when this survey occurs. Setting a hatchling quota creates the opportunity to legally harvest hatchlings should it become a part of a total management program. However, it should be noted that hatchling collections are infrequent and the impact of harvest of this stage of the life cycle has to date been insignificant.

### **500 juveniles (animals 0.4 - 2.2 m)**

This upper limit of 500 juveniles represents a harvest of 0.8% of the total population. The population of crocodiles classed as juveniles is estimated at 23,500 individuals or 39% of the total population. Thus the upper limit of juveniles represents 2.1% of the juvenile population.

### **600 adults (animals >2.2 m)**

This upper limit of 600 adults to be removed from the total Northern Territory population represents an increase of 200 individuals from the previous management program and a harvest of approximately 1.0% of the estimated total population. The population of crocodiles classed as adults is estimated at 32,600 or 54% of the total population. Therefore the upper limit of adults to be harvested represents 1.8% of the estimated adult population.

### **Total non-egg harvest**

The proposed non-egg harvest limits outlined above represent 2.6% of the estimated total population in 1998. The adult and juvenile quotas include the 100 to 150 crocodiles that are removed each year as problem crocodiles. The quota increase will allow for expansion of the wild harvest to more areas in the Top End within the life of this management program, particularly on Aboriginal lands. Effective pre- and post-harvest monitoring will add to our knowledge of the population dynamics of *C. porosus*, especially details of any compensatory reactions to harvesting.

## 9. BACKGROUND INFORMATION

### 9.1 Historical background

Crocodile meat and eggs are thought to have been used as a food source by Aboriginal people for up to 40,000 years (McBryde 1979; Flood 1983). The importance of crocodiles in Aboriginal culture is reflected in a complex system of totems and ceremonies which is still evident in northern Australia today (Lanhupuy 1987).

In the Northern Territory, commercial hunting of *C. porosus* began in 1945 and continued until 1971 when the species was protected. Prior to that, there were trial shipments of crocodile skins and experiments with a minor curio industry, but neither became established (Webb *et al.* 1984). The total number of *C. porosus* skins from the Northern Territory entering trade is estimated to have been 113,000 between 1945 and 1971: 87,000 between 1945 and 1958 and 26,000 between 1959 and 1971 (Webb *et al.* 1984).

*Crocodylus johnstoni* was hunted intensively in the Northern Territory for only five years, from 1959 to 1964, before the species was protected in 1964.

### 9.2 Species distribution and habitat description

#### 9.2.1 *Crocodylus porosus*

*Crocodylus porosus* inhabits coastal rivers and swamps, the open sea and island shorelines, and extends well inland via major rivers and floodplain billabongs into freshwater rivers, creeks and swamps. They occur in high densities in the tidal portions of some mangrove-lined rivers, particularly those associated with extensive freshwater wetlands or floodplains. Saltwater crocodiles may therefore occur in any salt or fresh water within their range. Detailed descriptions of *C. porosus* habitats are available for the Northern Territory (e.g. see Messel *et al.* 1979-1987; Magnusson 1980; Magnusson *et al.* 1978; Magnusson and Taylor 1980; Webb *et al.* 1977, 1983).

The status of wetland habitats in the Northern Territory is generally good compared to the more developed parts of Australia, although a number of problems with weeds, feral animals and saltwater intrusion are evident in some areas. The mangrove fringe along the coastline is largely in a pristine condition. Further information on wetlands significant to *C. porosus* is available (Usback and James 1993).

The climate of the Top End of the Northern Territory is dominated by a monsoonal pattern of rainfall and sufficient change in temperature to give three significant seasons: "wet-warm", "dry-cool" and "dry warm" (Webb 1991). The habitat available for crocodiles in the Northern Territory varies according to the above seasons: it is extensive in the wet-warm season when the floodplains are inundated, and markedly contracted in the dry-warm season when waters have receded to permanent billabongs and major water courses.

The spread of Mimosa (*Mimosa pigra*) in the Northern Territory (Braithwaite *et al.* 1989; Lonsdale 1992) is a serious threat to the integrity of some freshwater swamps, but does



not necessarily impact adversely on *C. porosus*. For example, in the Finnis River, floating mats of vegetation used by *C. porosus* as nesting platforms were disappearing due to grazing pressures and the loss of tall vegetation surrounding billabongs (Hill and Webb 1982); these mats have recovered dramatically within billabongs surrounded by *M. pigra*. The destruction of the majority of the feral water buffalo (*Bubalus bubalis*) population, for bovine disease control, has also led to a significant recovery of freshwater wetlands throughout much of the Northern Territory (Skeat *et al.* 1996).

