

SALTWATER CROCODILE (*Crocodylus porosus*) MANAGEMENT PROGRAM:

2010-2011 Monitoring Report

Keith Saalfeld and Yusuke Fukuda
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Department of Natural Resources, Environment, the Arts and Sport
PO Box 496
Palmerston NT 0831

Summary

The Management Program of the Saltwater Crocodile (*Crocodylus porosus*) in the Northern Territory of Australia, 2009 – 2014, requires annual reporting on the implementation of the Management Program. This monitoring report reviews the performance in 2010/2011 (financial year). Data for each year of the current management (2009/2010 & 2010/2011) program are included throughout the report.

Northern Territory Department of Natural Resources, Environment the Arts and Sport (NRETAS) conducted spotlight surveys in 3 out of 8 monitoring rivers in 2011 as scheduled. The results showed that the population of non-hatchling *C. porosus* in most rivers continued to increase or remain stable. The slight decline in non-hatchling numbers observed for the Adelaide River in recent years was not reflected in the 2011 survey data; the population appears stable. Concurrent with this the population is showing a proportional shift to larger animals, particularly in the two to three metre size range, which is interpreted as indicating a stabilising mature population. The Mary River has shown stable population numbers in recent years coupled with a proportional shift to larger animals, also interpreted as indicating a stabilising mature population. The Daly River continues to show a fixed linear rate of increase since protection and exponential rate of increase of biomass, which is interpreted as indicating as still strongly recovering population.

Parks Australia North plans to survey 4 monitoring rivers in Kakadu National Park in November 2011. The South Alligator, West Alligator and Wildman Rivers showed possible declines in the recent years. Given that the South and West Alligator Rivers are 'control' rivers without any form of harvest; it is thought to be caused by environmental factors rather than human-induced factors. These trends are yet to be confirmed as results have not been available to NRETAS since 2008.

Survey results also indicated that the size of individual animals (estimated from size structure and biomass) has been increasing in most rivers, reflecting the continued maturity of the population still recovering from the unregulated hunting in the period 1945 to 1971.

A total of 290 problem crocodiles were removed in 2010/2011 by NRETAS staff for public safety and to protect stock in pastoral areas, of which 78% were males and 64% were caught in the Darwin Harbour.

NRETAS continues to promote community awareness for safety and participation through CROCWISE campaign programs using a variety of media. NRETAS delivered local schools with educational programs.

Under the ceiling of 50,000 live eggs, 50,000 eggs were allocated to harvest, but only 36,796 live eggs were collected in 2010/2011.

Under the ceilings of 500 hatchlings, 400 juveniles and 500 adults provided in the Management Program, 0 hatchlings and 13 juveniles and 103 adults were harvested in 2010/2011. The adults

harvested were strongly biased to females (71.4%). The average body size of the harvested animals was about 2.5 metres for females and 2.8 metres males.

Seven crocodile farms operated in 2010/2011 in the Northern Territory. They produced 10,563 eggs through on-farm breeding and processed 21,582 crocodiles. Most of the live crocodiles exported from the Northern Territory went to Queensland.

Permit compliance and animal welfare was closely monitored and inspected by NRETAS and the Northern Territory Department of Resources. A few minor non-compliance cases were identified and dealt with through warning letters, caution notices or infringement notices as appropriate.

INTRODUCTION

The Northern Territory Department of Natural Resources, Environment the Arts and Sport (NRETAS) and the Northern Territory Department of Resources review compliance to, and the operation of, the Management Program for the Saltwater Crocodile in the Northern Territory of Australia, 2009 – 2014 (Leach *et al.* 2009). The annual revision is reported to the Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). This is the second Monitoring Report of the Management Program, reviewing the implementation and performance in 2010/2011.

The Management Program was approved by the Administrator for the Northern Territory as an approved management program under section 34(2) of the *Territory Parks and Wildlife Conservation Act* on 22 August 2009 and by the Minister for the Environment, Heritage and the Arts as an Approved Wildlife Trade Management Plan under Subsection 303FO(3) of the *Environment Protection and Biodiversity Conservation Act* 1999 on 29 September 2009.

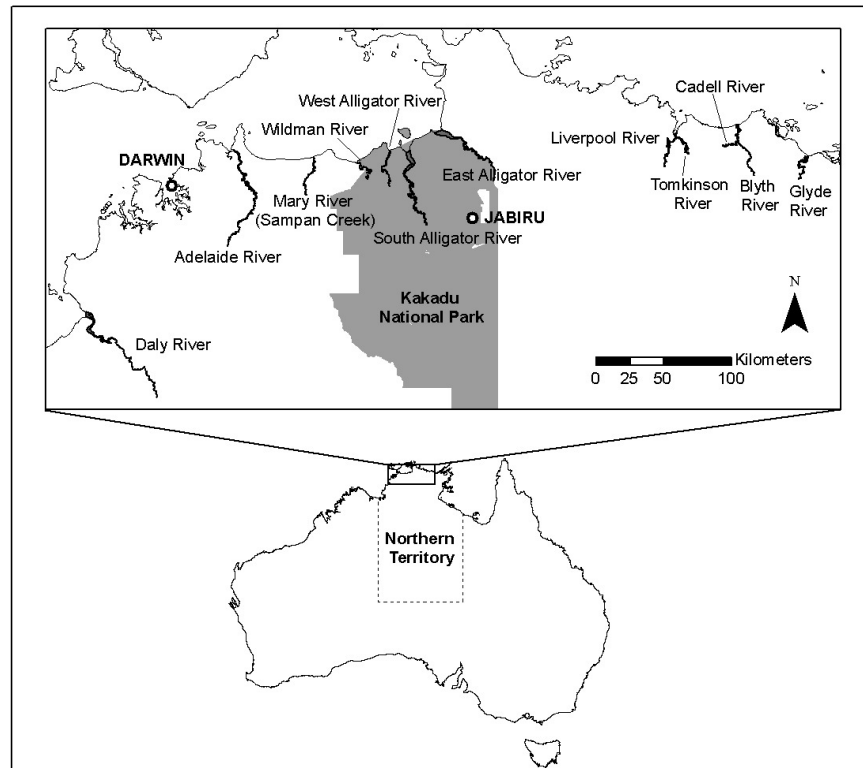
The Management Program has four objectives:

1. To facilitate the sustainable use of Saltwater Crocodiles;
2. To promote community awareness and public safety;
3. To ensure the humane treatment of Saltwater Crocodiles; and
4. To monitor and report on the impact of the harvest of Saltwater Crocodiles.

The reporting requirements are outlined in Section 4.9 under Objective 4. The status of each milestone as defined as performance indicators in the Management Program is summarised in Appendix 1. The results of the population surveys and farm stock audits are provided in Appendix 2 and 3, respectively.

