Saltwater Crocodile (*Crocodylus porosus*) and Freshwater Crocodile (*Crocodylus johnstoni*) Management Plan for Western Australia 2004-2008

For submission under the federal *Environment Protection and Biodiversity Conservation Act 1999.*

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Background Information

Preamble

The Saltwater and Freshwater Crocodile Management Plan is a management strategy for the Saltwater Crocodile (*Crocodylus porosus* Schneider, 1801) and the Freshwater or Johnston's River Crocodile (*Crocodylus johnstoni* Krefft, 1873) in Western Australia. A management plan for Saltwater and Freshwater Crocodiles has been in place in Western Australia since 1993 [see CALM (1993) and Anon (1993)], and wild crocodile populations have been monitored and managed in a less formal manner since the late 1960s (e.g. Bustard 1970; Messel *et al.* 1977; Burbidge and Messel 1979).

There are many stakeholders in the management and conservation of crocodile species within Western Australia. The Government of Western Australia makes significant contributions to both the conservation and management of crocodiles through the maintenance of protected areas and targeted conservation management projects. The commercial crocodile industry and the general community are also stakeholders in crocodile management. Every member of the community has the potential to benefit from the effective conservation and management of crocodile species in Western Australia.

Aboriginal people have a unique social and cultural interest in crocodiles. This document works within the boundaries of the *Native Title Act 1983* and section 23C(1) of the Western Australian *Wildlife Conservation Act 1950* and Regulation 63 of the *Wildlife Conservation Regulations 1970*.

This management plan and the management strategies described in it are designed to integrate with the natural resource management (NRM) strategies of the Western Australian government.

Species Covered in this Plan

The Saltwater crocodile (*Crocodylus porosus*) and the Freshwater crocodile (*Crocodylus johnstoni*) are the only two members of the order Crocodylia naturally occurring in Australia. Both species of crocodile are currently considered 'otherwise specially protected' under section 14(2)(ba) of the Western Australian *Wildlife Conservation Act 1950* (see Table 1). ['Otherwise Specially Protected' fauna are fauna that are in need of special protection for reasons other than that they are rare or likely to become extinct, or that they are fauna that are the subject of agreements between the governments of Australia and Japan relating to the protection of migratory bird species.]

Crocodylus porosus and *C. johnstoni* are both considered common and locally abundant in Western Australia and are not listed as threatened under Western Australian or Commonwealth legislation.

Table 1: Crocodile species of Western Australia, and their conservation status in Western Australia and Australia.

Species	Conservation Status	
	Western Australia*	Australia**
Family Crocodylidae		
Saltwater Crocodile *Crocodylus porosus*	Otherwise Specially Protected	Not threatened, CITES Appendix II
Freshwater Crocodule *Crocodylus johnstoni*	Otherwise Specially Protected	Not threatened, CITES Appendix II

*Conservation status as per Schedule 4 of the Western Australian *Wildlife Conservation (Specially Protected Fauna) Notice 2003*.

**Conservation status as per the *EPBC Act 1999*. [Note: The Saltwater Crocodile is listed as a 'Species of least concern' in the Northern Territory and as 'vulnerable' in Queensland. Internationally 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 *Environment Protection and Biodiversity Conservation Act 1999* enables its obligations under the Convention to be discharged.

Species Disadvantaged by Human Settlement

Aboriginal Harvests

Crocodile meat and eggs have been used as a food source by Aboriginal people for some 20,000 to 40,000 years prior to European contact (McBryde 1979; Flood 1983). This use continues but for Western Australia the size and impact of the harvest are unknown. However, Aboriginals are skilled hunters, 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).

Hunting for the Skin Trade

The 1988/89 survey (G Webb Pty Ltd 1989c) confirmed previous conclusions (Messel *et al.* 1987; Burbidge 1987) that nesting habitat and population levels are limited in Western Australia, particularly in comparison with prime areas in the Northern Territory. Further confirmation of this has been provided by subsequent surveys in various localities (unpublished data, CALM). Burbidge (1987) commented:

> *"The areas of the Kimberley inhabited by* C. porosus *differ markedly from most of the Northern Territory ... The Kimberley coastline and hinterland are chiefly composed of steep, rugged, ancient, deeply faulted sandstones. Access up many rivers is blocked to crocodiles by waterfalls and their associated gorges. There are few areas of floodplain and very few freshwater swamps; hence breeding habitat is scarce. It would appear, therefore, that the carrying capacity of the Kimberley river systems and the Kimberley as a whole is much less than that of the Northern Territory."*

In summary, *C. porosus* was extensively hunted for the skin trade in the 1950's and 1960's, and while the pre-harvest population size is unknown, the species apparently suffered a decline in numbers throughout its range in Western Australia. It is considered that the total population of *C. porosus* in Western Australia is now only of the order of a few thousand non-hatchlings. Nesting habitat is limited, with very few nests located during the surveys conducted to date. Nevertheless, from anecdotal information and limited surveys, *C. porosus* appears to be recovering from past hunting, and still occupies its historical range.

The number of *C*. *porosus* killed for trade prior to the species being protected in Western Australia is unknown. However, Webb *et al*. (1984) estimated that a total of between 270,000 and 330,000 *C*. *porosus* were killed in Australia from 1945 to 1972, with the upper estimate comprising 271,500 skins exported, 13,500 (5%) assumed killed and not retrieved, and 45,000 juveniles killed for the curio trade. Webb *et al*. (1984) estimated that 10% of the skin harvest was from Western Australia, and it therefore seems likely that some 25,000 *C*. *porosus* were harvested in Western Australia from 1946 until they were legally protected in Western Australia in April 1970. Webb *et al*. (1987) considered that the earlier estimate of the number of juveniles killed for the curio trade was probably an overestimate.

There are no published estimates of the numbers of *C*. *johnstoni* killed in Western Australia for the skin trade prior to the species being protected in 1958 (Burbidge 1987). While the intensity of legal hunting of *C*. *johnstoni* in Western Australia was always low, there was significant poaching in accessible habitat during the 1960's and early 1970's (Bustard 1970; Burbidge 1987).

Legislation and Scope of this Plan

This management plan is restricted in its application to the conservation and management of *C. porosus* and *C. johnstoni*. The plan covers the wild harvesting, captive breeding and ranching (i.e. the rearing of wild harvested specimens in a controlled environment) of crocodiles for commercial purposes. The wild harvest component includes the taking of eggs and crocodiles and may include the removal of 'problem' crocodiles for the protection of the human population or commercial livestock.

The *Saltwater Crocodile and Freshwater Crocodile Management Plan for Western Australia 2004-2008* has been developed to satisfy the requirements of the federal *Environmental Protection and Biodiversity Conservation Act 1999* (the *EPBC Act*).

Considered within this management plan is the commercial utilization of both the *C. porosus* and *C. johnstoni*. The export of commercial crocodile products from Australia requires Commonwealth government approval under the *EPBC Act*.

Crocodiles and all native fauna in Western Australia are protected under the *Wildlife Conservation Act 1950*. The harvesting of a protected crocodile species in Western Australia requires a licence under Regulation 15 of the *Wildlife Conservation Regulations 1970*. The taking of crocodiles in Western Australia is regulated via licence and tag procedures detailed in licence conditions under this Act. This legislative framework applies to the entire State of Western Australia.

The non-commercial destruction of crocodiles and the harvest of crocodiles for indigenous traditional use or the holding of crocodiles for exhibition by zoos or wildlife parks is not considered within this management plan. This management plan covers commercial harvest management actions and is submitted for approval as an *Approved Wildlife Trade Management Plan* under the *EPBC Act.*

This management plan is valid for a five-year period, from 1 January 2004 to 31 December 2008.

Goals and Aims

Goals of this Management Plan

This management plan has three goals:

- maintain viable populations of *C. porosus* and *C. johnstoni* over their natural range in Western Australia in an ecologically sustainable manner;
- provide for public safety by maintaining public awareness and providing a mechanism for removing "problem" crocodiles; and
- where possible, to manage crocodile species as a renewable natural resource providing the conservation of the species is not compromised.

For the purpose of this management plan, the use of the term *ecological sustainability* encompasses the following principles as they relate to crocodile conservation and management:

- Protect biological diversity and maintain viable populations of *C. porosus* and *C. johnstoni* across their natural range;
- Apply a precautionary approach to management, to ensure that management actions conducted within this management plan minimize the risk of unwanted or unintended outcomes to crocodiles, their habitat and ecosystems (the precautionary principle);
- Provide for inter-generational equity by ensuring that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- Ensure that decision-making processes relating to *C. porosus* and *C. johnstoni* effectively integrate both long-term and short-term economic, environmental, social and equitable considerations; and
- Ensure that conservation and management programs for crocodiles acknowledge and accommodate the interests of Aboriginal stakeholders where appropriate.

Measures of Performance

This management plan has four aims that set strategic directions for the management of commercial crocodile harvest in Western Australia. Under each aim are one or more objectives that detail operational directions for crocodile management.

Progress towards each objective will be measured by the completion of key actions and clearly defined performance targets and measurable indicators.

Objectives will be audited against performance measures annually, with a major assessment and review at the end of the five-year term of the management plan. Mechanisms will be developed to ensure that performance measures are linked to future management strategies, by incorporating that learnt from previous successes and failures (i.e. adaptive management).

AIMS OF THE MANAGEMENT PLAN

The aims of this management plan for *C. porosus* and *C. johnstoni* are:

1. **Ensure conservation of crocodiles through monitoring and promotion of research.**

   Monitor crocodile populations using appropriate survey techniques, support research targeted to key areas identified for *C. porosus* and *C. johnstoni*, and promote the regional conservation of crocodile populations across their natural range.

2. **Manage** *C. porosus* and *C. johnstoni* **populations as a sustainable commercial harvest.**

   Manage commercial harvest of crocodiles through a best practice harvest quota system, effective licence and tag procedures, and monitoring and maximizing compliance with relevant legislation. Improve understanding of the impacts of commercial harvest on crocodiles, their habitat and ecosystems.

3. **Adhere to best practice animal welfare standards in conservation and management programs for** *C. porosus* and *C. johnstoni***.**

   Adhere to animal welfare standards by maximizing compliance with the Western Australian *Animal Welfare Act 2002* and *Animal Welfare Regulations 2003* and the draft *Code of Practice for the Humane Treatment of Captive and Wild Australian Crocodiles*.

4. **Ensure effective communication and education of crocodile conservation and management programs throughout the community.**

   Promote the Western Australian Saltwater and Freshwater Crocodile Management Plan through public education and consultation. Promote legislation and policy relevant to crocodile management in Western Australia.

Aim 1. Conservation

Ensure conservation of C. porosus and *C. johnstoni through monitoring and promotion of research*

Conservation of crocodile populations within Western Australia is the key aim of this management plan. All management actions conducted within this management plan must not be detrimental to the long-term conservation and population viability of *C. porosus* and *C. johnstoni* across their natural range.

1.1 MONITORING

Objective: **Monitor regional** *C. porosus* and *C. johnstoni* **populations using an appropriate survey technique.**

Adequate monitoring of a population is essential to ensure its proper management. The Department of Conservation and Land Management (DCLM) have conducted or arranged for the conduct of standard aerial and spotlight boat surveys of Western Australian crocodile populations since 1989 (see G. Webb Pty Ltd 1989a-d; Webb 1990, 1992; Wildlife Management International (WMI) 1994a-b and 1995-2003 inclusive, for details of methodology), providing a high quality monitoring dataset on which to base management decisions. In addition, regular monitoring provides direct information on population trends of crocodile populations in Western Australia.

Crocodiles occur in the Kimberley and Pilbara regions of Western Australia. The majority of the populations of both species occur in the Kimberley region and monitoring is limited to the Kimberley Region (see Appendix 1, Figures 1a-d).

The following two techniques may be used for monitoring crocodile populations:

1. Targeted daytime aerial survey using rotary wing aircraft survey methodology; and
2. Targeted night-time boat spotlight surveys along standard stretches of some sections of rivers that are also surveyed from the air.

Saltwater Crocodile

The first documented report on the status of *C. porosus* populations in Western Australia was that of Bustard (1970), who in 1969 conducted limited boat spotlight surveys in several areas. Bustard concluded that *C. porosus* "has been hunted to the verge of extinction" and recommended that the species be protected for ten years.

The first systematic surveys of *C. porosus* populations in Western Australia were conducted in 1977 (Messel *et al.* 1977) and 1978 (Burbidge and Messel 1979). These boat spotlight surveys covered the estuarine portions of major river systems across most of the range of *C. porosus* in Western Australia. The combined results yielded the estimates of the non-hatchling populations in the surveyed portions of each river system given in Table 2. Extrapolating from the survey results to correct

for unsurveyed areas, Burbidge and Messel (1979) estimated that there were about 2,000 non-hatchling *C. porosus* in the whole of Western Australia.