### 9.2.2 *Crocodylus johnstoni*

The Freshwater Crocodile, *C. johnstoni*, is endemic to northern Australia. In general, it is found in billabongs and the upper reaches of coastal rivers, while *C. porosus* generally inhabits the downstream tidal reaches. The distributions of *C. porosus* and *C. johnstoni* overlap in many river systems, with recognisable zones of sympatry. Individuals of one species are sometimes found in areas dominated by the other, either well upstream or downstream of the sympatric zone (Webb *et al.* 1987).

In the Northern Territory, *C. johnstoni* inhabits wetlands and river channels upstream of the tidal reaches of coastal rivers. In the dry season, *C. johnstoni* tends to congregate in isolated permanent and semi-permanent billabongs along secondary creek lines in both rocky escarpments and floodplains (Webb *et al.* 1987).

## 9.3 Conservation status

The Northern Territory has the largest population of *C. porosus* in Australia. The original size of the wild population was estimated at no more than 100,000 individuals, including young-of-the-year (Webb *et al.* 1984).

The population in 1984 was estimated at about 40,000 (Webb *et al.* 1984). Trends in total population size are now monitored by helicopter counts in a large number of tidal rivers (Webb and Manolis 1992; Webb *et al.* 1994) and the results of this monitoring program show that:

- the population of *C. porosus* in the Northern Territory has increased by 50% since ranching was introduced in 1984,
- the population increased at around 4-5% per year during the 1980's and early 1990's but appears now to be slowing or approaching an equilibrium,
- the ranching/harvesting program introduced in 1984 has not had a detrimental effect on expansion of the population; and,
- the 1998 population estimate, scaled from the 1984 estimate (Webb *et al.* 1984), is around 60,000 to 65,000 individuals.

Annual spotlight counts in seven river systems monitor the changing size structure of the population. The results from surveys in the Blyth-Cadell River system conducted over 20 years indicate that the recovery of *C. porosus* has involved increasing numbers of larger animals (>7') including adults [females >7.5'; males >11'(Webb and Manolis 1989)] and decreasing numbers of intermediate-sized juveniles (3-6'). There is compelling evidence (e.g.

Messel *et al.* 1979-87; Messel and Vorlicek 1985, 1986; Webb and Manolis 1992) that the most significant constraint on *C. porosus* population expansion is density-dependent mortality; larger crocodiles eating smaller ones, or displacing them into sub-optimal environments. The collection of eggs under the ranching program has not constrained the continued increase of the total population, nor the sub-population(s) within individual rivers subject to harvesting.

Although the availability of *C. johnstoni* habitat in the Northern Territory has not been quantified, Webb *et al.* (1987) estimated that the Northern Territory population of *C. johnstoni* was in the order of 30,000 to 60,000 individuals in 1987.

#### **9.4 Representation in nature conservation reserves**

Parks, reserves and sanctuaries in the Northern Territory provide a mosaic of secure areas in which crocodiles and their habitats are protected. They also provide areas where the public can view and learn about crocodiles and their conservation. Significant areas of crocodile habitat are contained within the following major parks:

1. Kakadu National Park. 19,120 sq. km. (Alligator Rivers Region).
2. Gurig National Park. 2,207 sq. km. (Cobourg Peninsula).
3. Nitmiluk National Park. 1,803 sq. km. (Katherine and Edith Rivers).
4. Gregory National Park. 10,499 sq. km. (Victoria River System).
5. Keep River National Park. 2,620 sq. km. (Keep River System).
6. Litchfield Park 1,554 sq. km. (Finniss and Reynolds Rivers.)
7. Mary River National Park. 1,217 sq. km. (Mary River System).

In addition to the above parks and reserves, Melacca Swamp, covering an area of 23 sq. km. was acquired by the Parks and Wildlife Commission specifically for the conservation of *C. porosus* nesting habitat that occurs there. The area has been fenced and destocked. Melacca Swamp is part of the Adelaide River system and is the main research area for monitoring the extent and timing of *C. porosus* nesting.

Approximately 60% of the *C. porosus* habitat in the Northern Territory occurs within Aboriginal lands where access by non-Aboriginal people is restricted by permit.

#### **9.5 Biology and ecology**

The information presented in this section is derived from published research reports. A general description of Crocodylia is provided by Cogger (1993); morphology, physiology, natural history, biogeography and phylogeny are discussed by Grigg and Gans (1993), Cooper-Preston and Jenkins (1993) and Molnar (1993). Detailed discussion of many topics concerning crocodile biology may be found in Webb *et al.* (1987).