POPULATION MONITORING

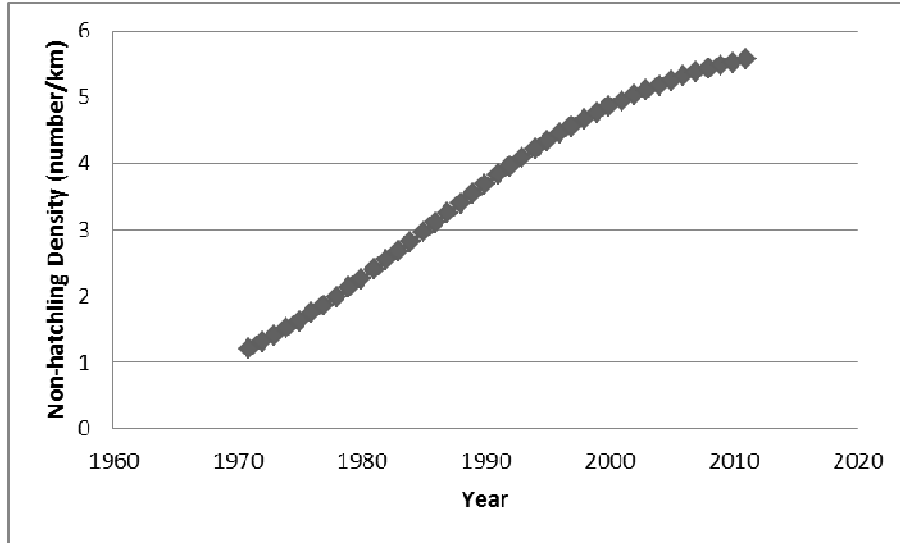
Populations of *C. porosus* have been monitored in the Northern Territory since the species was declared protected in 1971 through a range of varied monitoring projects undertaken by the University of Sydney, Parks Australia North (Kakadu National Park), Wildlife Management International (WMI), NRETAS and individual NRETAS parks. The standardised spotlight surveys started in 1975 and have continued since then in the Adelaide River, Blyth River, Cadell River, Daly River, Glyde River, Liverpool River, Mary River and Tomkinson River on a biennial basis (Figure 1, Appendix 2). In addition four rivers (Wildman River, West Alligator River, South Alligator River and East Alligator River) in Kakadu National Park are surveyed annually by Parks Australia North. Data from the Kakadu rivers up to 2007 only are available to NRETAS at this time. Surveys have been carried out in these rivers post 2007, however processing and analysis constraints by Kakadu National Park Service have resulted in this data being unavailable for this report. Kakadu National Park Service have indicated that the data will be available for future reporting.

Figure 1 Rivers surveyed to monitor *C. porosus* populations in the Northern Territory.

General trends

Results from the monitoring programs show that the number of non-hatchlings (>2 ft or >0.6 m) of *C. porosus* has largely increased since protection in 1971 and the introduction of farming in 1980 (Figure 2). Analyses of surveys continue to suggest that the rate of increase of crocodile populations in a majority of rivers is slowing or approaching an asymptote in recent years. Most of the monitored rivers show large increases since protection and some have stabilised at an asymptote in recent years. Analysis of each individual river is provided in Appendix 2. There is no evidence that the harvesting program has had a detrimental impact on crocodile population in the NT.

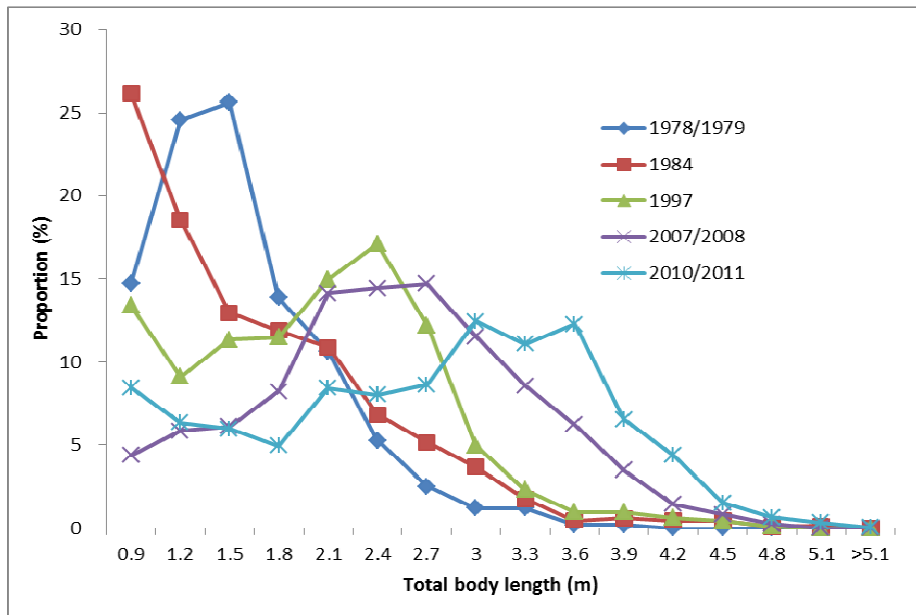
Figure 2 Modelled abundance density of non-hatchling (>0.6 m, including eyes-only) of *C. porosus* derived from standardised spotlight surveys in 12 tidal rivers since 1975.



Size Structure

Results indicate that the size structure of the crocodile population appears to be shifting from smaller crocodiles to a higher proportion of larger crocodiles (Figure 3) with an associated large increase in biomass in recent years (Appendix 2). This is consistent with the ongoing maturing of a population of a large, slow growing species recovering from substantial unregulated harvest. Analysis of each individual river is provided in Appendix 2.

Figure 3 Changes in proportion (%) of saltwater crocodiles at each size class from 0.3 - >5.1 m (1 - >17 ft) in 12 monitored rivers combined in the Northern Territory, Australia in 1978/1979 (10 rivers in 1978 and 1 river in 1979; no data available for Mary River), 1984, 1997, 2007/2008 (6 rivers in 2007 and 6 rivers in 2008) and 2010/2011 (6 rivers in 2010 and 3 rivers in 2011).



PROBLEM CROCODILES

Problem crocodiles are defined broadly 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 around Darwin, the Katherine River near Katherine and designated swimming areas in National Parks, any *C. porosus*, regardless of size, is classed as a problem animal. These areas are intensively managed through an active trapping and surveillance program by NRETAS staff to maintain a very low crocodile density. NRETAS also responds to reports of problem crocodiles on a case by case basis. Darwin Harbour and Katherine River have detailed management strategies with defined zones and specific management actions to remove crocodiles.

Removal of Problem Crocodiles

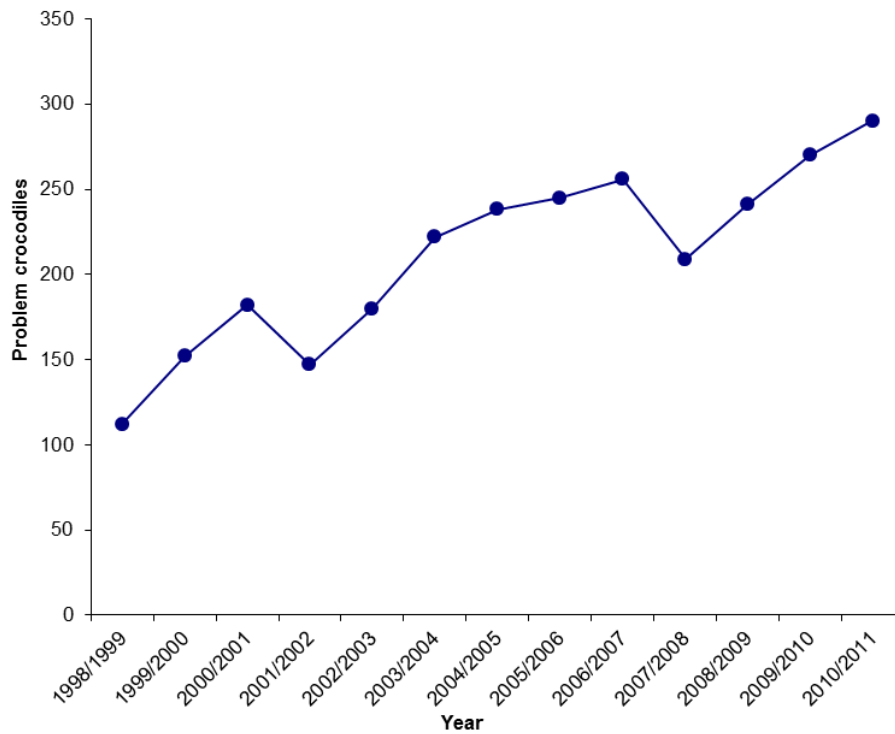
Removed problem crocodiles are sold to crocodile farms to be consumed for skin and meat production or captured and used as stock in crocodile farms. Problem crocodiles are not relocated because relocated crocodiles rapidly return to the site of initial capture (Walsh and Whitehead 1993, Read *et al.* 2007).