In 1986, most of the areas surveyed in 1977 and 1978 were resurveyed, as well as some additional areas (Messel *et al.* 1987), resulting in a Kimberley-wide population estimate of 2,500 non-hatchling *C. porosus*. The 1986 survey revealed a significant increase in the proportion of large crocodiles in the population, and showed that the largest populations were in the Cambridge Gulf, and the Prince Regent and Roe River systems.

Since 1986, no further large-scale population surveys covering most of the range of *C. porosus* in the Kimberley have been conducted. However, the *C. porosus* population in King Sound and Stokes Bay was surveyed for the first time in 1989, resulting in an estimated population of the order of 25 (G Webb Pty Ltd 1989a). The low density of *C. porosus* in the King Sound area reflects a generally poor environment at the extremity of the main part of the range of *C. porosus*.

Table 2: *C. porosus* non-hatchling population estimates from 1977-1978 boat spotlight surveys (after Messel *et al.* 1977; Burbidge and Messel 1979).

River	**Population Estimate**	**River**	**Population Estimate**
Ord	235-306(a)	Roe	177-230
Lawley	44-57	Prince Regent	190-246
Mitchell	60-78	Glenelg	200-259
Hunter	51-67		
Total	(all surveyed rivers)		**957-1243**

(a): this estimate was subsequently revised to 245-297 by Messel *et al*. 1987.

Associated with the Western Australian Government's 1988 decision to permit crocodile farming, the West Arm river systems in the Cambridge Gulf that had been surveyed in 1986 were resurveyed in 1989, 1990, and 1992-2003 inclusive (G Webb Pty Ltd 1989b, 1990 and 1992, Wildlife Management International, 1994b, 1995-2003). In 1992 the Ord River, which had been partly surveyed in 1978 and 1986, was fully surveyed for the first time (G Webb Pty Ltd 1992). As a result of the 1989-1993 surveys, WMI developed helicopter monitoring zones for the East Arm (Ord River) and West Arm areas of the Cambridge Gulf. After trial development and proofing, population estimates from 1994-on have been based on the results of the helicopter surveys of monitoring areas. The Ord River has been surveyed annually during the period 1993-2003 (Wildlife Management International 1994a, 1994b, 1995-2003).

Monitoring zones for *C. porosus* comprise the following areas.

West Arm	**East Arm**
Parrys Creek	Ord River (East Bank) 20-60 km
King River	Ord River (East Bank) 60-80 km
Pentecost River	

Durack River
Forrest River
Patrick River
West Arm (East Bank) 0-40 km
West Arm (East Bank) 40-62 km

The results of crocodile population monitoring surveys (helicopter count indices and spotlight data) in the Cambridge Gulf river systems are summarised in Table 3 and Figure 2. The results from the 2003 survey shows that the 2003 population estimate for the West Arm of Cambridge Gulf is almost 50% greater than the estimate for 1989. In the East Arm the 2003 population is slightly more than 50% above the original (1992) estimate.

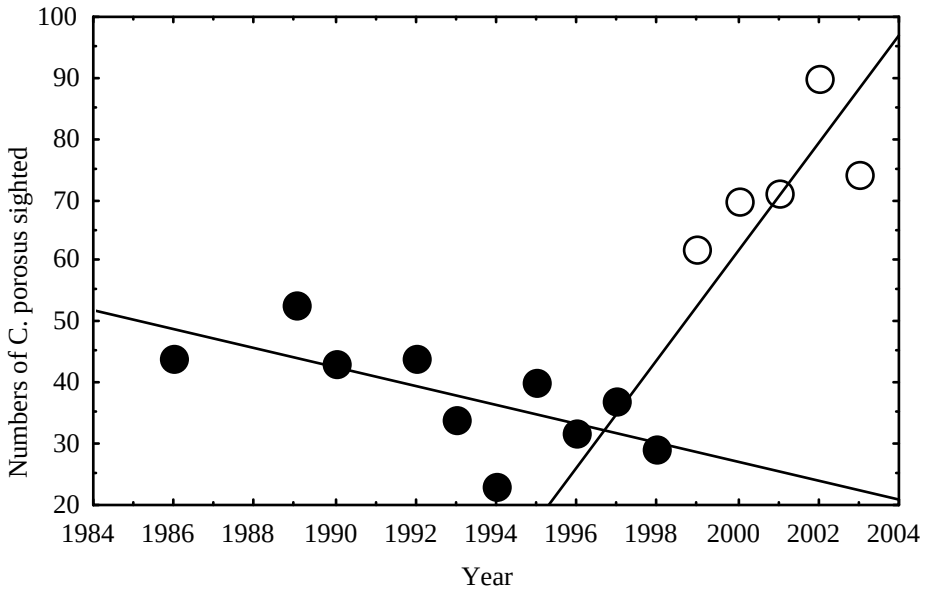

Figure 2. Numbers of non-hatchling *C. porosus* sighted during helicopter surveys of the West Arm monitoring zone, 1986-2003. Lines indicate linear regression relationships (1986-1998; r^2= 0.45, p= 0.03; 1998-2003, r^2= 0.66, p= 0.048).

Table 3. Helicopter count indices for *C. porosus* in the Cambridge Gulf and Ord River (values for 1978-1990 were derived from spotlight count data only.) (Source: Wildlife Management International, 2003).

	Index	Index	Estimate	Estimate
Year	Ord River	West Arm	Ord River	West Arm
1978	64	-		
1986	67	44		
1989	-	53		
1990	-	43		
1992	65	44	379	198
1993	72	34	410	153
1994	70	23	370	100
1995	74	40	422	173
1996	67	32	382	139
1997	74	37	422	161
1998	47 (Too hot)	29 (Too hot)	(268) 400	(126) 150
1999	69	62	394	270
2000	91	70	518	304
2001	67	71	381	308
2002	84	90	478	391
2003	99	74	564	321

The Cambridge Gulf river systems have been the principal source of *C. porosus* for crocodile farms in Western Australia. The combined population estimates for the two survey areas give a total population in 2003 of 885, which is a 53% increase on the first combined estimate available (577 in 1992). These results demonstrate that *C. porosus* populations are being conserved in the Cambridge Gulf through the operation of successive crocodile management programs.

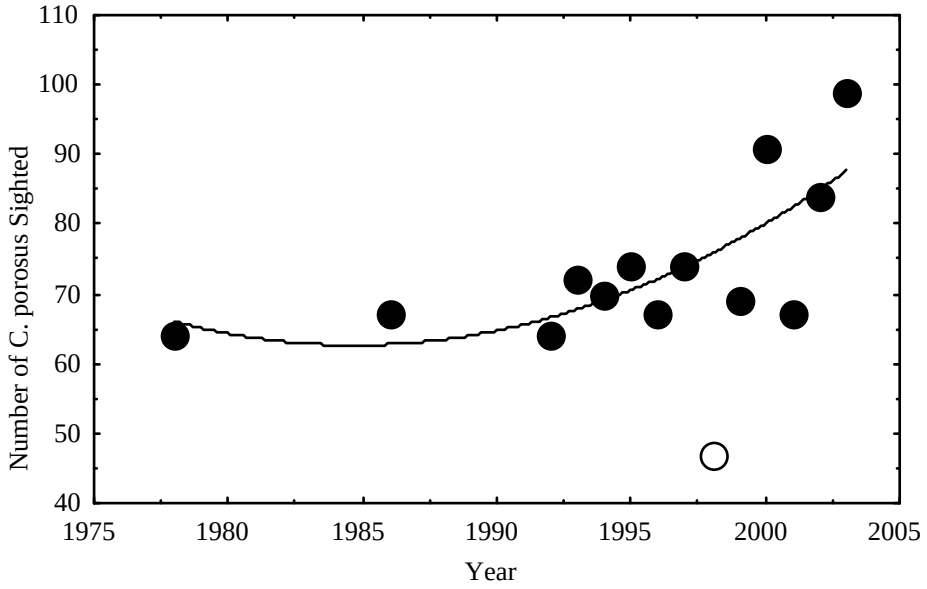

Figure 3. Helicopter index for *C. porosus* in the Ord River monitoring zone, 1978-2003. Line indicates significant second-order polynomial regression (r^2= 0.54, p= 0.02) with all years (1998 excluded; see text). Values for 1978-1990 were derived from spotlight count data.

A helicopter survey was conducted in the 1988/89 breeding season to locate *C. porosus* nests between Cambridge Gulf and the Prince Regent River (G Webb Pty Ltd 1989c). This survey provided for the first time an assessment of nesting levels in the Kimberley through a direct count of nests. The river systems in which nests were found, and the number of nests found, are listed in Table 4.

Details of *C. porosus* population monitoring results for the 2003 survey and previous years are provided in Appendix 1.

Table 4: *C. porosus* nesting survey results (after G Webb Pty Ltd 1989c).

Rivers	Nests recorded
Cambridge Gulf Rivers	
Ord River	6
King River	8
Other Rivers	
Drysdale River	1
Admiralty Gulf Creek	1
Roe River	20
Prince Regent River	1
Total	**37**

Freshwater Crocodile

Prior to 1989, there had only been very limited surveys of *C. johnstoni* populations in Western Australia. As a consequence of the 1988 decision by the Western Australian Government to allow crocodile farming, there has been a considerable increase in knowledge about Western Australian *C. johnstoni* populations. In 1989, boat spotlight surveys yielded non-hatchling population estimates of 25,000 in Lake Argyle and 7,500 in Lake Kununurra (G Webb Pty Ltd 1989d). The earlier construction of two dams on the Ord River impounded Lake Kununurra (in 1963) and the very large Lake Argyle (in 1972).

Also in 1989, boat spotlight and helicopter surveys yielded a population estimate of 13,000 non-hatchling *C. johnstoni* along 172 km of the Fitzroy River and in some of its tributaries and Seventeen Mile or Camballin Dam (G Webb Pty Ltd 1989a). Boat spotlight surveys in 1992 and 1993 yielded estimates of 2,100, and 2,900 *C. johnstoni* respectively in the Ord River downstream of the Diversion Dam which forms Lake Kununurra, all within 90 km of the dam (G Webb Pty Ltd 1992, Wildlife Management International 1994a). During 1994 a comparison of boat spotlight and helicopter counts was undertaken by Wildlife Management International in order to provide helicopter count indices for future population monitoring. Helicopter counts

were repeated in 1995-2003, giving the monitoring results displayed in Table 5 and Figure 4. There has not been a more recent survey of the total Western Australian *C. johnstoni* population since that conducted in 1989 (G Webb Pty Ltd 1989d), nevertheless the species is clearly common in suitable habitat and would have a total population in the order of an integer x $10^{4,}$ if not higher.

Table 5: Helicopter count indices for non hatchling *C. johnstoni* in Cambridge Gulf and associated lakes (after Wildlife Management International, 2003)

Year	Ord River	L Kununurra	L Argyle	Total
1988/89	-	218	2124	-
1992	217	194	857	1267
1993	266	142	1238	1646
1994	413	157	1621	2191
1995	478	329	1411	2218
1996	358	189	846	1393
1997	527	156	996	1679
1998	247	247	480	974
1999	400	322	810	1532
2000	426	266	1176	1868
2001	174	201	1001	1366
2002	555	158	917	1630
2003	430	148	897	1475

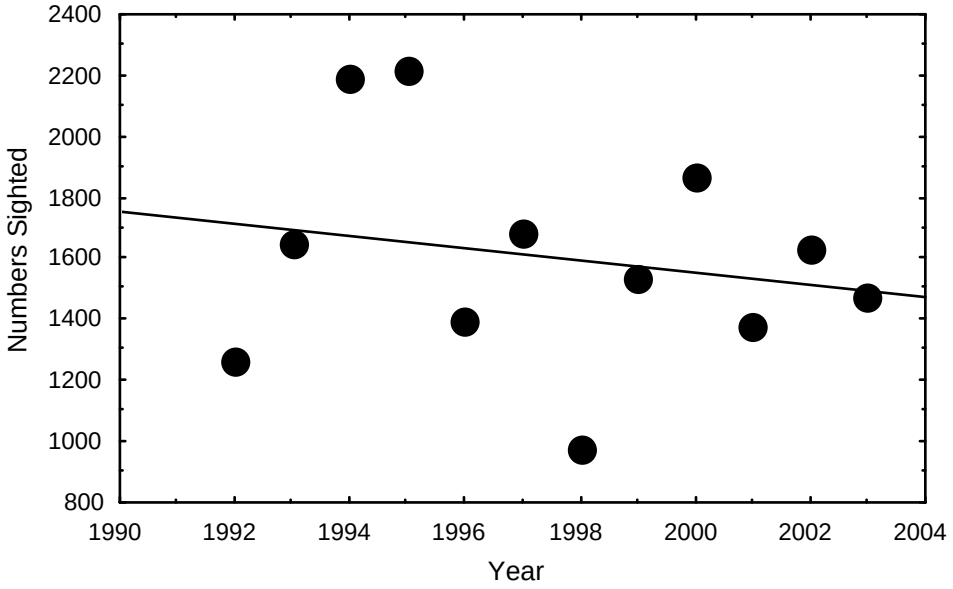

Figure 4. Numbers of *C. johnstoni* sighted in Lake Argyle, Lake Kununurra and Ord River, 1992-2003. Line indicates the non-significant linear regression relationship (r^2= 0.04, p= 0.54).