Considerable research has been conducted into the biology and status of both Saltwater and Freshwater crocodiles in northern Australia, particularly in the Northern Territory. Their biology, population dynamics, recovery since protection and management have been the subject of intensive research efforts over the last 22 years, the details of which are contained in a variety of publications (e.g. Bayliss and Messel 1990; Burbridge 1987; Messel *et al.* 1979-84; Messel and Vorlicek 1985, 1986; Taplin 1987, 1990; Webb *et al.* 1984, 1987; Webb and Manolis 1989, 1992).

### **9.5.1 Survivorship**

There is a high mortality rate of crocodiles from egg to maturity. Webb and Manolis (1993) predicted rates of survival for several size classes of *C. porosus* in the wild: at least 25 percent of eggs usually hatch; 54 per cent of hatchlings survive to one year; 30 per cent of one year old crocodiles survive to two years; 60 per cent of two year olds survive to three years of age; 56 per cent of three year olds survive to four years of age; 56 per cent of four year olds survive to five years of age. It follows that about 18 crocodiles would survive to five years from 1000 eggs laid. The actual rates of survival between age five and maturity have never been estimated; however, Webb and Manolis (1993) predict less than one per cent survive to breed. The survival rate of mature animals is unknown.

### **9.5.2 Sub-adults and adults**

Entanglement in fishing nets is known to be a cause of mortality for crocodiles in Australia. Losses of *C. porosus* due to accidental capture and drowning in barramundi fishing nets was assessed in the early 1980's (Webb *et al.* 1984). Firm data on the level of mortality and the effect of that mortality on crocodile populations are not available for the Northern Territory, as indicated by Webb *et al.* (1987). An estimate of around 100 crocodiles per year is approximate. Commercial fishing has been banned from within a number of important river systems for *C. porosus*, such as the Mary, Roper and Alligator Rivers. Fishermen are not allowed to utilise wild crocodiles that drown in their nets.

### **9.5.3 Illegal trade/harvesting**

Nationally, 16 infractions of State/Territory law involving *C. porosus* have been the subject of legal charges over the last 5 years; 9 involved the killing and/or possession of *C. porosus* or parts of *C. porosus* without the appropriate permits. Trade in illegal *C. porosus* or parts of *C. porosus* was involved in one case. Of the 16 cases, 11 were prosecuted successfully with the imposition of fines ranging from \$90-\$2850.

## **9.6 Aboriginal attitudes and traditional use of crocodiles**

Attitudes of Aboriginal people to *C. porosus* conservation and management vary in different regions. Although *C. porosus* is a traditional food source in most areas where they occur, they are sometimes regarded as pests and a threat to public safety. Wildlife authorities receive numerous requests to kill or remove *C. porosus* from Aboriginal lands or near Aboriginal communities. In some areas, *C. porosus* has totemic significance to specific groups of people and disturbance of them, particularly of large individuals, is viewed with concern (Lanhupuy 1987).

One crocodile farm in the Northern Territory is owned by Aboriginal people and employs Aboriginal staff. Logistical difficulties (e.g. availability of food, technical skills and support services) may restrict the application of conventional crocodile farming in remote Aboriginal lands (Webb 1992). However, there are various avenues through which Aboriginal people can and are gaining financially from the sustainable use of *C. porosus* (Webb 1992). The ability to directly harvest part of the annual quota of *C. porosus* will increase the benefits Aboriginal people receive from the wild *C. porosus* population. Such an initiative is consistent with the general Aboriginal desire to link their commercial activities to the maintenance of natural habitats and traditional occupations such as hunting.

The extent of traditional harvests of crocodiles is difficult to quantify and varies greatly from area to area and year to year. The number of eggs and non-hatchling crocodiles harvested in the last several years for traditional purposes is estimated to be around 2,000 and 150 respectively (based on a reassessment of estimates derived in 1984 (Webb et al. 1994). Since the Northern Territory ranching program was initiated, which provides income from crocodiles, there has been a reduction in the local, subsistence use of crocodiles in some areas, although this was not a goal of the management program.

However, Aboriginal people are very skilled hunters who are especially adept at locating nests of both species, and the impact of their harvesting, even though unknown, "should not be lightly dismissed" (Webb et al. 1987). Section 122 of the Territory Parks and Wildlife Conservation Act 1993 provides for traditional harvest of crocodiles and their eggs for hunting, food gathering (otherwise than for purposes of sale), ceremonial and religious purposes by Aboriginal people. The removal of crocodiles and/or crocodile eggs from the wild for commercial purposes requires a permit issued under section 43 of the Act.

### **9.7 Commercial harvests**

Initial management programs for the Northern Territory included the provision for wild harvest of eggs, hatchlings, sub-adults and adults for raising in captivity for production purposes. The last management program continued all these uses, but in addition, provided for non-hatchlings to enter trade directly after harvesting, without the need to spend time in a farm.