A total of 290 problem crocodiles were removed between July 2010 and June 2011 (Table 1, Figure 4). Whilst the vast majority of these animals were removed from Darwin Harbour, a number have been removed from the greater Darwin area and a few animals from the Katherine area and other communities.

Table 1 Total number of *C. porosus* removed by NRETAS staff as problem crocodiles, sex ratio as proportion of males, the proportion of problem crocodiles caught in the Darwin Harbour in 2009/2010 and 2010/2011.

Year	Problem crocodiles	Males	Darwin Harbour
2009/10	270	73%	63%
2010/11	290	78%	64%

Figure 4 Changes in the numbers of problem *C. porosus* removed by NRETAS staff in 1998/1999 – 2010/2011.



Community Awareness and Participation

The Northern Territory Government promotes crocodile awareness among residents and visitors by disseminating educational information through a CROCWISE plan. Public awareness campaign continues to be conducted regularly to minimise harmful interactions between people and crocodiles. The campaign uses a variety of the media including TV, DVD, papers and radio to ensure messages about safe behaviour are effectively conveyed to both locals and visitors. Local events such as the show circuit, tour guides, park visitor centres, and park ranger talks are avenues to further disseminate messages in a face to face setting. NRETAS staff also visits local schools to deliver the educational program to teachers and children. Signs at popular water entry points are placed to reduce risks with crocodiles. The Northern Territory Government also promote relevant legislation, policy and guidelines to the commercial crocodile industry and wider community via promotion of this management program, relevant fact sheets, and through the Northern Territory Government permit system.

HARVESTS FROM THE WILD

Eggs

The harvest ceiling was 35,000 total eggs for 2008/2009. Under the new 2009-2014 Management Program, the quota was increased to 50,000 live eggs for 2009/2010 and the same quota of 50,000 live eggs was maintained in 2010/2011. The number of eggs harvested was below the harvest ceiling in all years (Table 2). The harvest in 2010/2011 was lower than the number of eggs permitted due to a combination of factors, which included the loss of significant numbers of nests to flooding from unseasonal rains, delays in the issue of some permits and infrastructure limitations on some farms. Permit delays arose from extended negotiations with Aboriginal Traditional Owners. Egg collection permits issued in 2010/2011 were, in a number of instances, issued for a period of up to 4 years depending on landholder agreement.

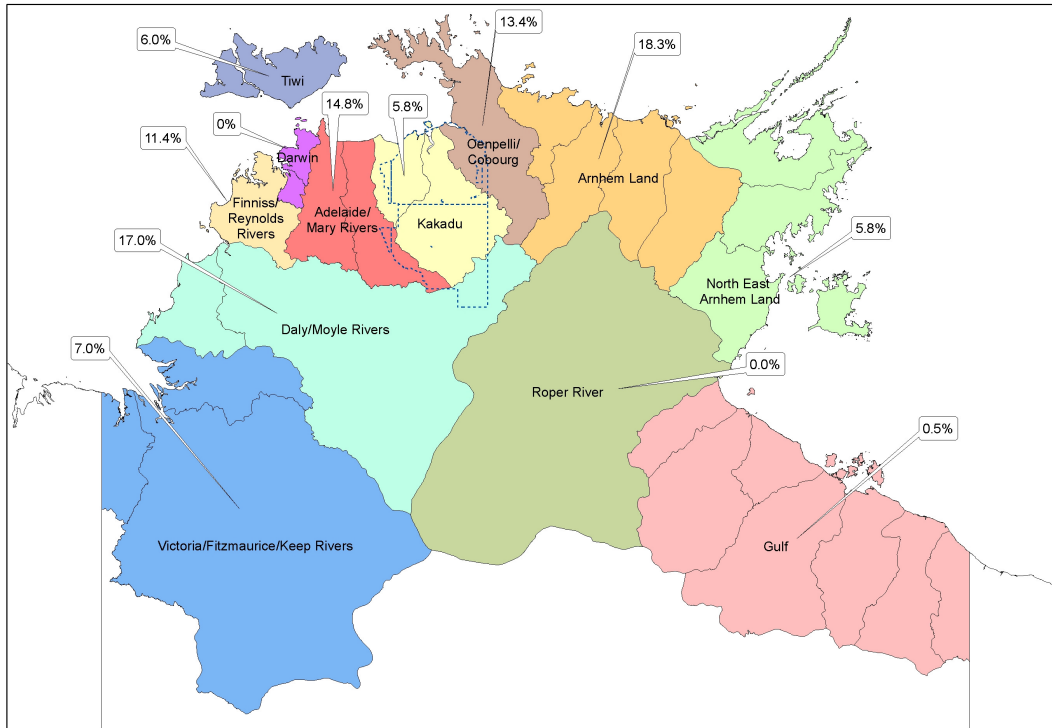
The number of eggs permitted and collected varies between the different regional catchments (Figure 5), depending on a number of factors as outlined in Section 4.1 of the Management Program.

The returns of permit holders were closely monitored to ensure that the stock taken under each permit complies with the conditions of the permit (see Permits & Compliance below).

Table 2 The number of eggs of *C. porosus* harvested for commercial use in 2008/09, 2009/10 and 2010/2011. The definition of “live” and “total eggs” follows those in the Management Program 2009-2014 (Leach *et al.* 2009).

Season	Harvest Ceiling	Eggs permitted	Eggs harvested
2008/09	35,000 (as total)	34,774 (as total)	33,117 (as total)
2009/10	50,000 (as live)	49,970 (as live)	33,078 (as live)
2010/11	50,000 (as live)	50,000 (as live)	36,796 (as live)

Figure 5 Average proportion of *C. porosus* egg harvest in the regional catchments for 2010/2011, relative to the total NT harvest. Note that the boundary of Kakadu regional catchment is different from Kakadu National Park (KNP) and no eggs were harvested in KNP.



Hatchlings, juveniles and adults

The Management Program allows up to 500 hatchlings (total body length <0.6 m), 400 juveniles (total body length 0.6 - 2.1m) and 500 adult (total body length >2.1m) *C. porosus* can be directly harvested from the wild each year. These quotas do not include any problem crocodiles removed by NRETAS staff (reported separately in Table 1 above).

A small number of hatchling, juvenile and adult *C. porosus* were harvested from the wild in both 2009/2010 and 2010/2011 (Table 3). Variation in the sex ratio of harvested adults is influenced by the harvest purpose; skin and meat harvest or female breeding stock for farms. In 2010/2011 the sex ration was strongly biased to females, indicating that animals were being collected for farm breeding stock, whilst in 2009/2010 the ratio was biased to males (Table 4), indicating that larger animals were being targeted rather than females. Crocodiles were harvested from pastoral properties and aboriginal land. The average size of non-hatchlings (juveniles and adults combined) was similar between females and males (Table 5). It is not known how many of these animals were harvested as problem crocodiles by private operators because it is often difficult to determine whether the primary aim of the harvest is for safety for public and livestock or commercial gain for farming.

Table 3 The number of hatchlings, juveniles and adults of *C. porosus* harvested for commercial use in 2009/10 and 2010/11.

Year	Hatchlings	Juveniles	Adults
2009/10	151	46	36
2010/11	0	11	105

Table 4 Sex ratio of adults of *C. porosus* harvested for commercial use in 2009/10 and 2010/11.

Year	Female
2009/10	33.3%
2010/11	71.4%

Table 5 Average body size of *C. porosus* (juveniles and adults combined) for each sex harvested for commercial use in 2009/10 and 2010/11. Small juveniles whose sex was unknown are not included in the figures.

Year	Female	Male
2009/10	2.08 m	2.20 m
2010/11	2.52 m	2.77 m

Harvest review

The management program requires that harvest ceilings be reviewed every 2 years. This review is due in 2010/2011 and 2012/2013 in the management program.