C. *johnstoni* was given legal protection under the *Wildlife Conservation Act 1950* on 11 June 1958. The species is formally declared to be "otherwise specially protected" under the *Wildlife Conservation Act*, giving it the same level of protection as *C. porosus*.

Details of *C. johnstoni* population monitoring results for 2003 are provided in Table 5 and 6 of Appendix 1.

Surveys and methodology to be undertaken during the life of the plan

Surveys conducted annually over the past 11 years have shown a slow but steady increase in the populations of both species of crocodile within the monitored areas, consistent with the reproductive capacity of crocodiles and the variation in rainfall in the region. The outcomes of recent analyses (see Stirrat *et al.* 2001) on the influence of differing survey techniques on the capacity to accurately detect significant changes in crocodile populations are noted. Accordingly, during the life of this plan crocodile populations will be surveyed annually or as otherwise determined by CALM but sufficient to ensure that significant changes in crocodile populations are detected and measured. Surveys, when conducted will include both boat spotlight and daytime helicopter surveys.

Reviews of survey methodology for both species of crocodile, such as the revision of species correction factors and the extent and frequency of monitoring events, may be conducted in the future. CALM will inform the Department of the Environment and Heritage of any changes to the frequency and extent of the monitoring. If the Department of the Environment and Heritage no longer considers the quotas appropriate it may, with 12 months prior consultation with CALM, revise the quota downwards.

Key Actions:

- Monitor the survey zones (see Appendix 1) in full annually or as otherwise determined by CALM; and
- Review survey techniques regularly, and update practices where necessary.

Performance Measures:

- Crocodile populations described and quantified in a manner that allows for informed management decisions to be made. Measured via:

  Crocodile management areas monitored; and

  Precision of population estimates.

1.2 RESEARCH

Objective: **Support research into key areas specified for *C. porosus* and *C. johnstoni*.**

Along with regular monitoring, the promotion and completion of strategic research is an integral component of successful wildlife management. Research improves scientific knowledge of a species and its interaction with its environment, and can allow for the experimental testing of management strategies. Results of research can be used to guide and prioritize future management decisions and actions.

CALM will base involvement in crocodile research on key research areas, which are currently considered most important and relevant to crocodile conservation and management in Western Australia.

Research projects are currently focused on the following key area:

1. Population dynamics, distribution and abundance of *C. porosus* and *C. johnstoni* in Western Australia.

Specific projects that may be promoted for research in the future include revision of crocodile correction factors and aerial survey methodology for Western Australia, and an assessment of remote sensing or a combination of remote sensing (e.g. see Harvey and Hill 2003) and aerial survey methodology as tools for better identifying survey areas for Freshwater crocodiles since changes in water levels in Lakes Argyle and Kununurra can influence both the survey effort required and the accuracy of the data obtained. Future research may be promoted as part of an adaptive management experiment (see text box page 17). CALM may also support or promote future research in other relevant areas (e.g. animal welfare and the influence of agricultural chemicals on crocodiles living within catchments supporting irrigated agricultural lands).

The CALM will endeavour to maintain a current understanding of crocodile research being conducted in government departments, industry and universities within Australia. Worldwide trends in wildlife management will also be assessed. Literature surveys of crocodile and wildlife management research will be completed regularly, with key findings and results disseminated to staff as appropriate and included within current practices when necessary.

Key Actions:

- Conduct periodic literature reviews of current research;
- Maintain regular contact with university and industry partners conducting research on crocodiles; and
- Incorporate research findings into current techniques where appropriate.

Performance Measures:

- Networks established and maintained with university and industry research partners allowing the CALM to maintain a current understanding of crocodile research developments and issues. Measured via:

  Number of active crocodile research projects with CALM endorsement or involvement; and
  Number of industry and university research partners.
- Attendance and involvement of CALM staff at scientific conferences and workshops relevant to crocodiles.

1.3 REGIONAL CONSERVATION

Objective: **Facilitate the conservation of *C. porosus* and *C. johnstoni* across their natural range**.

In Western Australia large areas of land have been reserved as national parks and nature reserves for the purpose of conserving native fauna and flora and natural ecosystems. The area of land reserved for national parks and conservation parks at 30 June 2002 was 5,799,416 hectares and 10,825,039 hectares were reserved for the conservation of flora and fauna as nature reserves, giving a total area reserved for conservation of 16,624,455 hectares or 6.5% of Western Australia. The

identification and acquisition of parks and reserves is an ongoing process and updates of the areas of land reserved are published in CALM's annual reports (see http://www.naturebase.net/about_calm.html).

Parks and reserves incorporating natural drainage systems contribute directly to the conservation of crocodiles throughout their natural range. Considering only those national parks, conservation parks and nature reserves larger than 2,000 hectares in area, as at June 2002 there were more than 10 such conservation areas, totalling in excess of 1.6 million hectares, which include riparian and lacustrine habitat that is inhabited by either *C. porosus*, *C. johnstoni* or both species. By virtue of the narrow linear nature of rivers and streams the total area of habitat suitable for crocodiles is obviously a small proportion of most of the conservation estate. Within these areas commercial harvesting of crocodiles is not permitted except that problem crocodiles taken under Regulation 4 licences can be used by commercial crocodile farms.

Table 6: Existing Western Australian conservation reserves where crocodiles occur.

Conservation Reserve	**Area (ha)**	***C. porosus***	***C. johnstoni***
Prince Regent Nature Reserve	634,952	Present	Present
Geikie Gorge National Park and Conservation Park	8,468	Absent	Present
Drysdale River National Park	448,264	Absent	Present
Ord River Nature Reserve	79,842	Present	Present(*)
Parry Lagoons Nature Reserve	36,111	Present	Present
Purnululu (Bungle Bungle) NP/CP	319,325	Absent	Present
Windjana Gorge National Park	2,134	Absent	Present
Coulomb Point Nature Reserve	28,676	Present(*)	Absent
Brooking Gorge CP	7,967	Absent	Present
Tunnel Creek NP/Devonian Reef CP	41,462	Absent	Present

(*): indicates that the species occasionally occurs in the reserve.

Population monitoring includes monitoring of crocodile populations in parts of the State outside of those areas currently available for commercial harvest (e.g. National Parks and other lands vested in the Conservation Commission of Western Australia and lands under Aboriginal management). These surveys will provide a more complete picture of crocodile density and distribution in Western Australia, and ensure that the conservation of crocodiles covers regions with both high and low densities of Saltwater and Freshwater crocodiles.

Key Actions:

- Map public and privately owned nature reserves, including the extent of suitable crocodile habitat; and
- Ensure population monitoring includes surveys of *C. porosus* and *C. johnstoni* outside the areas currently subject to commercial harvest .

Performance Measures:

- Regional conservation of crocodiles is facilitated by determining the extent and distribution of available habitat for crocodiles. Measured via:

  Number of regions supporting *C. porosus* and *C. johnstoni*; and

  Density of *C. porosus* and *C. johnstoni* in each region.

Adaptive Management

Adaptive management is currently being suggested as more appropriate for natural systems than traditional management approaches. Adaptive management ("learning by doing") addresses the inherent uncertainty and complexity of natural systems by directly manipulating management actions, and using the results to obtain an optimal management capacity. It promotes the use of information gained from the successes and failures of management actions, instead of the sole use of detailed scientific studies.

Adaptive management is appropriate for a socially complex system such as crocodile management, as the conflicting goals and desired outcomes of all user-groups will be considered in the development of future management strategies.

The actions covered by this management plan will incorporate the use of adaptive management principles and strategies where possible.

Aim 2. Ecologically Sustainable Commercial Harvest

Manage crocodile populations as a sustainable commercial harvest

Commercial harvest allows for a specified number of *C. porosus* and *C. johnstoni* to be taken for commercial utilisation. Commercial harvest limits are set using quotas that specify the maximum number of each species that can be harvested for commercial utilisation in a calendar year.

The commercial harvest of crocodiles in Western Australia is managed by the CALM, through a system of licensed field crocodile collectors or takers operating on one or more waterway.

Commercial harvest limits and quotas are set at the population level, using survey data from the Crocodile Monitoring Zones (see Table 7). Commerical harvest will normally be limited to those areas that have been subject to survey and that support the largest numbers of crocodiles. Harvesting may occur in other areas so long as the conservation of crocodiles can be maintained. Harvesting, with the exception of the removal of problem crocodiles, will not be permitted in lands and waters managed for conservation purposes. Given the low historical level of harvest since 1983 (see Tables 8 and 9) for both *C. porosus* and *C. johnstoni* and current stock levels in the two licensed crocodile farms in Western Australia the future demand for eggs, hatchling and non-hatchling crocodiles is expected to remain low.

Table 7: Western Australian Crocodile Monitoring Zones

	Saltwater Crocodile	Freshwater Crocodile
West Arm, Cambridge Gulf[1]	Yes	No
Ord River[2]	Yes	Yes
Lake Argyle[3]	No	Yes
Lake Kununurra[4]	No	Yes

[1]Includes Parrys Creek, King river, Pentecost River, Durack River, Forrest River, Patrick River, West Arm of Ord River (mainstream east bank 0-40km from mouth and south bank 40-62km from mouth).
[2] Ord River includes tidal mainstream (east bank 20-87.5km from mouth) and non-tidal mainstream (5 sections both banks; Diversion Dam – Ford Beach Rapids, Ford Beach Rapids – Ivanhoe Crossing, Ivanhoe Crossing – Bullocks Crossing, Bullocks Crossin - Tararra Bar, Tararra Bar (at 87.5km) - House Roof Crossing.
[3] Lake Argyle section covers 299.5km of lake margin.
[4]Lake Kununurra section covers 64.5km of lake margin.

The total number of *C. porosus* (Table 8) and *C. johnstoni* (Table 9) that have been harvested to supply the commercial crocodile farms in Western Australia are shown below. The number of *C. porosus* taken in any year and from any one location has been small. The number of *C. johnstoni* taken in any one year and from any one location has been higher, but those numbers represent only a very small proportion of the animals existing in those waterways supporting, in particular Lake Argyle where the estimated population exceeds 10,000 animals.

Table 8: Collections of *C. porosus* from the wild in Western Australia, by location of capture (including "problem" animals and farm stock acquisition captures) 1983-2003.

	Location of Capture				
	Cambridge Gulf system			Elsewhere (King Sound)	Total
	East Arm/ Ord River	West Arm	Total		
Non-hatchlings					
1983 - 1985	8	0	8	6	14
1986 - 1988	6	0	6	7	13
1989 - 7/92	34	81	115	18	133
8/92 - 6/93	50	38	88	6	94
7/93 - 6/94	12	2	14	0	14
7/94 - 6/95	8	4	12	15	27
7/95 - 6/96	14	1	15	2	17
7/96 - 6/97	7	1	8	0	8
7/97 - 6/98	1	3	4	0	4
7/98 - 6/99	1	0	1	0	1
7/99 - 6/00	2	0	2	0	2
7/00 - 6/01	0	1	1	0	1
7/01 - 6/02	0	2	2	0	2
7/02 – 6/03	0	3	3	0	3
TOTAL	**143**	**136**	**279**	**54**	**333**
Viable eggs/hatchlings					
1983 - 1985	0	0	0	0	0
1986 - 1988	0	0	0	30	30
1989 - 1992	0	268(a)	268	0	268
1993	0	0	0	0	0
1/94 – 6/95	0	6	6	0	6
1995/1996	0	19	19	0	19
7/97 - 6/98	0	0	0	0	0
7/98 - 6/99	0	58	58	0	58
7/99 - 6/00	0	301	301	0	301
7/00 - 6/01	0	0	0	0	0
7/01 - 6/02	0	22	22	12	34
7/02 – 6/03	0	0	0	16	16
TOTAL	0	**674**	**674**	**58**	**732**

(a): taken from the King River.