Harvest of eggs is the most important collection that is made and since ranching started in the early 1980's, the total number of eggs collected has increased from 2,320 in 1984 to around 20,000 in the past few years. The number of eggs collected each year depends to a large extent on the timing and extent of rainfall, which can cause nest flooding and therefore greatly influence egg survival. Two farms/ranches in the Northern Territory also produce significant numbers of eggs through captive breeding.

Although there is a quota in the management program for a hatchling harvest, this part of the collection has been minimal and the impacts of hatchling harvests on the population have been insignificant. Adult and juvenile crocodiles have been removed from the wild over the past two decades to stock crocodile farms with breeding animals. Only 67 crocodiles have been captured for this purpose. In 1997, 16 adult crocodiles were harvested from the Liverpool and Mary River systems in the first commercial harvest of adults direct from the wild since 1971, when the species was protected in the Northern Territory.

Problem animals caught by the Parks and Wildlife Commission are considered part of the

annual quota for non-hatchling crocodiles and are distributed to farms as they are captured. These animals may be used for breeding stock or processed for skins and meat along with farmed animals. The majority of problem crocodiles are caught alive in Darwin Harbour and relocated to crocodile farms/ranches within the Northern Territory. In the early to mid 1980's the problem crocodile program in Darwin Harbour involved the use of a few traps in addition to regular patrols by rangers and at this time around 40-50 crocodiles were removed each year. Through late 1980's more traps were installed and since the early 1990's 19 traps have been in place. In the 1990's, between 130 and 240 crocodiles each year have been captured as problem crocodiles from all areas in the Northern Territory.

## 9.8 Production and trade

The first crocodile farm in the Northern Territory was established in 1980. There are currently eight licensed crocodile farms in the Northern Territory, which, collectively, held 36,438 *C. porosus* and 481 *C. johnstoni* as at 31 December 1997. Details of commercial crocodile farm production in the Northern Territory are given in Table 1.

**Table 1:** Numbers of skins produced (but not necessarily exported) and quantity of meat produced (in kilograms) since 1987.

Year	No. farms	Skins		Meat	
		<i>C. porosus</i>	<i>C. johnstoni</i>	<i>C. porosus</i>	<i>C. johnstoni</i>
1987	4	251	323	2,072	1,200
1988	4	962	1,020	3,171	3,171
1989	4	1,402	923	2,675	2,675
1990	4	1,954	1,373	4,939	1,138
1991	6	2,381	908	data not available	
1992	6	3,277	2,314	4,017	
1993	6	4,796	4,066	13,850	
1994	7	3,595	4,034	17,401	
1995	8	6,917		26,626	
1996	8	6,410	505	35,411	
1997	8	8,448	604	34,621	

In the Northern Territory the crocodile industry relies heavily on the annual egg harvest from the wild. Where utilisation involves products derived from ranching or wild harvesting, products can only be exported from Australia after a State/Territory Management Program has been approved by the Commonwealth government.

A State/Territory management program for wild populations is not required if a State/Territory elects to limit utilisation to captive breeding. However, even crocodile farms based solely on captive breeding in Australia have to be registered under the *Wildlife Protection (Regulation of Exports and Imports) Act 1982*, before permission to export products is granted.

## 9.9 Review of research

In the late 1960's and early 1970's international recognition of the plight of crocodiles began. Numerous research projects covering virtually all species commenced over the last 10-15 years and knowledge of crocodile natural history has improved considerably (IUCN 1993, 1994). However, only in the USA and Australia has much progress been made beyond collection of basic biological data and attempts to manage dwindling stocks of crocodiles. The greater progress in the USA and Australia has been possible because more resources are available to investigate crocodilian populations.

The majority of the research into the biology of *C. porosus* in Australia to date has been carried out in the Northern Territory. The Northern Territory program began in 1971 with a joint Northern Territory Government/University of Sydney project which generated much basic information on the natural history of *C. porosus* covering aspects of reproduction, feeding habits, population status and distribution (Webb *et al.* 1987). This phase of descriptive ecological studies has been followed by a period of more experimental studies, including:

- salinity tolerance and osmoregulation;
- respiratory physiology;
- nesting biology of freshwater swamp populations;
- capture-related acidosis in large crocodiles;
- husbandry of crocodiles in farms;
- temperature dependent sex determination and its implications for farming and ranching of crocodiles; and
- survey techniques and population density estimates.

As a result of this major research effort, management in the Northern Territory proceeded to a stage in the 1980's where managers are able to propose management plans for commercial exploitation of wild populations of *C. porosus*. These proposals were backed up by preliminary models of population dynamics giving the ability to assess the impact of experimental harvesting programs on exploited populations (Webb *et al.* 1984, Webb and Smith 1987).