In 2010/2011 the population monitoring data and the crocodile egg harvest data indicate that the current crocodile egg harvest ceiling and actual egg harvest level is having no measurable impact on the population level. This result is supported by the crocodile population and harvest model (Fukuda *et. al.*, in prep), which clearly indicates that the impact of crocodile egg harvest is of little or no significance compared to the impact of adult (> 2.1 m) harvest. The modelling indicates that a crocodile egg harvest of between nil up to 150,000 eggs per year would have very little impact on the population level over a 30 year period. The model shows that the population level would continue to increase in the absence of adult harvest. With adult harvest introduced into the model, crocodile egg harvest has little influence until the adult harvest reaches about 1,200 adult animals per year, at which point population growth ceases.

Based on monitoring results and the harvest model, increasing the egg harvest ceiling from 50,000 to 60,000 live eggs in 2011/2012 as proposed in the management program is not expected to have any detectable impact. Consequently the egg harvest ceiling will be increased to 60,000 live eggs in 2011/2012. The current adult harvest ceiling of 500 adult animals per year is substantially less than the 1,200 adult animals in the model and will be maintained as proposed in the management program.

FARM PRODUCTION

Eight crocodile farms operated in the Northern Territory in 2008/2009 and 2009/2010. In 2010/2011 this reduced to seven farms with the closure of the Gove Crocodile Farm (Table 6). On average the farms produced 10,563 *C. porosus* eggs in 2010/2011. The number of *C. porosus* processed for production was 21,582 in 2010/2011.

Details of the products produced by these farms are provided in Table 7. The number of *C. porosus* (eggs, hatchlings, and juveniles/adults) exported to other States is also provided (Table 8).

Queensland had the highest number of live crocodiles exported from the Northern Territory. These animals were incubated and raised on these farms and then exported to the other States.

Department of Resources undertakes audits of the hatchlings in farms every year to validate farm returns, as required in the Management Program. Farms have the option of full or 10% of stock audit. Details of the stock held on each farm at the end of 2010/2011 are provided in Appendix 3.

Table 6 The number of crocodile farms operating in the Northern Territory, *C. Porosus* eggs produced and *C. porosus* processed on these farms in 2009/10 and 2010/11.

Year	No. of farms	Farm-bred eggs	Crocodiles processed
2009/10	8	8,211	10,445
2010/11	7	10,563	21,582

Table 7 *C. porosus* products produced and/or exported in the Northern Territory in 2009/10 and 2010/11.

Products	2009/10	2010/11
Belly overseas	11,095	18,041
Belly domestic	188	158
Backstrap overseas	10,247	17,019
Backstrap domestic	1,693	3,541
Feet	700	1,340
Heads	300	544
Hornbacks	0	20
Teeth	12,500	
Stuffers	10	94
Tail tips	600	146
Tissue Samples/Skin pieces	6,539	
Infertile eggs	11	11
Items manufactured	2,430	3,809
Whole carcasses	5	
Live sales	10,610	23,954
Bloods (ml)	328	
Swabs	0	
Flesh domestic (kg)	57,697	64,835

Table 8 *C. porosus* (live eggs, hatchlings, and Juveniles/Adults) exported to other States in 2009/10 and 2010/11.

State	2009/10			2010/11		
	Eggs	Hatchlings	Juveniles/Adults	Eggs	Hatchlings	Juveniles/Adults
QLD	750	0	9,916	600	0	10,927
WA	0	495	0	0	0	0
VIC	0	1	2	0	5	0
SA	0	0	0	0	1	1
NSW	0	10	6	0	0	1

PERMITS & COMPLIANCE

The following is a summary of permits and compliance for the 2010/2011 egg harvest season:

- A total of 40 individual permits to collect crocodile eggs were issued.
- Five crocodile farms were audited to check quantities of eggs in incubators against farm records and returns for crocodile egg collection permits submitted to NRETAS. No discrepancy was detected. The level of cooperation with the compliance audits was high.
- Two egg collection permits were field audited to check reported nest locations against actual field locations for nests. No discrepancy was detected.
- NRETAS has standardised the format of monthly and final returns of egg collection. The return forms require the minimum amount of data as specified in the Management Program. The forms were provided both electronically and in hardcopy with each permit as permit conditions.
- There were no reported compliance issues for the 2010/2011 egg collection season that required investigation.
- Crocodile egg collection permit holders were required to submit the monthly returns during the 2010/2011 crocodile egg collection season (December - May) and the final return after the close of the season (31 July). All monthly returns were submitted, however in a number of instances final returns were submitted either late or only after direct intervention by NRETAS. Non-compliance was dealt with through warning letters and caution notices. No infringement notices were issued as all returns were received after caution.
- For the 2010/2011 crocodile egg collection season, collectors were required as a condition of permit, to provide prior notification of date and location of collection activity via a dedicated email address or a dedicated phone number and message bank. Compliance for this system was generally good. Non-compliance was dealt with through warning letters only. Compliance lifted to full compliance after warnings,
- There was regular interaction with all other relevant jurisdictions; including a one day meeting with Commonwealth, Queensland and Western Australian agencies, largely to discuss permitting of crocodile harvest and other matters of joint concern.

WELFARE

The Code of Practice on the Humane Treatment of Captive and Wild Australian Crocodiles was endorsed by the Natural Resource Management Ministerial Council on 21 May 2009. This Code outlines an achievable minimum standard of humane conduct in regard to the treatment of wild and farmed crocodiles.

During 2010/2011, one farm had issues regarding captive crocodile welfare. The farm received an official warning and is rectifying of the problem.

ACKNOWLEDGMENTS

Northern Territory Department of Resources is responsible for farm management and provided data on farm stock. Parks Australia North provided data on the East Alligator, South Alligator, West Alligator and

Wildman Rivers. The traditional owners of the Indigenous lands assisted NRETAS with the surveys, giving permission to survey on their land.

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APPENDIX 1. ANNUAL MILESTONE MATRIX FOR 2009-2014 PROGRAM

Milestone	Program Reference	2010/11	Status for 2010-11 Monitoring report
Objective 1 - To facilitate the sustainable use of Saltwater Crocodiles			
Ensure all harvest permits minimise the possible negative impact on or conflict with tourism, social or cultural interests.	4.1 Restrictions on live animal harvesting.	Ongoing	Done. Compliant. Standard part of permit assessment process.
Develop and implement a GIS database to assist with both allocation of eggs and monitoring harvest effort and compliance.	4.1 Harvest ceilings.		Crocodile harvest spatial database completed and in use. Egg allocation spatial model developed and basis of 2010/2011 allocation.
Investigate and take appropriate action on all suspected local impacts on the population.	4.1 Harvest ceilings.	Ongoing, review	Adelaide River population reaching stable status, minor decline in abundance attributed to stabilising population.
Instigate adaptive management actions should there be any increased threats to the Saltwater Crocodile and their habitat.	4.1 Harvest ceilings.	Ongoing, review	No actions required as no perceived threats.
Ensure the harvest ceiling is set in accordance with the provisions of this management program.	4.1 Harvest ceilings.	July – September	The 2010/11 harvest ceiling was set at 50,000 live eggs as per agreement with DEWHA. Permits were issued to harvest a total of 50,000 live eggs.
Assess all permit applications and ensure egg allocation is distributed across harvest regions in accordance with the provisions of this management program.	4.1 Harvest ceilings	September – October	All permits applications were assessed. Eggs were allocated across the harvest regions as per the management program and publicly available criteria published on the internet.
Ensure that the annual commercial harvest of Saltwater Crocodiles does not exceed the approved ceiling for each category.	4.2 Permits and compliance.	July – September	2010/11 – compliant all categories.
Assess applications and issue permits under the <i>TPWC Act</i> .	4.2 Permits and compliance	Ongoing	2010/11 - compliant. Standardised assessment process.
Monitor and audit harvest applications, approvals and returns and investigate and resolve any discrepancies.	4.2 Permits and compliance	Ongoing, review	Compliant; this is a standard part of the permitting system and processes.
Ensure all permit applications have correct landholder approval.	4.2 Permits and compliance	Ongoing, review	Compliant.
Ensure monthly farm stock returns comply with permit conditions and are reported half yearly to farms and NRETAS.	4.2 Permits and compliance	Ongoing, review	Compliant for 2009/2010 season and returns are being finalised for 2010/2011.
Audit farm hatchlings annually.	4.2 Permits and compliance	annually	Annual hatchling audits undertaken for the 2010/2011 harvest season. Audits currently in progress for the 2010/11 egg harvest season.
Ensure compliance with the issue of skin tags and permits.	4.2 Permits and compliance		Compliant for skin tag and permits.
Conduct random checks on farm stock numbers.	4.2 Permits and compliance	Ongoing	In 2010/11 egg numbers were checked against permits semi-randomly at five farms. High level of compliance with permit requirements.