Table 9: Collections of *C. johnstoni* from the wild in Western Australia, by location of capture (including "problem" animals and farm stock acquisition captures) 1983-2003.

	Location of Capture				
	Cambridge Gulf system			Elsewhere (Fitzroy River)	Total
	L. Argyle Ord River	West Arm	Total		
Non-hatchlings					
1983 - 1988	0	0	0	0	0
7/89 - 6/90	0	185	185	0	185
7/90 - 6/91	0	0	0	0	0
7/91 - 6/92	0	22	22	0	22
7/92 – 6/93	0	2	2	0	2
7/93 – 6/94	122	0	122	0	122
7/94 - 6/95	24	0	24	0	24
7/95 - 6/96	0	0	0	0	0
7/96 - 6/97	66	0	66	0	66
7/97 - 6/98	159	0	159	0	159
7/98 - 6/99	0	0	0	0	0
7/99 - 6/00	0	0	0	0	0
7/00 - 6/01	0	0	0	0	0
7/01 - 6/02	0	0	0	0	0
7/02 – 6/03	0	0	0	0	0
TOTAL	**371**	**209**	**580**	**0**	**580**
Viable eggs/hatchlings					
1983 - 1988	0	0	0	0	0
1989	0	1671	1671	248	1919
1990	1717	0	1717	445	2162
1991	856	0	856	0	856
1992 -2003	0	0	0	0	0
TOTAL	**2573**	**1671**	**4244**	**693**	**4937**

2.1 QUOTA SETTING

Objective: **Determine the number of** *C. porosus* and/or *C. johnstoni* **to be taken for commercial harvest through a best practice system that takes account of regional priorities and the conservation status of the two crocodile species.**

The total number of *C. porosus* and *C. johnstoni* that can be taken for commercial harvest within Western Australia in a calendar year is the *commercial crocodile quota.* The quotas set out in Table 10 are the quotas that are in force at the commencement of the plan. The quotas may be revised during the life of the plan provided the changes are made in accordance with the procedures set out below.

Revising the quota

Prior to making a decision to revise the quotas upwards CALM must take into account:

- current trends in population size and structure;
- seasonal effects on breeding, recruitment and survivorship;
- management objectives for specific areas;
- proportion of the total habitat subject to harvesting;
- any non-commercial mortality events within populations;
- review of previous harvests; and
- review of research information.

In order to increase the quota the CALM must seek approval from the federal Department of the Environment and Heritage (DEH) prior to increasing the quota. CALM will provide the DEH with a written quota proposal that provides the rationale for increasing the quota and a summary of relevant information (monitoring, weather etc).

If the decision is to decrease the quota or close specific areas then DCLM does not have to seek the approval of the DEH but should notify the DEH of the proposed change as soon as is practicable.

In assessing the quota the DEH will consider whether the revised quota is consistent with the goals and aims of the management plan and whether there is sufficient information provided to justify the change. The DEH will notify CALM in writing its decision.

Table 10: Annual Harvest Quotas for the operation of the Western Australian Saltwater and Freshwater Crocodile Management Plan.

Crocodylus porosus			*Crocodylus johnstoni*	
Viable eggs /Hatchlings	400		Viable eggs /Hatchlings	1500
Non-Hatchlings	50		Non-Hatchlings	200

Mortality of eggs and hatchling crocodiles is high (*C. porosus* mortality rate; egg laying to 1 year of age ca. 86%; *C. johnstoni* mortality rate; egg laying to 1 year of age >95%; Webb *et al.* 1987, pp 115). Survivorship amongst sub-adult *C. porosus* is lower than for *C. johnstoni* due to predation by larger *C. porosus*. With such high natural mortality amongst the early age classes in both species the removal of a small number of eggs or hatchlings has no impact on the overall population. Adult survivorship in both species is considerably higher allowing for a limited harvest to be undertaken without adversely affecting the stability of the populations or their capacity to increase.

Commercial Quotas

Commercial quotas are set to provide stock for the licensed commercial crocodile farms in Western Australia (currently numbering two). Harvest limits are set so as to ensure that wild stocks are not significantly reduced, with variations possible in response to rapid population growth or population decline. These harvest levels are conservative, and populations harvested at these levels are expected to fluctuate primarily in response to seasonal conditions such as rainfall and breeding habitat availability and quality.

Crocodiles that pose a threat to human safety or to primary production (i.e. problem crocodiles) may be removed from the wild under the provisions of a licence issued by CALM and provided to licensed crocodile farms for commercial purposes. As a condition of commercial crocodile farm licences, licensees are required to accept problem *C. porosus* as stipulated by CALM and subject to such conditions as CALM may impose with respect to the use of those animals for breeding or slaughter for commercial use. Problem crocodiles taken under licence will not be considered as part of the commercial harvest quota and may be taken from areas that are not part of the commercial harvest zone.

In addition to the harvest strategy identified above, the following management action will be completed for commercially harvested *crocodiles*:

1. Harvest returns will be analysed regularly to check for the presence of sudden or severe shifts in the sex (non-hatchlings only) or size structure bias of commercial harvest from those stipulated in licences to take crocodiles. Where these shifts are detected, further population monitoring may be conducted, and/or commercial harvest in the region may be restricted or the region may be closed to commercial harvest. This management action serves as a safeguard

during adverse environmental conditions such as drought, to ensure that commercial harvest does not negatively impact on the sex or size structure of crocodile populations to their long-term detriment.

Key Actions:

- Monitoring and harvest data are analysed to see if quotas need to be revised or harvest areas need to be closed;
- Revisions to quotas are done in accordance with the procedures set out in this section.*; and*
- Review and refine quota setting procedures as required.

Performance Measures:

- No change to State wide conservation status of crocodiles due to commercial harvest.

Crocodiles as a Resource

Crocodiles were once very abundant in suitable habitat in the north parts of Western Australia. Unregulated commercial hunting for meat and skins drove the Saltwater crocodile to the brink of extinction in this State while the numbers of Freshwater crocodiles were considerably reduced in some areas.

Over the last 10 years, management plans for crocodiles and the scientific literature have suggested that crocodiles should be considered as a resource (see Webb and Manolis 1993). The Western Australian Crocodile Management Program has promoted this ideal for the past 10 years, and continues the promotion of resource use within this management plan.

Crocodiles are top order predators and when in high numbers can have a marked impact on the size of populations of other species in riverine ecosystems, and in the case of Saltwater crocodiles they can also impact upon Freshwater crocodile populations in those areas where they share habitat.

This management plan does not promote crocodiles as pests or species that must be controlled. Rather, this management plan promotes the use of crocodiles as a sustainable resource.

Crocodiles have the potential to be a significant economic resource to rural communities. Commercial harvest and subsequent ranching may enable people to generate an economic return from direct involvement in the industry.

Crocodile meat is recognised as high quality game meat, being both low in fat and cholesterol. Crocodile meat has been approved for human consumption in Western Australia since 1989 and crocodile meat products for human consumption are sold within Australia and exported overseas. Crocodile skins provide a high quality and durable leather for a number of uses. Harvest of crocodiles in Western Australia is permitted to supplement breeding stocks in licensed crocodile farms. There is no legal harvest of crocodiles permitted for the direct production of skins and meat independent of crocodile farms.

2.2 LICENSING AND COMPLIANCE

Objective: **Maintain effective regulation of the commercial *crocodile* industry through licence and tag procedures, and monitoring of compliance.**

Licences and Tags

Licence to Take Crocodiles

The commercial crocodile industry in Western Australia is closely regulated via a number of licence and tag procedures. Crocodiles are protected pursuant to section 14(2)(ba) of the *Wildlife Conservation Act 1950* throughout all parts of Western Australia. Crocodiles cannot be taken from the wild without the written authorization of the Executive Director of CALM. Such authorization is be provided by means of a licence to take fauna issued pursuant to Regulation 15 of the *Wildlife Conservation Regulations 1970*. Problem crocodiles removed from the wild to protect human populations and livestock are taken under licences issued pursuant to Regulation 4 (Dangerous fauna) and Regulation 15 of the *Wildlife Conservation Regulations*. Those crocodiles taken under Regulation 4 licences are taken by lethal means and do not enter the commercial crocodile farms. Only those animals taken under Regulation 15 licences are taken alive and may enter the licensed crocodile farms.

Licence to Farm Crocodiles

Crocodiles or their eggs may only be taken live and transported to a licensed crocodile farm. Crocodile farms are licensed pursuant to Regulation 14 of the *Wildlife Conservation Regulations 1970*. Crocodile products (meat, skins, curio products) may only be exported or sold by licensed crocodile farms, with approved tags (for skins) or labels (meat and curio products) attached. Approved crocodile tags are of a standard design used throughout Australia and are provided to CALM by the DEH. Approved labels must show the name and current CALM Regulation 14 crocodile farm licence number, and must also identify the species of crocodile from which the product was derived.

Farmed crocodiles are either ranched or captive bred. Ranched crocodiles are crocodiles that have been harvested from the wild either as eggs or live crocodiles and raised in captivity. Captive bred crocodiles are crocodiles that are derived from eggs laid and hatched in licensed crocodile farms. The breeding stock must be established in a way that is not detrimental to the survival of the species in the wild and with sustainable introduction of specimens from the wild.

Licence to Process Crocodiles

All crocodiles culled on licensed premises may only be processed in facilities that are licensed for the processing of crocodiles and that also meet all of the requirements of the Western Australian Department of Health. Both licensed crocodile farms in Western Australia currently possess licences to process crocodiles issued pursuant to Regulation 7 of the *Wildlife Conservation Regulations 1970*.

Reporting Requirements for Licences

Licensed crocodile farmers and processors are all required to submit monthly returns in an approved format. Non-compliance may result in prosecution and or the cancellation of the relevant licence. Licensed crocodile takers are required to submit

licence returns at the expiry of their licence, which have a maximum duration of 12 months, but in the case of the removal of problem crocodiles, licences are issued for much shorter periods.

CROCODILE TAKER

Licence issued under *Wildlife Conservation Regulations 1970*

Regulation 15

Allows:

The licence holder to take/collect crocodiles or their eggs from the wild in an approved manner subject to certain conditions, and to direct those crocodiles or eggs to a licensed crocodile farm within Western Australia. Crocodile takers are currently restricted to licensees or the employees of licensed crocodile farms.

Relevant detail:

- The licence holder must comply with all relevant provisions of the Act and Regulations.
- The maximum number of each species of crocodile (harvest limits) that may be taken under any one licence and the location(s) from which they may be taken are specified on the licence.
- During the term of the licence the licensee will furnish the CALM Regional Manager written progress reports by the 15th of each month specifying the number, size and location of each animal taken. Within 14 days of the capture of the last crocodile or at the expiration of the licence, whichever occurs first, the licensee will furnish the Executive Director of CALM with a full report on in the approved format.
- Live crocodiles or their eggs must not be taken from any Nature Reserve, Wildlife Sanctuary, National Park, or Marine Park without prior written permission of the Executive Director of CALM.
- No fauna or their progeny taken under this licence is to be released into the wild without the prior written approval of the Executive Director of CALM.
- All non-hatchling crocodiles taken from the wild under this licence must be scute marked in the approved manner, and the use of such animals may be limited to breeding stock only. The slaughter of stock designated as breeding stock may only occur with the prior written permission of the Executive Director of CALM.
- The licence holder must keep up to date records of all stock taken, under this licence and supply returns to CALM in the approved format and at specified dates.
- Crocodiles collected from the wild under licence will be handled and cared for under conditions consistent Regulations 33, 34 and 34A of the *Wildlife Conservation Regulations* and with the draft *Code of Practice for the on the Humane Treatment of Captive and Wild Australian Crocodiles*.

CROCODILE FARMER

Licence issued under *Wildlife Conservation Regulations 1970*

Regulation 14

Allows:

The licence holder to farm crocodiles in an approved facility subject to certain conditions, and to sell farmed crocodiles to other licensed crocodile farmers or to export crocodiles to or import crocodiles from licensed facilities in other States or Territories.