## 9.10 Survey and monitoring

Underlying all the work in the Northern Territory has been an extensive monitoring program of crocodile numbers in tidal waterways. The University of Sydney surveyed and resurveyed crocodile numbers across the Northern Territory coastline, providing a unique data set on population recovery (Messel *et al.* 1979-87). The then Conservation Commission of the Northern Territory initiated a program of research into the biology and management of *C. johnstoni* (Edwards 1983; Ferguson 1985; Smith and Webb 1985; Webb 1982, 1985, 1986a, b; Webb and Gans 1982; Webb and Manolis 1983; Webb and Smith 1984; Webb *et al.* 1982) and addressed specific management problems with *C. porosus* (Bennet *et al.* 1985; Ferguson 1985; Seymour *et al.* 1985; Webb *et al.* 1983, 1988, 1989a). A wide ranging survey of *C. johnstoni* recruitment (Webb and Smith 1984) and *C. porosus* population densities (Bayliss *et al.* 1986; Webb *et al.* 1984) was also conducted (Webb *et al.* 1987). Environment Australia (formerly the Australian Nature Conservation Agency) surveyed *C. porosus* populations within the Alligator Rivers region over a number of years (Jenkins 1979; Jenkins and Forbes 1984).

Spotlight and helicopter counts in selected river systems within the Northern Territory are the standard methods of monitoring for both species. The *C. porosus* monitoring program is based on helicopter counts in a large number of within 70 tidal rivers around the coast, and spotlight counts in a smaller number of rivers in harvest areas. Corrections for seasonal biases are available (Webb *et al.* 1989b) and this work will be continued subject to an overall review of the methodology.

### 9.10.1 *C. porosus*

Figure 1 shows the relationship between mean density of *C. porosus* per kilometre of river surveyed and the years since the species was protected in the Northern Territory in 1971. For this relationship  $R^2 = 0.73$ , indicating that 73% of the variation in crocodile density is explained by the independent variable time.

**Figure 1.** Relationship between mean density of *C. porosus* derived from helicopter surveys and years since protection commenced in 1971 (year 27 = 1998). Helicopter surveys commenced in 1989 and values prior to this (years 4 – 17) are corrected spotlight counts.

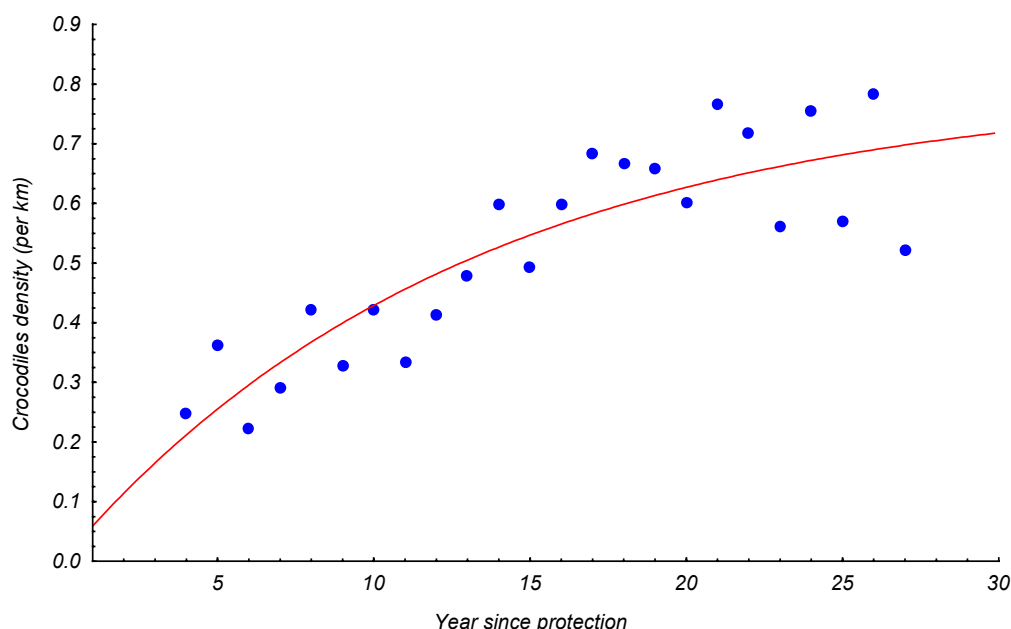


Figure 1 indicates that crocodile density increased rapidly in the 1980's (at around 8% annually) but by the early 1990's the increase had slowed. Further monitoring will determine whether or not the population is approaching an asymptote.