Milestone	Program Reference	2010/11	Status for 2010-11 Monitoring report
Review permit conditions annually and amend where necessary.	4.2 Permits and compliance	July - September	Permit to Take Protected Wildlife including amendments to Permit Schedules and Conditions were updated for 2009/10 egg harvest season and same for 2010/11. NRETAS and the Department of Justice are currently reviewing all permits issued under the TPWC Act.
Ensure compliance with permit conditions is at or near 100% and addressing permit breaches through warning letters, caution notices, infringement notices or prosecution is at or near 100%.	4.2 Permits and compliance	annually	Known compliance with permit conditions is very high. Since 2008 investigation of non-compliance has increased and has been at or near 100%. Non-compliance has been dealt with through warning letters, caution notices or infringement notices as appropriate.
Review and analyse available data to describe changes to Saltwater Crocodile populations and their distribution and publish the outcomes as appropriate.	4.3 Management-focused research.		In progress. Stage-based structured matrix model of crocodile population in the Northern Territory has been developed and in preparation for publication.
Develop population/harvest simulation models to provide an additional decision support tool to assess harvest options and possible harvest impacts at different spatial scales.	4.3 Management-focused research.		Completed and implemented, subject to ongoing refinement.
Objective 2 - To promote community awareness and public safety			
Analyse the risk of areas where human interaction with crocodiles may occur and prepare options for the appropriate level of management actions.	Risk Assessment		Completed and implemented, subject to ongoing refinement.
Analyse problem crocodile capture data to assess trends and identify areas of increasing risk to humans.	Risk Assessment		Completed and implemented, subject to ongoing refinement..
Develop and implement a 'CROCWISE' plan to educate and heighten the awareness of the dangers of crocodiles in the Northern Territory's waterways.	Risk Assessment		Completed and implemented, subject to ongoing refinement..
Issue permits to remove problem crocodiles as necessary and appropriate.	4.4 Removal of problem crocodiles.	Ongoing, as needs	Ongoing.
Maintain the program to remove all crocodiles in designated 'Intensively Managed' zones.	4.4 Removal of problem crocodiles.	Ongoing	Ongoing.
NRETAS responds to reports of problem crocodiles and implements appropriate management measures.	4.4 Removal of problem crocodiles.	Ongoing as needs	Ongoing.
Re-define the Darwin Harbour 'Intensively Managed' zone to include high risk areas of the entire catchment and include the waterways of the Darwin rural area.	4.4 Removal of problem crocodiles.		Completed; management options currently under consideration.
Continue to conduct public awareness, safety and educational message campaigns through Northern Territory Government staff, effective use of the media and on the Northern Territory Government website.	4.5 Community awareness and participation.	Ongoing, as needs	Implemented.

Milestone	Program Reference	2010/11	Status for 2010-11 Monitoring report
Conduct market research to assess the best communication methods for targeting and informing all sectors of the community about living safely with crocodiles.	4.5 Community awareness and participation	Ongoing, as needs	Implemented.
Develop and implement a public safety communication plan.	4.5 Community awareness and participation	Ongoing, as needs	Implmented.
Objective 3 - To ensure humane treatment of Saltwater Crocodiles			
Ensure the requirements of the Code of Practice are a condition on all permits and that a copy of the Code is distributed to all new permit holders	4.6 Animal welfare	Ongoing	Compliant.
Ensure all successful permit applicants are competent to comply with the relevant animal welfare standards.	4.6 Animal welfare	July - September	Increased and ongoing presence on Farms and with other permit holders.
Ensure all crocodile farms meet animal welfare standards.	4.6 Animal welfare	Ongoing	Ongoing audits and on an as-needs basis. Welfare conditions are audited when NTG staff are on Farms or visiting other permit holders
Inspect farms regularly to ensure animal welfare standards are met.	4.6 Animal welfare	Ongoing	Ongoing audits and on an as-needs basis.
Investigate and take appropriate action on any suspected breaches of the <i>Animal Welfare Act</i> or the Code of Practice.	4.6 Animal welfare	Ongoing as needs	One minor incident is currently being investigated.
Objective 4 - To monitor and report on the impact of the harvest of Saltwater Crocodiles			
Continue the population survey program for Saltwater Crocodiles as stipulated in this program.	4.7 Monitoring	Commence June-September	Compliant.
Analyse and assess the results of the survey program and implement any resulting management recommendations.	4.7 Monitoring	July - September	Potential decline in Adelaide River crocodile population detected and identified as minor abundance decline associated with stabilisation of population at carrying capacity.
Annually audit the progress of the Management Program against each of the performance indicators and adjust management practices as necessary.	4.8 Reporting	March	As recorded in this report.
Submit annual reports to the Australian Government and provide a summary on the Northern Territory Government website.	4.8 Reporting	October	As recorded in this report.
Review and update the Management program by 2014.	4.8 Reporting		Not applicable.

APPENDIX 2. MONITORING METHODS & RESULTS - SPOTLIGHT SURVEYS

Since 1975 spotlight surveys have followed the standardised procedures described by Messel *et al.* (1981) and Bayliss (1987). Surveys are mostly conducted during the dry season, between June and October, when water levels are low. Specific sections of river, including both the mainstream and accessible sidecreeks are traversed at night by boat. Surveys are restricted to either side of low tide, when mudbanks are exposed and crocodiles are mostly at the water's edge and not hidden amongst fringing vegetation. The water surface, banks and fringing vegetation are scanned with a spotlight and crocodiles are located by their distinctive reflective eye shine. They are approached as close as possible to estimate their TL in 1-foot (0.3 m) intervals and to confirm species (some freshwater crocodiles, *C. johnstoni*, extend down into the tidal parts of some rivers). If no size estimate is possible they are recorded as "eyes only". Given that "eyes only" animals tend to be large animals (Webb and Messel 1979, Webb *et al.* 1989), they are all regarded as non-hatchlings.

Distances surveyed were measured along the mid-line of streams in kilometers to the nearest 0.1 km, originally using survey maps (Messel *et al.* 1982) but in later years standardised to more accurate distances measured with a Geographic Information System. Most of the available surveys had the same or similar start and finish points, such that mean densities are considered directly comparable from year to year.

NRETAS monitors 8 rivers and each river is surveyed biennially except for the Adelaide River (which is monitored annually) (Table 9). Parks Australia North surveys 4 rivers in KNP annually.

Table 9 Monitoring rivers for *C. Porosus* surveyed by NRETAS and Parks Australia North in 2009-2012.

Agent	Region	River	2009	2010	2011	2012
NRETAS	Darwin	Adelaide	Done	Done	Done	Scheduled
		Daly	Done	-	Done	-
		Mary	Done	-	Done	-
	Arnhem Land	Blyth	-	Done	-	Scheduled
		Cadell	-	Done	-	Scheduled
		Glyde	-	Done	-	Scheduled
		Liverpool	-	Done	-	Scheduled
Tomkinson	-	Done	-	Scheduled		
Parks Australia North	Kakadu	East Alligator	Done	Unavailable	Unavailable	Scheduled
		South Alligator	Done	Unavailable	Unavailable	Scheduled
		West Alligator	Done	Unavailable	Unavailable	Scheduled
		Wildman	Cancelled	Unavailable	Unavailable	Scheduled

Analysis of non-hatchling density in individual rivers

For this analysis only survey data from the mainstems of the rivers (rather than sidecreeks) were used, because visibility biases increase with narrowing stream width (Webb *et al.* 1989). Some surveys in some years were excluded from analysis because they did not follow the standardised survey procedures and were surveyed during unfavourable conditions (eg wet seasons, high tides) or included only a small proportion of the standardised mainstream survey section. Following Messel *et al.* (1981), hatchlings (<0.6m) were excluded due to high variance in both annual nest abundance and hatching success.