Relevant detail:

- The licence holder must comply with all relevant provisions of the Act and Regulations.
- The maximum number of crocodiles that may be kept may be varied subject to lawful acquisition and breeding pursuant to the provisions of this Regulation.
- Live crocodiles or their eggs shall not be obtained, accepted, transferred, sold or otherwise disposed of without prior written approval of the Executive Director of CALM.
- Crocodiles shall not be processed by the licensee unless he/she has been issued with a licence to Process crocodiles in accordance with Regulation 7 of the Wildlife Conservation Regulations.
- Crocodiles shall not be taken from the wild without the authority of a licence to do so in accordance with the Act.
- Crocodiles held under the licence shall be provided with adequate shelter, food and water and with clean surroundings in accordance with Regulations 33, 34 and 34A of the *Wildlife Conservation Regulations* and under conditions consistent with the draft *Code of Practice for the on the Humane Treatment of Captive and Wild Australian Crocodiles*
- The licence holder shall secure the services of a qualified veterinarian for the treatment of diseased or injured crocodile stock.
- The licence holder must keep up to date records of all stock received, disposed of, bred, or that dies and record the cause of death (natural, predation, slaughter for processing, euthanasia, injury or congenital defect or any other cause) and supply returns to CALM in the approved format and at specified dates.

CROCODILE PROCESSOR

Licence issued under *Wildlife Conservation Regulations 1970*

Regulation 7

Allows:

The licence holder to process crocodile meat products, skins and curio products.

Relevant detail:

- Licence holder must comply with all relevant provisions of the Act and Regulations.
- The licence holder must only accept crocodile carcasses from a licensed Crocodile farmer or in accordance with a valid import licence.
- The licence holder must not sell any crocodile meat processed under this licence unless the processing complies with relevant Local Government by-laws and any Health Act or similar statutory requirements.
- The licence holder must only accept crocodile carcasses that have an approved tag affixed.
- The licence holder must supply returns to CALM in the approved format and at the specified dates.

IMPORT OR EXPORT LICENCE

Licence issued under Wildlife Conservation Regulations 1970

Regulations 18 (Export) and 19 (Import)

Allows:

The licence holder to export or import crocodiles or crocodile products.

Relevant detail:

- Every consignment of crocodiles or crocodile products must be accompanied by an import or export licence issued by CALM.
- Licences are only valid for single consignments and for the date(s) specified on the licence.
- Licences to export or import crocodiles or crocodile products will only be issued if the relevant authority in the State, Territory to which the consignment is destined to, or originates from, approves the import/export of the fauna to/from that State,or Territory.

NB: Export or import of crocodile products from or to Australia requires a separate permit issued by the Australian Department of the Environment and Heritage

Monitoring of Compliance

CALM is responsible for overseeing enforcement and monitoring of compliance with the *Wildlife Conservation Act 1950* and *Wildlife Conservation Regulations 1970* and specified conditions of licences. Specialist investigations and compliance staff may be involved in compliance or enforcement issues that relate to crocodile management. At the time of the development of this plan at least four CALM Wildlife Officers were involved in compliance and enforcement issues within the commercial crocodile industry in regional areas on a regular basis, and a further 15 Wildlife Officers were available to assist them.

Non-specialist operational and administrational staff that operate within the Crocodile Management Program of CALM are involved in compliance checks on a regular basis. All serving Western Australian Police officers and Fisheries Inspectors are *ex officio* Wildlife Officers under the Act and may also conduct compliance checks and operations on behalf of CALM.

CALM officers conduct regular and random checks of crocodile farms and processing works. Each approved crocodile tag carries a unique identification number, and is valid for a particular species (letter prefix coded) and is registered to a Crocodile Processor. This number can be used to track an intact carcass/skin detailing when and where it was slaughtered, by which Crocodile Farmer, and to which Crocodile Processor it was sold or consigned. During such inspections checks are made of cage facilities, security, stock numbers and animal welfare and compliance with Regulations 33, 34 and 34A of the *Wildlife Conservation Regulations*.

Ensuring compliance with the Western Australian *Health Act* and the relevant regulations relating to game meat is the responsibility of officers of the Western Australian Health Department.

Crocodile Farmers and Crocodile Processors are required to submit returns to CALM on a monthly basis. Crocodile Takers are required to submit provide regular updates on there progress towards executing licences to take crocodiles from the wild and a single return within 14 days of the expiry of the licence to take crocodiles. CALM maintains a hardcopy of this return information along with all licence details. Reports will be compiled and checked for compliance (e.g. correct details for approved collections from the wild, imports and exports against changes in stock numbers, details of stock slaughtered against matching reductions in stock at hand, and successful hatchings against stock increases), and reports on potential offenders will be provided to field-based compliance staff in a timely manner.

CALM will regularly review its crocodile management compliance strategy and operations, to ensure that compliance efforts are strategically targeted and cost-efficient, are adequate to detect non-compliance incidents, and are adequate to promote and enforce compliance with relevant legislation.

Key Actions:

- Maintain effective licence and tag issue procedures for the commercial crocodile industry (e.g. Crocodile Takers, Crocodile Farmers and Crocodile Processors);
- Maintain up-to-date records and produce reports for regular compliance checks; and
- Conduct regular and random unannounced compliance checks at crocodile farms and crocodile processing facilities.

Performance Measures:

- Compliance program, including maintenance of records and field monitoring, are adequate to evaluate levels of compliance within the commercial crocodile industry.

  Measured via:

  Number of compliance checks at crocodile farms and processing facilities.
  Number of staff involved in compliance that relates to commercial crocodile harvest, farming and processing.
  Extent and type of compliance reports produced.

- Levels of compliance with legislation (*Wildlife Conservation Act*, Regulations under this Act, Conditions of Licences) maintained above 90% and approach 100% within the commercial crocodile industry in Western Australia. Measured via:

  Number of non-compliance incidents and expiations.

2.3 IMPACTS OF COMMERCIAL HARVEST ON CROCODILES

Objective: **Improve understanding of the impacts of sustainable commercial harvest on crocodiles, their habitat and the ecosystems of which they form part.**

Monitoring and minimizing the potential negative impacts of the activities covered by this plan are classed as high priorities among regular management actions, particularly for the activity of commercial harvest. This is consistent with the requirements of federal and State legislation that oversee harvesting of native species, and the precautionary approach that is used for management actions covered by this plan.

Monitor Harvest Levels

Data on the commercial harvest of crocodiles will be collated. This information will be submitted to the DEH as required and presented to stakeholders and the public via the CALM's annual report (see http://www.naturebase.net/about_calm.html). Harvest figures will also be considered in combination with numbers removed through other methods (e.g. non-commercial destruction), and with environmental conditions that may impact on population size or structure (e.g. drought).

Information on the demographics of the crocodile harvest (currently size class and sex of non-hatchling crocodiles) is obtained through harvest returns submitted by Crocodile Takers. Total harvest levels since 1989 have been low to moderate and have not had any adverse impacts on wild populations to date (WMI 2003).

Identify Potential Impacts of Harvest

Potential positive and negative impacts of harvest on crocodile populations, habitat and ecosystems are discussed in Appendix 2. Within Western Australia, these impacts are likely to vary both spatially and temporally.

The following recommendations are given to improve understanding of the impacts of commercial harvest:

1. Identify all potential positive and negative impacts to crocodiles, their habitat and ecosystems. Expand on current knowledge through regular perusal of scientific literature, results of previous actions, and consultation with key stakeholders and community;
2. Develop ways to monitor the presence of the impacts identified in (1); and
3. Identify or develop management controls that can be implemented to minimize or prevent negative impacts.

Information to assist this process may be obtained through an adaptive management approach or through current research projects in which are taking place in other parts of Australia.

Key Actions:

- Record and analyse number and size of crocodiles taken through commercial harvest;
- Submit reports to the DEH detailing numbers removed through commercial harvest, problem crocodiles directed to commercial farms and other methods (e.g. non-commercial destruction) as well as size class; and
- Use literature survey and consultative techniques to identify all potential impacts of harvest on crocodiles, their habitat and ecosystems.

Performance Measures:

- Potential impacts of harvest documented and monitored in a way that allows for the development of management controls to minimize the potential negative impacts of harvest on crocodiles, habitat and ecosystems. Measured via:

  Documented totals of commercial harvest and other methods (e.g. non-commercial destruction); and
  Extent and type of monitoring conducted to detect potential impacts.

Aim 3. Animal Welfare

Adhere to best practice animal welfare standards in conservation and management programs for crocodiles

Minimization of animal suffering is a key aim of the management of crocodiles in Western Australia. All reasonable efforts will be made to ensure management actions covered within this management plan are humane and minimize animal suffering.

3.1 MAXIMISE COMPLIANCE WITH ANIMAL WELFARE LEGISLATION

Objective: **Maximise compliance with the Western Australian *Animal Welfare Act 2002* and *Animal Welfare Regulations 2003*.**

All crocodiles taken in Western Australia under the Provisions of Regulation 15 of the *Wildlife Conservation Regulations* must be taken in such a manner so as to minimize any pain or suffering.

Efficient and humane capture techniques for crocodiles are well established (see Webb and Messel 1977; Walsh 1987). Similarly the physiological impact of capture, handling and transport on crocodiles are also well documented (see Seymour *et al.* 1987). A good understanding of crocodilian behaviour and the differences between behaviour in *C. porosus* and *C. johnstoni* greatly reduce the likelihood of injury of suffering during capture, transport and farming of crocodiles (Land 1987).

Administration of the newly established Western Australian *Animal Welfare Act 2002* is not the responsibility of the CALM. However, CALM Wildlife Officers are also authorized inspectors under the provisions of this Act and have the authority to issue compulsory orders, infringement notices or to seize animals that are being mistreated.

A draft *Code of Practice for the on the Humane Treatment of Captive and Wild Australian Crocodiles* has been developed. While the code has yet to be ratified by the relevant State, Territory and federal governments, the concepts set out in the draft code should be followed wherever possible. If, during the life of this management plan, the draft code of practice is ratified by the relevant governments, then commercial crocodile farms in Western Australia will be required as a condition of their licence to abide by the code of practice.

Key Actions:

- Include animal welfare checks as part of routine compliance inspections.

Performance Measures:

- Levels of compliance with animal welfare legislation maintained at or near 100% for all actions detailed within this management plan. Measured via:

Number of non-compliance incidents and expiations
Extent of monitoring and compliance activities.
Extent and type of anecdotal reports and public concerns.
Results of commissioned reviews and reports.

Aim 4. Communication and Education

Ensure effective communication and education throughout the community

The public profile of crocodiles and crocodile management in Western Australia is high, in part due to the limited understanding the public have of crocodiles and the real threat to public safety that large *C. porosus* pose. CALM records show that humans have been attacked by Saltwater crocodiles at least 11 times in Western Australia since 1947, with six (one fatal) of those attacks being recorded in the past 20 years. The maintenance of effective communication links between CALM, industry stakeholders, regional land management and conservation groups, and the wider community is considered an important component to the success of the program. CALM will also focus on the development of strong links with other crocodile and wildlife management organizations within Australia.

Effective communication structures are essential for adaptive management experiments, which require high levels of stakeholder involvement. Both industry and community are likely to benefit from their involvement, by the incorporation of their feedback into future management policies and practices for crocodiles.

4.1 PROMOTE CROCODILE MANAGEMENT PROGRAM

Objective: **Promote the Western Crocodile Management Program through public education and consultation with stakeholders and the community.**

The Western Australian crocodile management program will be promoted to the commercial crocodile industry and the general public. Promotion may include the use of radio and print media, and attendance at scientific conferences and rural field days. A copy of this management plan will be placed on CALM's website (see http://www.naturebase.net/about_calm.html) and hard copies will be made available to anyone requesting them. Annual reports on the program will also be provided to the DEH.

CALM will develop factual information sheets for the major stakeholders in the commercial crocodile industry, including landholders, regional Natural Resource Management (NRM) groups, Crocodile Farmers and Crocodile Processors. Information sheets will cover background information on commercial harvest and detail current legislation, licence procedures and conditions. Fact sheets will also be developed for the general public, schools and interest groups, providing an easy-to-read synopsis of crocodile management in Western Australia. Fact sheets will promote the need to manage crocodiles to assist conservation of biodiversity and to ensure continued public safety.

Key Actions:

- Promote the Western Australian Crocodile Management Program, through radio and print media and attendance at scientific conferences and field days;
- Maintain information on relevant to this plan on the CALM website as a point of access for the general public; and
- Develop fact sheets for major stakeholders in the commercial crocodile industry and the general public.

Performance Measures:

- Western Australian Crocodile Management Program promoted and explained in a manner that provides opportunities for both the commercial crocodile industry and the general community to be adequately informed on crocodile management issues and practices. Measured via:

  Number of media submissions and requests.
  Extent and type of feedback received by the CALM.
  Amount of consultation and communication with targeted groups.