The increase in crocodile numbers over time depicted in Figure 1 is confirmed by the data in Table 2, showing exponential rates of increase ( $r$ ) of *C. porosus* in rivers spotlight surveyed annually. In about half the systems monitored, the exponential rate of increase is positive and the relationship is significant. Only one out of 24 survey areas (Blyth River sidecreeks) shows a significant decline in crocodile numbers.

**Table 2:** Exponential rates of increase ( $r$ ) for *C. porosus* in rivers spotlight surveyed annually. (In 5 instances where no crocodiles were sighted in a particular creek, in any one year, 1 sighting has been added so that a log ( $ln$ ) value could be computed).

<b>River/survey area</b>	<b><math>N</math></b>	<b>Years</b>	<b><math>r</math></b>	<b><math>p</math></b>
<b>Adelaide River downstream</b>	16	1977-97	0.028	0.001
<b>Adelaide River upstream</b>	21	1977-97	0.049	<0.001
<b>Adelaide River sidecreeks</b>	17	1977-97	0.021	0.048
<b>Blyth River mainstream</b>	23	1975-97	0.019	0.003
<b>Blyth River sidecreeks</b>	21	1975-97	-0.043	0.003
<b>Cadell River mainstream</b>	23	1975-97	-0.007	0.301
<b>Daly River mainstream</b>	15	1979-97	0.061	<0.001
<b>Finniss River – Bulcoin</b>	8	1984-91	0.092	0.137
<b>Finniss River – Patj Patj</b>	10	1984-95	0.114	0.062
<b>Liverpool River – Gudjerama Creek</b>	20	1976-97	0.020	0.180
<b>Liverpool River mainstream</b>	21	1976-97	0.035	<0.001
<b>Liverpool River – Atlas Creek</b>	19	1976-97	-0.019	0.116
<b>Liverpool River – Maragulidban Creek</b>	21	1976-97	0.048	0.001
<b>Liverpool River – Morngarrie Creek</b>	21	1976-97	-0.024	0.208
<b>Liverpool River – Mungardobolo Creek</b>	21	1976-97	0.008	0.567
<b>Liverpool River – Tom’s Creek</b>	16	1976-97	0.081	0.001
<b>Reynolds River – Deep Hole</b>	14	1984-97	-0.064	0.130
<b>Reynolds River – Horseshoe</b>	14	1984-97	0.038	0.450
<b>Reynolds River – McEddy’s</b>	14	1984-97	0.041	0.305
<b>Reynolds River – Noaklies</b>	14	1984-97	0.067	0.008
<b>Reynolds River – Welltree Station</b>	14	1984-97	0.037	0.094
<b>Tomkinson River mainstream</b>	21	1976-97	0.007	0.386
<b>Mary River – Sampan/Alligator Creek</b>	11	1984-97	0.095	<0.001
<b>Mary River – Sampan/Shady Camp</b>	11	1984-97	0.131	<0.001

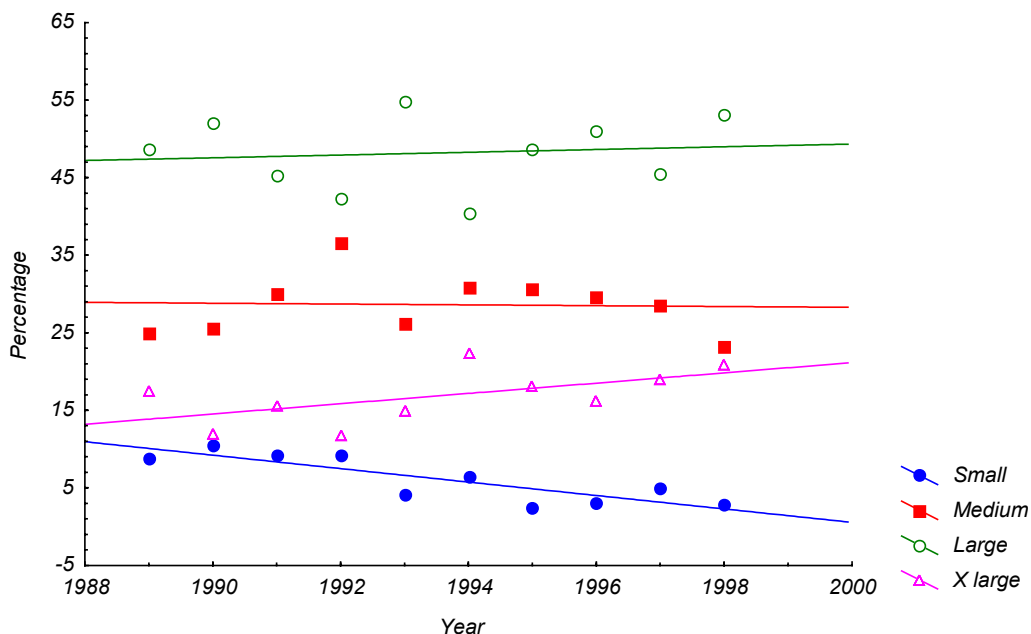
Using the data for the Adelaide River system in Table 1 the impacts of egg harvesting on crocodile populations can be assessed. The data show positive and significant increases in non-hatchling crocodile numbers over time in the entire Adelaide River system. Exponential rates of increase vary from 2.1% annually in sidecreeks to 4.9% in the upstream section of the river. These data indicate that, despite the fact that 27,882 viable eggs (around 40,000 eggs in total) have been harvested from this system since 1983/84, the crocodile population has increased significantly. Continued monitoring over the life of this management program will determine the exact trajectory of the Northern Territory population and local populations in harvest areas.