No corrections for visibility bias (Webb *et al.* 1984, 1989; Bayliss *et al.* 1986; Bayliss 1987) were applied, and so abundance is expressed as relative rather than absolute density: the number of non-hatchling *C. porosus* sighted, rather than the number present, divided by the midstream length of river surveyed (km). Observer bias in the number of crocodiles sighted within a spotlight survey appears slight (Webb *et al.* 1989), but observer bias in the estimated size of crocodiles sighted is more variable despite mean values being reasonably accurate (Choquenot and Webb 1987, Webb *et al.* 1989). Neither sources of error are considered further here.

Estimated density is plotted for all years since the standardised monitoring program began in each river. Four candidate regression models (linear, exponential, logistic and quadratic) were then fitted to both the abundance and biomass to approximate the population growth pattern in each river (Tables 10 and 11), with the line of best fit plotted for each river (Figures 6 and 7). The fit of each model was assessed using Information theoretic procedures (see Burnham and Anderson (2002) for detailed discussion on model selection).

Results: Non-hatchling density

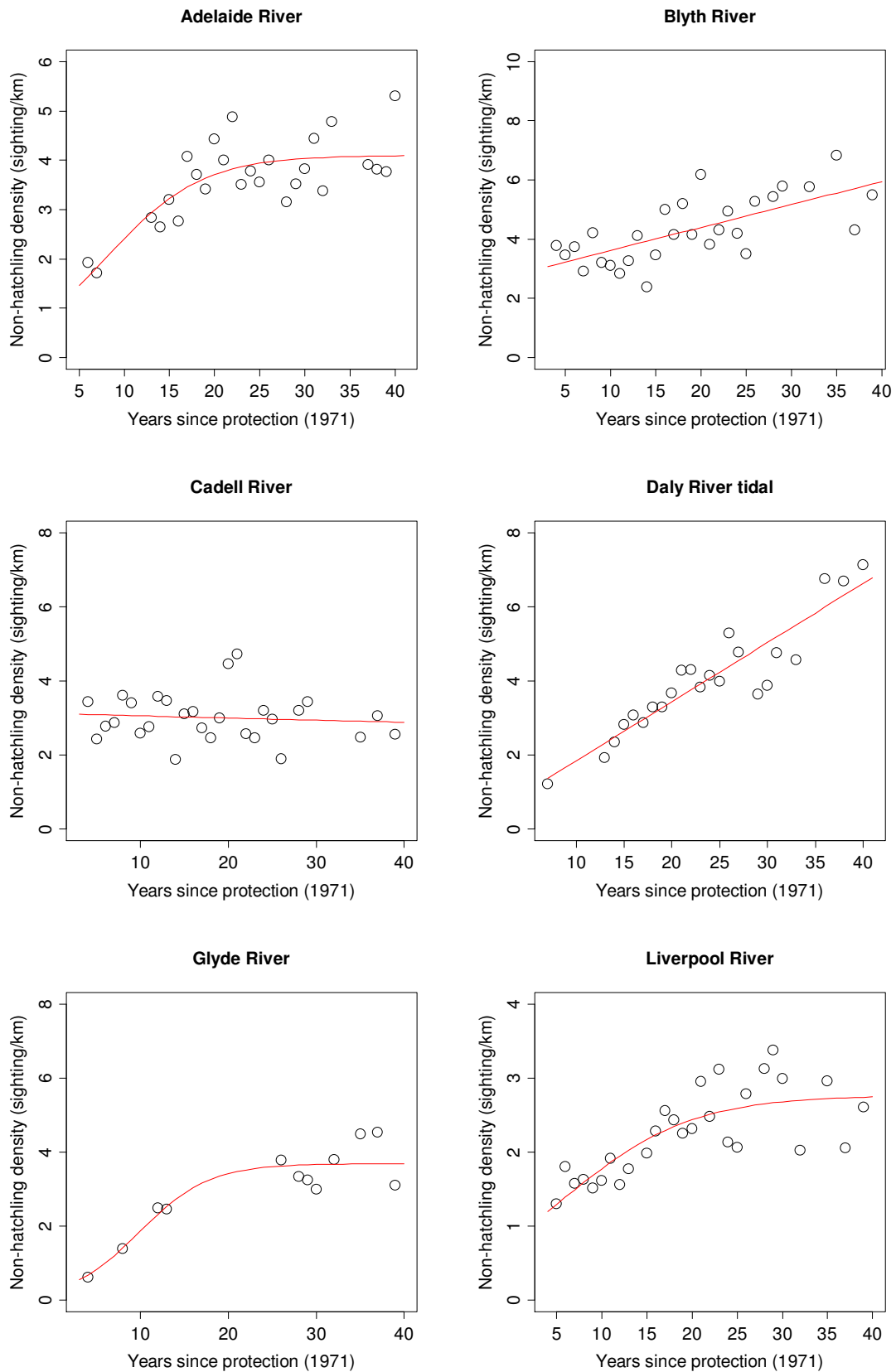
Most of the monitoring rivers showed increasing (linear or exponential) or stable (logistic or quadratic) populations (Figure 6, Table 10). The Adelaide, Glyde, Liverpool, Mary and South Alligator Rivers showed a sign of reaching or having reached an asymptote. Note that, even if the quadratic model was supported to describe the trend, it does not necessarily indicate population decrease but it rather suggests population being stable as in the logistic model (eg. Glyde and Liverpool Rivers). The Blyth, Daly, East Alligator and Tomkinson Rivers seem to be still increasing strongly.

The Cadell River shows almost stable or very gentle but consistent decline since protection. Given that this river was not harvested so heavily before protection for crocodile skins and the current harvest intensity for eggs is still low (NRETAS unpublished data 2010), it may be showing the natural size of the population rather than recovery from the harvest. The population is likely to stay stable rather than decrease dramatically.

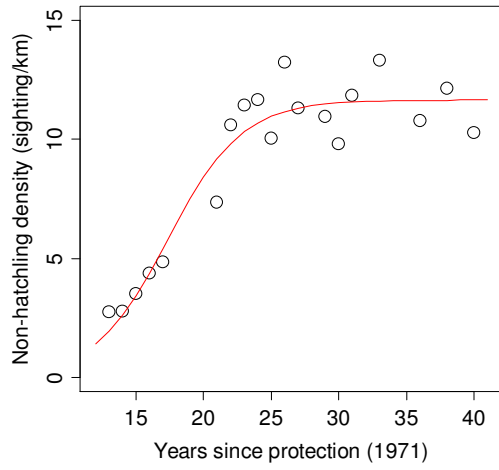
The Adelaide River showed possible slight decrease in the recent years after having reached an asymptote. Given that the Adelaide River is one of the most heavily harvested rivers (Figure 5) with significant breeding, and the harvest intensity for eggs increased in the last decade (NRETAS unpublished data 2010), it could be showing some effect of the recent harvest. Concurrent with the slight density decrease in the Adelaide River is an ongoing shift in the size distribution of the population showing a proportional shift to larger animals, particularly in the two to three metre size range. In considering this population shift to larger animals the slight population abundance decline, rather than indicating a harvest impact is more reasonably interpreted as indicating a stabilising mature population. The Adelaide River is the only river that NRETAS surveys annually and this trend was confirmed by the 2011 monitoring. NRETAS continues to closely monitor the river and will increase monitoring intensity (eg. two successive surveys to assess errors for confirming the trend) if necessary.