4.2 PROMOTE RELEVANT LEGISLATION AND POLICY

Objective: **Promote legislation, policy and guidelines relevant to conservation and management of *crocodiles.***

Crocodile management in Western Australia is influenced and regulated by a number of pieces of Commonwealth and State legislation and policy (Appendix 2). This legislation includes the *Wildlife Conservation Act 1950*, which provides for the protection of native species (Section 14), and the taking of native species (Section 15) and hunting and food gathering by Aborigines for non-commercial purposes (Section 23(1)). Other key guidelines or legislation for crocodile management in Western Australia include: the *Conservation and Land Management Act 1984* as amended*,* the *Land Administration Act 1997,* the *Native Title Act 1983* and the *Animal Welfare Act 2002.*

CALM will aim to promote relevant legislation, policy and guidelines to the commercial crocodile industry and the wider community, through one or more of the following measures:

1. Distribution of relevant legislation/policy as part of a licence issue process;
2. Inclusion of legislation/policy details and requirements on fact sheets for industry and community; and
3. Promotion of legislation/policy during media submissions and correspondence.

All staff that work on the Western Australian Crocodile Management Program will maintain a current awareness of relevant legislation and policy through regular information transfer or training.

Key Actions:

- Distribute legislation/policy as part of licence issue process where necessary;
- Incorporate promotion of relevant legislation/policy in fact sheets for stakeholders and community; and

- Promote legislation/policy wherever possible through involvement with media and on CALM website.

Performance Measures:

- Legislation promoted in a manner that provides an opportunity for all stakeholders in the commercial crocodile industry and interested members of the community to maintain awareness of relevant legislation. Measured via:

  Extent of distribution of legislation/policy with licences and fact sheets.

  Number of times legislation/policy promoted in media submissions and correspondence.

Glossary

Approved Tag
A royalty tag issued for attachment to the skin or carcass of a crocodile slaughtered and processed for commercial use.

Ecologically Sustainable Development
Uses the definition of the Commonwealth Government (1990), that ecologically sustainable development is "using, conserving and enhancing the community's resources so that ecological processes on which life depends are maintained, and the total quality of life now and in the future can be increased".

Crocodile
The two crocodile species to which this management plan applies: Saltwater crocodile (*Crocodylus porosus*) and Freshwater crocodile (*Crocodylus johnstoni*).

Crocodile Taker
A person who is allowed by licence to take crocodiles by means approved methods, to sell or consign live crocodiles or eggs to a Crocodile Farmer.

Crocodile Farmer
A holder of a Crocodile licence, allowing them to farm crocodiles, and sell live animals and whole carcasses.

Crocodile Processor
The holder of a Crocodile Processor licence, allowing them to buy, slaughter, process and sell crocodile meat, skins and curio products.

Precautionary Principle
Uses the definition of the Rio Conference on Environment and Development (1992), that the precautionary principle is "where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation". This is recognized as a principle of Ecologically Sustainable Development.

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Appendix 1:

Survey Results

Maps of the Crocodile survey monitoring zones in Western Australia are included in Figures 1a-d. Survey data is included in Tables 1-7. The numbers and the place names that appear on the maps relate to the numbers and names that are included in the relevant table.

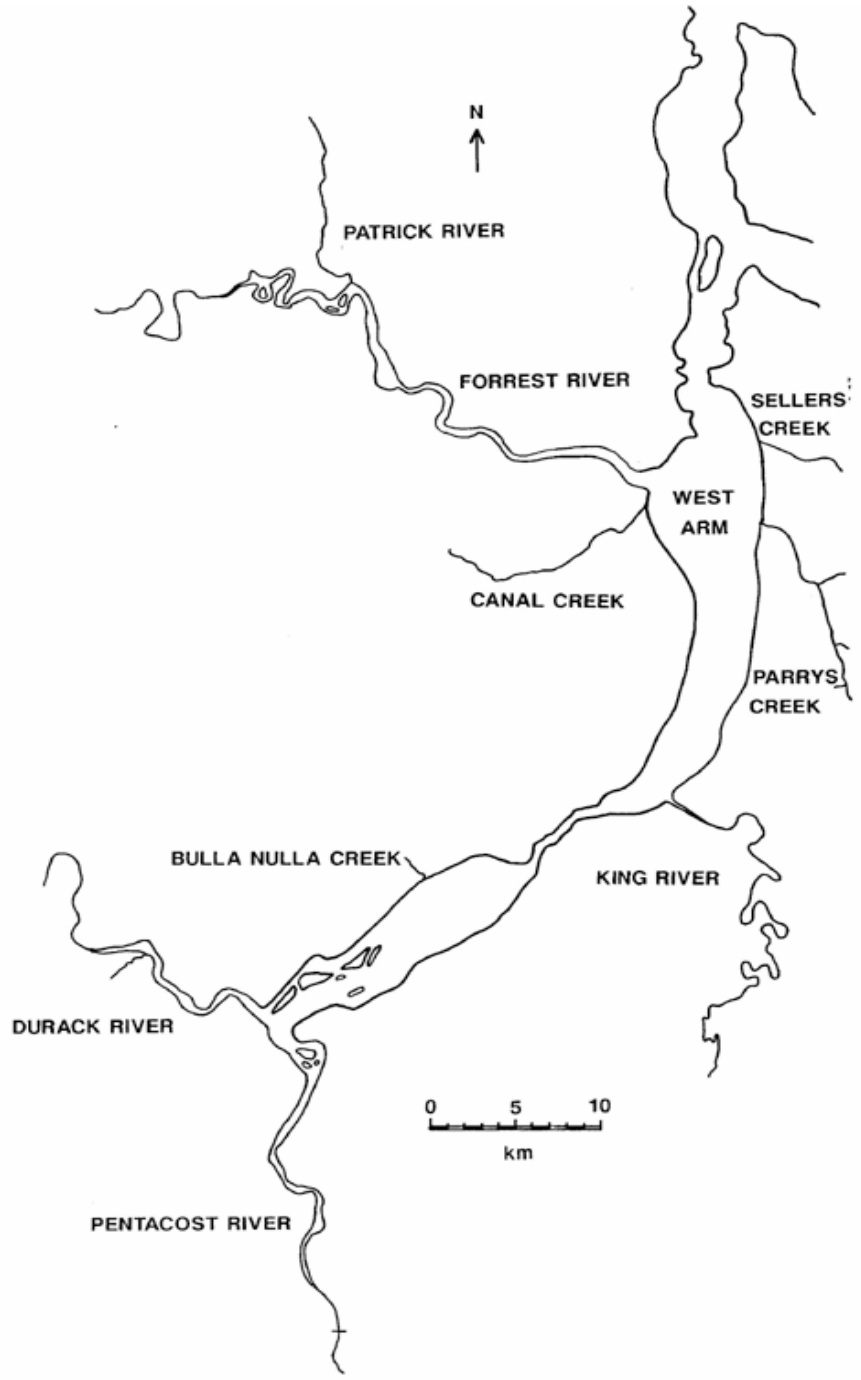

Figure 1a. Crocodile monitoring zone West Arm of Cambridge Gulf, Western Australia.

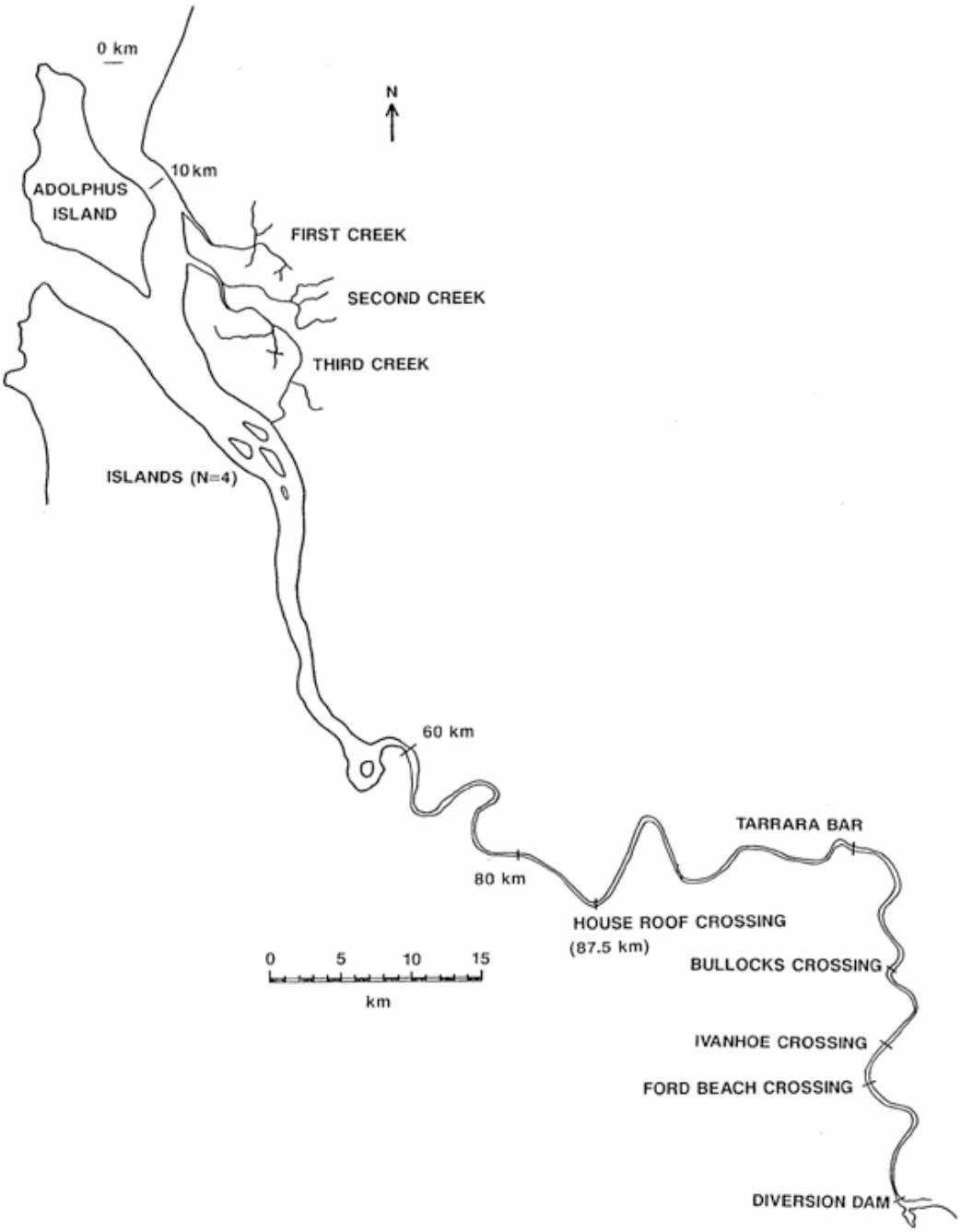

Figure 1b. Crocodile monitoring zone Ord River, Western Australia.

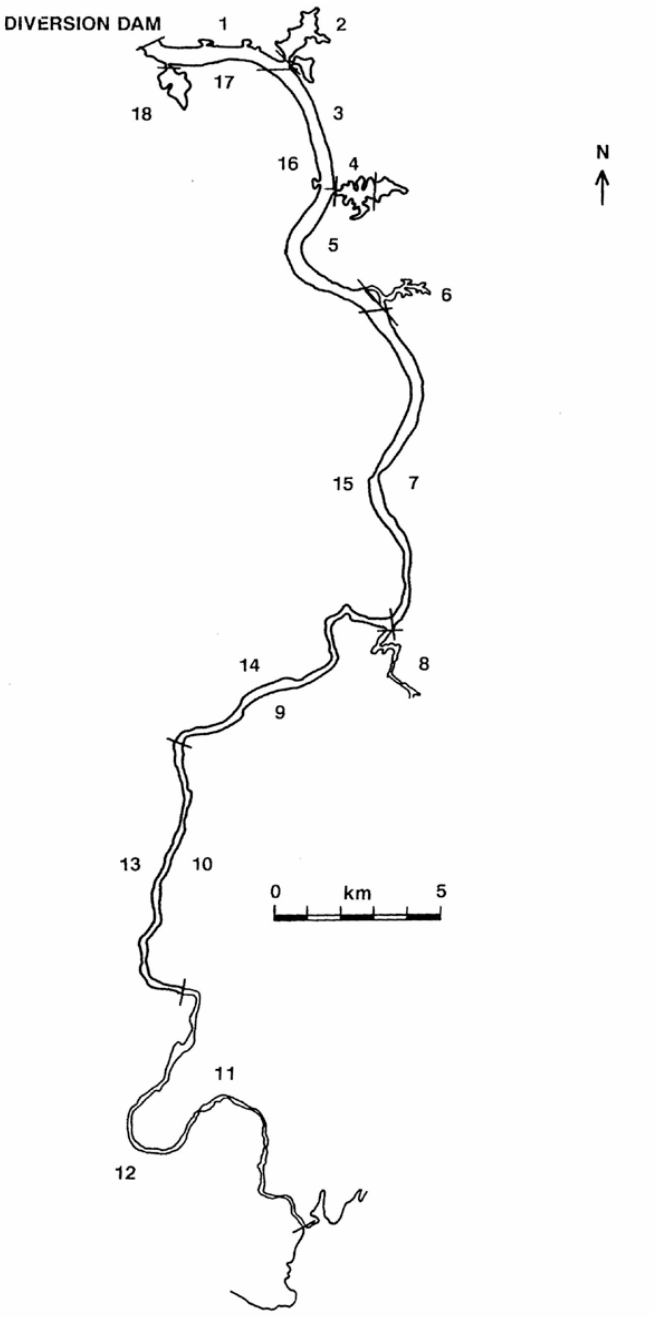

Figure 1c. Crocodile monitoring zone Lake Kununurra, Western Australia.