Figure 2 presents the size distribution of *C. porosus* sighted during helicopter surveys of the Northern Territory. Of the four size classes analysed, only small category (<4') shows a significant negative correlation ( $r = -0.85$ ,  $p = 0.002$ ,  $n = 10$ ), indicating that this size category is undergoing a significant decline. The factors behind this decline are unknown



at present, although as discussed above, predation by large crocodiles could be involved. The slope of the relationship for the extra-large size class (>11 ft) is positive ( $r=0.57$ ) and is approaching significance ( $p=0.082$ ).

**Figure 2.** Size distribution of *C. porosus* sighted during helicopter surveys of tidal rivers around the Northern Territory from 1989 to 1998. Size classes are as follows; small (<4 ft), medium (4 – 7 ft), large (7-11 ft) and extra-large (>11 ft).



During the life of this plan, the methodology of the monitoring program will be reviewed. Any wild harvests will also be monitored to ensure that harvest levels are adhered to, and to provide an objective means for assessing the extent to which measured fluctuations in the wild population have been influenced by harvest regimes.

### 9.10.2 *C. johnstoni*

While harvests of *C. johnstoni* were carried out in the 1980's, very little harvest from the wild has occurred in the 1990's. The value of skins from this species is much less than for skins of *C. porosus* and demand for product is currently negligible. Crocodile farms have existing stock from previous harvests and they cull some stock each year. There is also a small amount of captive breeding on farms. Nevertheless, the data on harvests and population surveys of *C. johnstoni* provide insights into the response of crocodiles to harvesting.

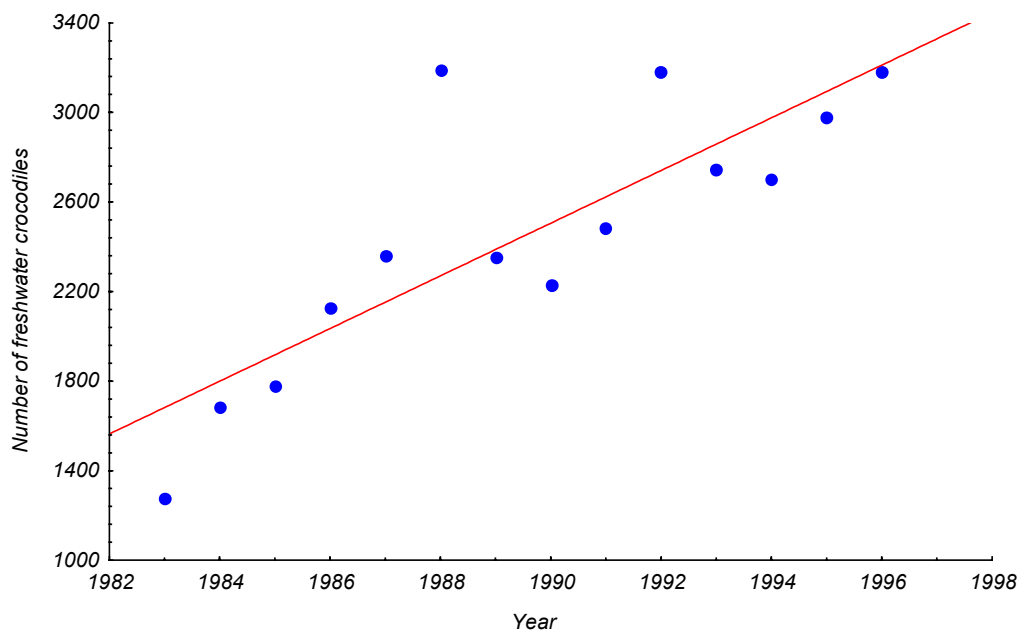
The Daly River was one of the main rivers from which *C. johnstoni* hatchlings were harvested in the 1980's. Table 3 shows estimates of the exponential rate of increase ( $r$ ) of *C. johnstoni* in seven harvested and two non-harvested segments of the Daly River, based on annual spotlight counts from 1983 to 1995. The intrinsic rate of increase is highly variable between segments (range 0.004 to 0.131), both within and between harvest regimes. Comparison of harvested with non-harvested segments is not attempted given the small sample size for non-harvested segments, however, the intrinsic rate of change for both was significantly positive.