Data for the Wildman, West Alligator, South Alligator and East Alligator Rivers collected by Parks Australia North in Kakadu National Park has not been available to DLRM since 2008. Results for these rivers will be presented once this data becomes available.

Figure 6 Abundance density (sighting/km) of non-hatchling *C. porosus*. Data are for 2010 for Adelaide and Arnhem Land Rivers and 2011 Daly and Mary Rivers.



Mary River (Sampan Creek)



Tomkinson River

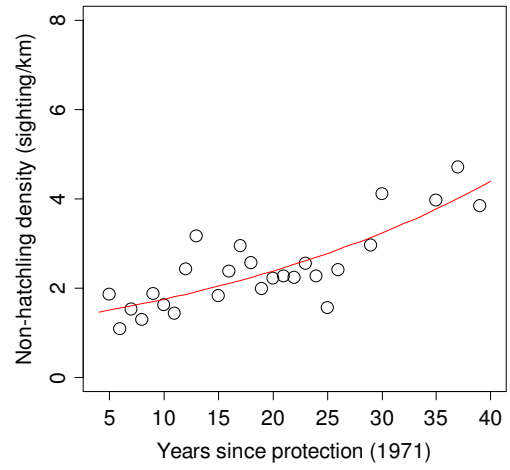


Table 10 Results of model selection fitted to the abundance density of non-hatchling *C. porosus*. N = number of years surveyed, AICc = Akaike information criterion corrected for a small sample size, Δ_i = difference in AICc, w_i = Akaike weight (-- not converged).

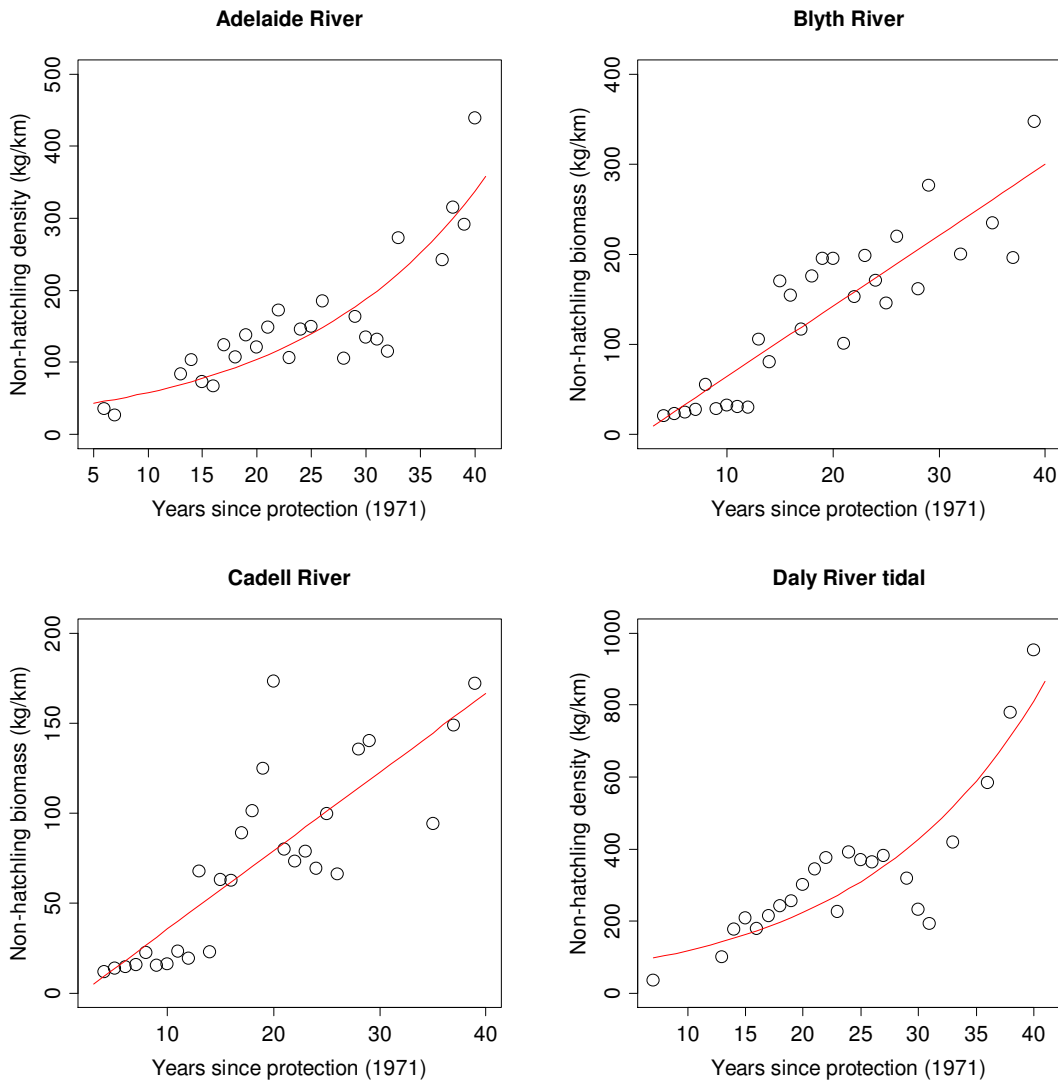
River	Year (N)	Model	AICc	Δ_i	w_i
Adelaide River	1977-2011 (27)	Logistic	46.44	0	65.03
		Exponential	53.38	6.94	2.03
		Linear	51.79	5.35	4.48
		Quadratic	48.10	1.65	28.45
Blyth River	1975-2010 (30)	Logistic	74.68	2.27	14.96
		Exponential	72.79	0.39	38.41
		Linear	72.40	0.00	46.62
		Quadratic	89.34	16.93	0.01
Cadell River	1975-2010 (30)	Logistic	--	--	--
		Exponential	57.78	0.01	49.90
		Linear	57.77	0.00	50.10
		Quadratic	80.86	23.09	0.00
Daly River	1978-2011 (23)	Logistic	46.26	3.71	6.15
		Exponential	43.85	1.30	20.50
		Linear	42.55	0	39.30
		Quadratic	42.83	0.27	34.06
Glyde River	1975-2010 (12)	Logistic	24.29	3.67	11.99
		Exponential	27.43	6.81	2.49
		Linear	24.54	3.92	10.57
		Quadratic	20.63	0.00	74.95
Liverpool River	1976-2010 (28)	Logistic	28.05	0.00	47.77
		Exponential	35.63	7.57	1.08
		Linear	33.27	5.22	3.51
		Quadratic	28.06	0.01	47.63
Mary River (Sampan Creek)	1984-2011 (19)	Logistic	63.59	0	99.99
		Exponential	92.77	29.17	<0.01
		Linear	87.85	24.25	<0.01
		Quadratic	85.84	22.24	<0.01
Tomkinson River	1976-2010 (28)	Logistic	--	--	--
		Exponential	44.17	0.00	75.86
		Linear	46.50	2.33	23.69
		Quadratic	54.43	10.26	0.45

Results: Non-hatchling biomass

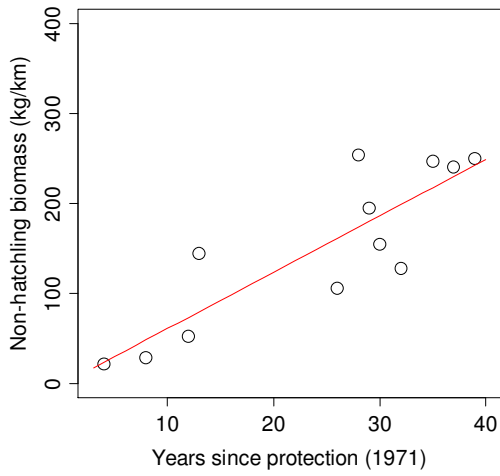
Unlike the abundance density, the biomass density continued to increase without reaching asymptote in most rivers (Figure 7, Table 11). This indicates that individual animals are still getting larger even in rivers where the number of crocodiles has reached a ceiling. This is consistent with the ongoing maturing of a population of a large, slow growing species recovering from substantial unregulated harvest.