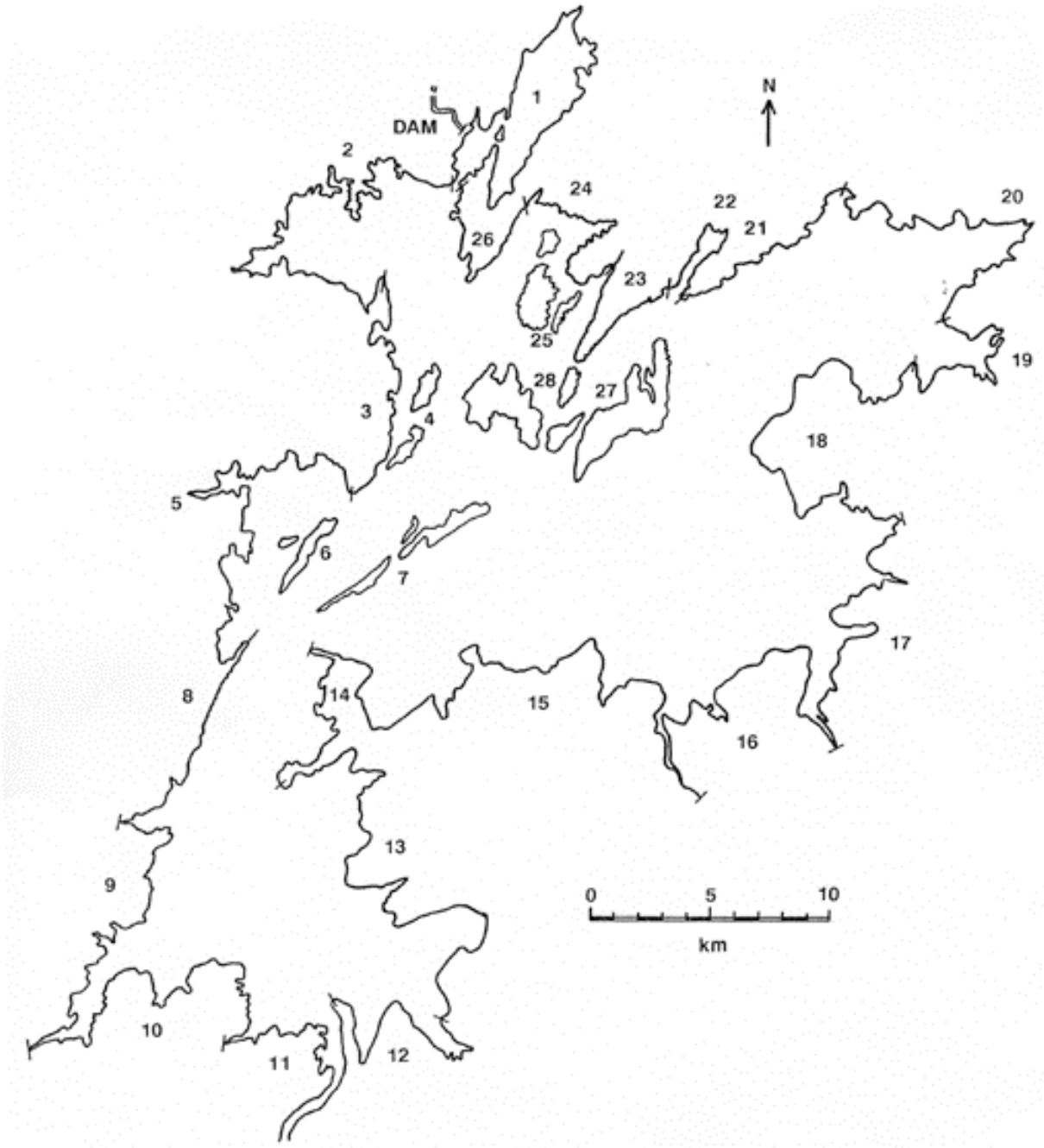

Figure 1d. Crocodile monitoring zone Lake Argyle, Western Australia.

Table 1: Numbers of *C. porosus* in each size class sighted in each area of West Arm in July 2003. SB= South bank, NB= North bank, etc. * indicate the monitoring zone. One *C. johnstoni* was sighted in the Forrest River in 2002. Unk. = animals whose size could not be allocated with certainty.

Area	Small (2-4')	Medium (4-7')	Large (7-11')	X-Large (>11')	Unk.	Total
Parrys Creek	1	3	1	1	-	6*
King River	6	7	9	4	-	26*
Pentecost River	3	2	4	-	1	10*
Durack River	-	1	-	-	-	1
Durack River	2	2	2	1	-	7*
Forrest River	-	-	1	-	-	1
Forrest River	4	1	2	-	-	7*
Patrick River	1	2	1	-	-	4*
West Arm (EB 0-40km)	5	4	2	2	-	13*
West Arm (SB 40-62km)	-	-	-	1	-	1*
West Arm (all areas)	22	21	22	10	1	76
West Arm (monitoring)	22	21	21	9	1	74

EB = East Bank, SB = South Bank

Table 2: Numbers of *C. porosus* of each size class sighted during helicopter surveys of the West Arm monitoring zone, 1992-2003. Values for 1978-1990 were derived from spotlight counts.

Area	Year	Small (2-4')	Medium (4-7')	Large (7-11')	X-Large (>11')	Unk.	Total
West Arm	1978	-	-	-	-	-	-
West Arm	1986	-	-	-	-	-	44
West Arm	1989	-	-	-	-	-	53
West Arm	1990	-	-	-	-	-	43
West Arm	1992	4	11	18	11	0	44
West Arm	1993	0	8	20	6	0	34
West Arm	1994	1	6	13	3	0	23
West Arm	1995	0	8	19	13	0	40
West Arm	1996	0	9	14	9	0	32
West Arm	1997	1	8	17	11	0	37
West Arm	1998	8	8	12	1	0	29
West Arm	1999	1	19	35	7	0	62
West Arm	2000	16	21	30	3	0	70
West Arm	2001	17	22	26	6	0	71
West Arm	2002	16	33	37	4	0	90
West Arm	2003	22	21	21	9	1	74

Table 3: Numbers of *C. porosus* sighted during helicopter surveys of the Ord River in July 2003. SB= South bank, NB= North bank, etc. * indicate the monitoring zone. One *C. johnstoni* was sighted in the Forrest River in 2002. Unk. = animals whose size could not be allocated with certainty.

Area	Small (2-4')	Medium (4-7')	Large (7-11')	X-Large (>11')	Unk.	Total
Ord mainstream (EB km20-60)	12	26	23	2	1	64*
Ord mainstream (EB km60-80)	10	15	7	3	-	35*
Ord mainstream (EB km80-87.5)	-	2	1	-	-	3
House Roof X'ing-Tararra (EB)Bar (EB)	-	1	5	-	-	6
Ivanhoe X'ing-Bullock's X'ing (EB)	-	-	1	-	-	1
Ivanhoe X'ing-Ford Beach (EB)	-	-	-	-	-	-
Ford Beach-Diversion Dam (EB)	-	-	1	-	-	1
Bullock's X'ing-Tarrara Bar (EB)	-	-	-	-	-	-
House Roof X'ing-Tarrara Bar (WB)	-	3	8	1	-	12
Ivanhoe X'ing-Bullock's X'ing (WB)	-	1	-	-	-	1
Ivanhoe X'ing to Ford Beach (WB)	-	1	-	-	-	1
Ford Beach-Diversion Dam (WB)	-	-	-	-	-	-
Bullock's X'ing-Tararra Bar (WB)	-	1	1	-	-	2
Ord River (all areas)	22	50	47	6	1	126
Ord River (monitoring)	22	41	30	5	1	99

EB = East Bank, WB = West Bank

Table 4: Numbers of *C. porosus* of each size class sighted during helicopter surveys of the Ord River monitoring zone, 1992-2003. Values for 1978-1990 were derived from spotlight counts.

Area	Year	Small (2-4')	Medium (4-7')	Large (7-11')	X-Large (>11')	Unk.	Total
Ord River	1978	-	-	-	-	-	64
Ord River	1986	-	-	-	-	-	67
Ord River	1992	0	7	28	29	0	64
Ord River	1993	0	12	35	25	0	72
Ord River	1994	1	14	30	25	0	70
Ord River	1995	0	7	25	42	0	74
Ord River	1996	0	7	32	28	0	67
Ord River	1997	0	10	37	27	0	74
Ord River	1998	3	13	22	9	0	47
Ord River	1999	3	19	35	12	0	69
Ord River	2000	4	37	37	13	0	91
Ord River	2001	3	16	34	14	0	67
Ord River	2002	2	28	31	23	0	84
Ord River	2003	22	41	30	5	1	99

Table 5: Numbers of *C. johnstoni* sighted during helicopter surveys of Cambridge Gulf in 2003. * indicates the monitoring zone.

Area	Section	Distance (km)	Number Sighted
West Arm	All areas	151.2	0
Ord River	Mainstream (EB 20-60km)	40.0	0
	Mainstream (EB 60-80km)	20.0	61
	Mainstream (EB 80-87.5km)	7.5	33
	House Roof X'ing-Tararra Bar (EB)	29.8	156*
	House Roof X'ing-Tararra Bar (WB)	29.8	113*
	Ivanhoe X'ing-Bullock's X'ing (EB)	7.5	36*
	Ivanhoe X'ing-Bullock's X'ing (EB)	7.5	32*
	Ivanhoe X'ing-Ford Beach Rapids (EB)	3.0	9*
	Ivanhoe X'ing-Ford Beach Rapids (EB)	3.0	4*
	Ford Beach Rapids-Diversion Dam (EB)	11.0	60*
	Ford Beach Rapids-Diversion Dam (WB)	11.0	20*
	Bullock's X'ing-Tarrara Bar (EB)	10.0	17
	Bullock's X'ing-Tarrara Bar (WB)	10.0	30
All Areas			571
Monitoring Zones			430

EB = East Bank, WB = West Bank

Table 6: Numbers of *C. johnstoni* sighted during helicopter surveys of Lake Kununurra and Lake Argyle in 2003. Numbers for sections correspond to number sections identified previously (G. Webb Pty Ltd 1989b; Figs 3 and 4). * indicates the monitoring zone. Dead *C. johnstoni* were sighted in Sections 2 (n=1), 11 (n=3) and 21 (n=1). Ns= not surveyed in 2003.