**Table 3:** Exponential rates of increase ( $r$ ) and their standard errors (s.e.) for *C. johnstoni* in 7 harvested and 2 non-harvested sections of the Daly River, based on annual spotlight counts.

Section of river	Length (km)	$r \pm \text{s.e.}$	$p$
	14.3	$0.019 \pm 0.014$	0.210
<b>Non-harvested</b>	21.6	$0.060 \pm 0.015$	0.003
<b>Total non-harvested</b>		$0.056 \pm 0.015$	0.003
	31.0	$0.131 \pm 0.030$	0.002
	15.5	$0.040 \pm 0.016$	0.030
	22.0	$0.026 \pm 0.018$	0.170
<b>Harvested</b>	18.9	$0.013 \pm 0.018$	0.500
	39.4	$0.047 \pm 0.019$	0.030
	17.1	$0.004 \pm 0.008$	0.650
	16.5	$0.073 \pm 0.018$	0.002
<b>Total harvested</b>		$0.045 \pm 0.010$	0.001

Figure 3 shows the total numbers of *C. johnstoni* sighted in spotlight surveys of the Daly River (harvested and non-harvested segments combined) from 1983 to 1996 (exponential rate of increase  $r = 0.054$ ,  $p = <0.001$ ). A total of 15,655 hatchlings (1982 to 1991), 866 eggs (1983 to 1984) and 27 sub-adults/adults were harvested from the Daly River during for small *C. porosus*. The number of *C. johnstoni* sighted as eye-shines only is increasing significantly ( $r = 0.613$ ,  $p < 0.05$ ,  $n = 11$ ). This category corresponds to the majority of sub-adult and adult animals (4' to >8') that cannot be approached close enough to identify size before they submerge. Taken together, Table 3 and Figure 3 demonstrate that for the Daly River the harvest of *C. johnstoni* has certainly not resulted in a measurable population decline.

**Figure 3.** Numbers of *C. johnstoni* (hatchlings and hon-hatchlings) sighted in spotlight surveys of the Daly River, 1983-1996.



The results for all river systems monitored regularly for *C. johnstoni* by spotlight counts are presented in Table 3. The populations in most of the non-harvested rivers systems have remained stable over the last decade, except for the Finnis River – Buffalo Hole area which increased in size between 1984 and 1990. Similarly, the numbers of *C. johnstoni* in most harvested river systems did not change over the periods they were monitored, the exception being the Daly River which has already been discussed in detail. These results indicate that populations of *C. johnstoni* in a range of river systems in the Top End have remained stable over the last decade regardless of whether they experienced periods of harvesting.

**Table 3:** Exponential rates of increase ( $r$ ) for *C. johnstoni* in river systems spotlight surveyed regularly in the Northern Territory ( $N$  = number of years surveyed).

Survey area	$N$	Years	$r$	$p$
<b>Unharvested river systems</b>				
East Baines River	3	1982-86	-0.002	0.97
Katherine Gorge	9	1980-88	-0.084	0.06
Mary River Bridge – downstream	10	1984-96	-0.003	0.86
Moyle River	4	1984-88	-0.025	0.91
Finniss River – Buffalo Hole	7	1984-90	0.176	0.02
Reynolds River – Waterhole	7	1984-90	-0.112	0.35
<b>Harvested river systems</b>				
TH Hole	7	1983-91	-0.017	0.72
Daly River	14	1983-96	0.054	<0.01
Finniss River – mainstream	14	1983-96	0.015	0.19
Mary River Bridge – upstream	14	1983-96	0.002	0.94
Reynolds River – mainstream	14	1983-96	0.035	0.12
Reynolds River – Fish Camp	13	1983-96	-0.033	0.31
Victoria River – Rockhole	7	1982-91	-0.019	0.56
Victoria River Bridge – upstream	5	1984-88	0.112	0.47
Victoria River – Pigeon Hole	5	1982-91	0.041	0.12
Victoria River Bridge – downstream	7	1982-88	0.101	0.28
Wickham River – Yarralin	5	1982-87	0.066	0.38
Wickham River - Homestead	5	1982-87	0.124	0.16

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