Only the South Alligator and West Alligator Rivers showed a sign of stable biomass in recent years. Both the rivers are 'control' rivers with no harvest. It may be linked to the recent decrease in the abundance density but the reason stay unknown until being confirmed with more recent data (analyses include survey results only up to 2007).

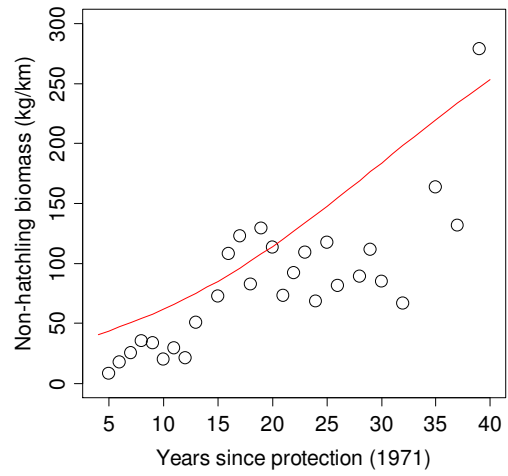
Figure 7 Biomass density (kg/km) of non-hatchling *C. porosus*. Data are up to 2007 for Kakadu Rivers, 2010 for Adelaide and Arnhem Land Rivers and 2010 for Daly and Mary Rivers.



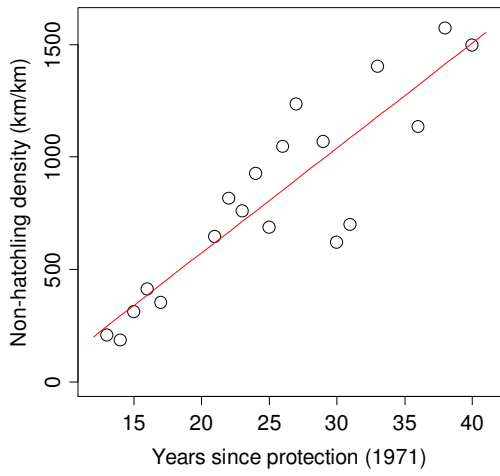
Glyde River



Liverpool River



Mary River (Sampan Creek)



Tomkinson River

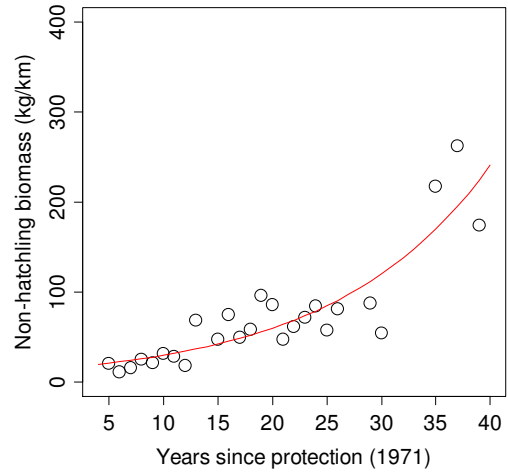


Table 11 Results of model selection fitted to the biomass density of non-hatchling *C. porosus*. N = number of years surveyed, AICc = Akaike information criterion corrected for a small sample size, Δ_i = difference in AICc, w_i = Akaike weight (-- not converged).

River	Year (N)	Model	AICc	Δ_i	w_i
Adelaide River	1977-2011 (27)	Logistic	--	--	--
		Exponential	272.72	0	89.59
		Linear	282.10	8.38	1.36
		Quadratic	278.31	4.59	9.05
Blyth River	1975-2010 (30)	Logistic	302.45	2.62	13.72
		Exponential	309.52	9.70	0.40
		Linear	299.83	0.00	50.94
		Quadratic	300.58	0.75	34.94
Cadell River	1975-2010 (30)	Logistic	272.13	1.50	20.57
		Exponential	277.37	6.73	1.50
		Linear	270.64	0.00	43.47
		Quadratic	271.10	0.46	34.46
Daly River	1978-2011 (23)	Logistic	--	--	--
		Exponential	279.89	0	88.94
		Linear	287.88	7.99	1.63
		Quadratic	284.38	4.49	9.42
Glyde River	1975-2010 (12)	Logistic	--	--	--
		Exponential	130.46	0.98	23.47
		Linear	129.49	0.01	38.24
		Quadratic	129.48	0.00	38.29
Liverpool River	1976-2010 (28)	Logistic	--	--	--
		Exponential	281.10	0.00	40.37
		Linear	281.84	0.74	27.94
		Quadratic	281.58	0.48	31.68
Mary River (Sampan Creek)	1984-2011 (19)	Logistic	261.95	4.17	7.11
		Exponential	261.83	4.05	7.56
		Linear	257.77	0	57.83
		Quadratic	259.21	1.44	27.95
Tomkinson River	1976-2010 (28)	Logistic	--	--	--
		Exponential	251.26	0.00	82.86
		Linear	260.25	8.99	0.93
		Quadratic	254.53	3.26	16.21

APPENDIX 3. Production statistics from crocodile farms (2008/09 – 2009/10).

C. Porosus stock and production on farms in the Northern Territory for 2009/10 and 2010/11 are summarised in Tables 12. For production purpose, hatchlings are defined as <9 months old, raisings as 9 – 24 months old and breeders as >24 months old.

Table 12 C. Porosus held on farms in the Northern Territory in 2009/10 and 2010/11. Individual farms are not named for commercial reasons.

	Farm A			Farm B			Farm C			Farm D		
	Hatchlings	Raisings	Breeders	Hatchlings	Raisings	Breeders	Hatchlings	Raisings	Breeders	Hatchlings	Raisings	Breeders
Total number at start of 2009/10 (1/7/2009)	2403	7399	76	6153	9876	203	5319	1349	15	2675	200	8
Processed/Lost/Sold	1041	1735	2	972	364	12	2902	3475	0	239	250	0
Gains	3673	11	4	7979	2021	1	4555	0	5	1359	0	4
Transfer -	1787	0	0	6043	7900	0	2463	0	0	2487	0	0
Transfer +	0	1787	0	0	7561	0	0	2463	0	0	2847	0
Total number at end of 2009/10 (30/06/2010)	3248	7462	78	7117	11194	192	4509	337	20	1308	2437	12
Processed/Lost/Sold	585	3751	1	802	8783	5	760	4689	0	2387	2297	5
Gains	3619	14	2	8926	49	0	7601	0	1	0	0	8
Transfer -	3225	0	0	7992	0	0	4512	0	0	1402	0	0
Transfer +	0	3225	0	0	7992	0	0	4512	0	0	1402	0
Total number at end of 2010/11 (30/6/2011)	3057	6950	79	7249	10452	187	6838	160	21	2293	1542	15

	Farm E			Farm F			Farm G		
	Hatchlings	Raisings	Breeders	Hatchlings	Raisings	Breeders	Hatchlings	Raisings	Breeders
Total number at start of 2009/10 (1/7/2009)	6323	15526	7	0	0	949	12360	42412	8
Processed/Lost/Sold	518	3827	0	0	0	17	1221	7498	1

Gains	8579	0	0	0	0	101	11803	128	0
Transfer -	6053	0	0	0	0	10	11479	1	8
Transfer +	0	0	0	0	0	1	0	11732	1
Total number at end of 2009/10 (30/06/2010)	8831	17752	7	0	0	1024	11463	46773	0
Processed/Lost/Sold	0	10383	0	0	0	212	942	9294	0
Gains	11073	0	0	0	0	338	13549	777	0
Transfer -	13868	0	0	0	0	0	11022	0	0
Transfer +	0	13868	0	0	0	0	0	11022	0
Total number at end of 2010/11 (30/6/2011)	5536	21237	7	0	0	1150	13048	49278	0