Area	Section	Distance (km)	Number Sighted
Lake Kununurra			
	12. WB: Ord River Dam – us Carlton Gorge	15.5	45*
	13. WB: us Carlton Gorge – ds Carlton Gorge	9.5	25*
	14. WB: ds Carlton Gorge – opp. Spillway Ck	9.5	19*
	15. WB: opp. Spillway Ck – opp Maxwell Pl. Ck	11.0	24*
	16. WB: opp Maxwell Plains Ck – opp Lilly Ck	10.0	22*
	17. WB: opp Lilly Ck – Diversion Dam	4.5	5*
	18. WB West Packsaddle Swamp	4.5	8*
	Total (monitoring zone)		148
Lake Argyle	2. Pintpot Bay	35.0	8*
	5. Ulysses Bay	30.0	102*
	8. Wood Belly Ck Point – Kangaroo Ck	12.0	76*
	9. Kangaroo Ck – Flying Fox Ck	21.0	67*
	10. Flying fox Ck – Ridgepole Ck	22.0	46
	11. Ridgepole Ck – Ord River	13.0	87*
	12. Ord River – Cooee Ck	13.0	139*
	13. Cooee Ck – Lily Spit	30.0	Ns
	14. Lily Spit – Lagoon Island	12.0	59*
	15. Lagoon Island – Behn River	35.0	174*
	16. Behn River – Stockade Ck	22.0	15
	17. Stockade Ck – Bull Ck	21.5	30*
	18. Bull Ck – Napoleon Bay	23.5	16
	19 Napoleon Bay	14.0	49*
	20. Carl Bay – Crooked Ck	19.5	54
	21. Crooked Ck – Spider Point	12.0	56*
	22. Hatchling Bay	7.0	84
	23. Dravo Peninsula	10.0	49*
	26. Gundarim Ridge	12.0	Ns
Lake Argyle (all areas)			1111
Lake area (monitoring zones)			897

WB = West Bank; us = up stream; ds = down stream

Table 7: Helicopter count indices for non-hatchling *C. johnstoni* in the monitoring zones in the Ord River, Lake Argyle and Lake Kununurra. Values for 1988/89 were predicted from spotlight count data.

Year	Ord River	L. Kununurra	L. Argyle	Total
1988/89	-	218	2124	-
1990	-	-	-	-
1991	-	-	-	-
1992	217	194	857	1267
1993	266	142	1238	1646
1994	413	157	1621	2191
1995	478	329	1411	2218
1996	358	189	846	1393
1997	527	156	996	1679
1998	247	247	480	974
1999	400	322	810	1532
2000	426	266	1176	1868
2001	174	201	1001	1376
2002	555	158	917	1630
2003	430	148	897	1475

Appendix 2:

Policy and Legislative Framework for Crocodile Management in Western Australia

There are a broad range of policies, legislation and guidelines that set a framework for the conservation and management of crocodiles in Western Australia. Legislation and policy exists at both the Commonwealth (National) and State level, and in addition, there are many plans that operate at the regional or local level which incorporate crocodile issues, such as regional natural resource management plans.

Key legislation and policy in place at the Commonwealth and State level are shown below.

COMMONWEALTH

- *Environment Protection and Biodiversity Conservation Act 1999* – Part 13A of this legislation provides the mechanism for the approval of wildlife management plans and the regulated export of crocodile products derived from the approved management plan.

  Under the EPBC Act, both crocodile species are included as listed marine species and *C. porosus* is included as a listed migratory species. It is an offence except in certain circumstances (such as human safety) to kill, injure, take, trade, keep or move a listed marine or migratory species on Commonwealth land or waters without a Commonwealth permit issued under Part 13 of the EPBC Act. In addition, the EPBC Act requires that actions that are likely to have a significant impact on matters of national environmental significance are subject to a rigorous referral, assessment and approval process. Matters of national environmental significance include listed migratory species.

- *Export Control Act 1982* – this legislation provides a mechanism for the Commonwealth to regulate the movement of prescribed goods, including animal products such as crocodile meat and skins, out of Australia.

- *National Residue Survey Administration Act 1992* – this legislation establishes a fund for the collection of monies levied under the *National Residue Survey (Excise) Levy Act 1998*.

- *National Residue Survey (Excise) Levy Act 1998* - this legislation provides a mechanism for the levying of the processors of game meat shot in the field and used for human consumption. Crocodiles are included in the definition of game animals under this legislation.

- *Native Title Act 1983* – this legislation does not give Aborigines or Torres Strait Islanders rights to use native wildlife such as crocodiles in any manner other than that prescribed in the *Wildlife Conservation Act 1950* specifically (Regulation 63), but it does give those people in whom particular lands are

vested under this Act the power to grant access to lands vested in them for purposes such as the commercial harvest of crocodiles.

STATE

- *Wildlife Conservation Act 1950* - this legislation and the associated regulations provide the mechanism for the licensed taking of crocodiles, the farming of crocodiles, the processing of crocodile products, commercial dealing in crocodile skins and meat and the import and export of crocodile products within Australia. It also provides the authority for the authorized officers responsible for ensuring compliance with the Act and regulations as they relate to the taking, harvest or keeping of crocodiles.

- *Conservation and Land Management Act 1984* - this legislation provides the head power for the establishment and management of conservation estate such as State forest, national parks and nature reserves. Crocodile harvesting in areas under these tenures is prohibited, thus providing sanctuary areas for crocodiles throughout Western Australia. Exceptions to this include 'necessary operations' carried out pursuant to section 33(3) of the *CALM Act 1984* to allow for the removal of problem crocodiles from National Parks, Nature Reserves and Conservation Parks.

- *Land Administration Act 1997*- this legislation provides a mechanism for the administration of unvested crown land. As with conservation estate, unvested crown lands are not accessible to commercial crocodile takers for the purpose of harvesting crocodiles, providing significant additional areas of protection for crocodiles.

- *Animal Welfare Act 2002* – this legislation provides for the humane treatment of all animals, domestic, pet or wild. The taking and keeping of crocodiles for commercial purposes is permitted under this legislation (section 7(2)) so long as it is done in accordance with licence issued pursuant to the *Wildlife Conservation Act 1950*.

Appendix 3:

Assessment of the Impacts of this Management Plan

BACKGROUND INFORMATION FOR THIS MANAGEMENT PLAN

Current Conservation Status of Crocodiles, Distribution and Extent of Habitat

The species of crocodiles covered by this management plan are listed as common in both Western Australia and Australia. The species are not listed on threatened species schedules for the Commonwealth or the Northern Territory, but *C. porosus* is listed as 'vulnerable' in Queensland. Both species of crocodile are however, listed as "Otherwise specially protected" pursuant to section 14(2)(ba) of the Western Australian *Wildlife Conservation Act 1950* in recognition of the potential impact that unauthorized taking can have on wild populations.

The distribution of crocodiles in Western Australia is detailed in Burbidge (1987), Grigg and Gans (1993), Cooper-Preston and Jenkins (1993) and Molnar (1993). Information on the annual distribution of crocodiles in Western Australia will be presented in the annual reports submitted to the Department of the Environment and Heritage. The current distribution of crocodiles generally reflects the extent of suitable habitat for these species. The extent of suitable habitat for crocodiles in the area subject to commercial harvest will be surveyed at a finer scale as part of an objective of this management plan (Aim 1: Objective 3).

Background Information to crocodile populations

The reproductive biology of crocodiles has been extensively studied (see review in Ferguson 1985). Female crocodiles are polygamous. Breeding of Saltwater (Webb *et al.* 1977) and Freshwater (Webb *et al.* 1983) crocodiles is seasonal, except under very poor environmental conditions. Eggs are laid into nests constructed by the female, where they are incubated under the influence of ambient conditions. Variations in ambient temperature influence the sex of the developing young (Webb and Smith 1984; Webb *et al.* 1987). Regardless of seasonal conditions, Australian crocodiles only produce one clutch of eggs per breeding season.

In the absence of human predation or hunting crocodile populations fluctuate primarily in response to seasonal conditions, such as rainfall and temperature (Webb and Smith 1984; Webb *et al.* 1987). Survival rates of juveniles and adults are highly variable, with much lower birth rates and survival of juvenile crocodiles during drought conditions.

History of Commercial Harvest

The commercial harvest of crocodiles in association with licensed crocodile farms in Western Australia has been managed by CALM since 1988.

Availability of the Restricted Parts of the State for Harvest

Except with the express written authorization of the Executive Director of CALM crocodiles may not be taken from any Nature Reserves, Wildlife Sanctuaries, conservation Parks, National Parks or Marine Parks and lands vested in the

conservation Commission of Western Australia. Circumstances under which taking from such areas might be considered would include taking for scientific research (under Regulation 17 licences) or the removal of problem crocodiles (under Regulation 4 or 15 licences. Similarly, licensed crocodile takers may not take crocodiles on other lands unless they have the written approval of the relevant land manager or owner for access to those lands (in addition to a licence issued by CALM). This management system limits the areas from which crocodiles may be taken and ensures that there are always areas from which all harvest activities are excluded.

Dynamics of Crocodile Harvest

Since 1989 commercial harvest levels in Western Australia have averaged 25 (range 0-68) adult, 30 (range 0-250) hatchlings and 43 (range 0-261) eggs of *C. porosus* in any year. For *C. johnstoni* the average annual harvest for adults has been 41 (range 0-185), 194 hatchlings (range 0-1202) and 158 eggs (range 0-856) in any year. The greatest harvest of *C. porosus* in Western Australia is from Cambridge Gulf while the greatest harvest of *C. johnstoni* has come from Lake Argyle.

Commercial harvest is biased towards hatchlings and eggs since the intent of the harvest was to provide stock for the commercial crocodile farms that could be grown on to market size and also provide breeding stock adapted to captive husbandry conditions. Only small numbers of adult crocodiles have been harvested, and a proportion of those crocodiles have been problem *C. porosus* removed from their natural environment because of the threat they posed to public safety. The only alternative to their capture and relocation to a crocodile farm would have been euthansia. The number of problem crocodiles that will need to be removed in the future will be influenced by changes in size structure in *C. porosus* populations in those waterways close to human populations and popular recreation sites.

Management of Crocodile Habitat

This success of this management plan will be influenced by how well key crocodile habitats are managed as part of other industries. For example efforts to fence off river frontages to exclude domestic cattle will result in increased vegetation along river banks which will provide increased feeding, breeding and nursery habitat for crocodiles. These actions are currently being undertaken as part of landcare and natural resource management programs in the Kimberley region of Western Australia.

LEGISLATIVE REQUIREMENTS

This management plan for *crocodiles* is required to satisfy the requirements of the legislation specified in Section 303FO of the federal *Environment Protection and Biodiversity Conservation Act 1999.* These requirements include ensuring that this plan must not be detrimental to the survival of the species covered by this plan, or any relevant ecosystem. In addition, the legislation requires that the impacts covered by this plan on the species and the species habitat are properly assessed, that the plan is ecologically sustainable, and that the plan includes measures to monitor any potential environmental impact(s).

Information to address these issues for crocodile management and the activities of this plan are covered below. An assessment of this plan against this piece of legislation is shown in Tables 2 and 3.

Potential Threats to Crocodile Species

Reviews by Groombridge (1987) and Jenkins (1987) have detailed potential threats or impacts to crocodile populations worldwide. As with all crocodilian species, the majority of threats impacting on the two Australian crocodile species, direct and indirect threat, are anthropogenic. A summary of these impacts is provided below.

- **Environmental impacts**

  Drought is likely to have a significant but not a long lasting environmental impact on crocodile populations. The rate of increase of crocodile populations is strongly linked to rainfall through its impact on habitat, nest material and food availability. Declines of crocodile populations during drought are likely to have occurred since prior to European settlement, as crocodiles are restricted to habitat around permanent waters. The increased availability of aquatic habitat in a few locations in Western Australia (e.g. Lakes Kununurra and Argyle) means that some populations have had the opportunity to increase considerably. Mortality during drought is highest at the nesting stage and amongst juveniles. In the absence of hunting by humans, *C. porosus* populations in Western Australia have low (ca. 2.5%; Ord River) to moderate (ca. 15-20% p.a.; West Arm of Cambridge Gulf)) rates of increase when conditions improve. Freshwater crocodile populations in Western Australia have shown more conservative rates of increase (1% p.a.; Lake Argyle) (WMI 2003).

  Flooding may impact on crocodile populations through decreasing the availability of suitable breeding habitat.

- **Habitat loss and modification**

  Since European settlement, large tracts of native riparian habitat have been cleared or degraded due to grazing by domestic cattle. Native vegetation remains in remnant patches and in National Parks and reserves and in a modified form in pastoral rangelands. Crocodiles have not benefited from changes to land use, with the exception of the increase in *C. johnstoni* populations following the construction of the dams that impounded Lakes Kununurra and Argyle.

Disease

Disease outbreaks have not been reported as causes of mortality in wild and captive crocodile populations in Africa (see Foggin 1987), there are few records of diseases affecting crocodiles in Australia but there have also been consistent but low levels of 'unexplained' mortality in some crocodile farms (see Onions 1987). Disease by itself is not considered an important mortality factor, but may have a synergistic effect in combination with stressful conditions such as over-crowding, lack of or poor quality food, or sub-optimal climatic conditions.

- **Predation**

Aside from humans the only other significant predators of crocodiles are larger crocodiles. This willingness to feed on smaller crocodiles is largely responsible for the low numbers or complete absence of *C. johnstoni* in some *C. porosus* habitat.

Entanglement in fishing nets is known to be a cause of mortality for crocodiles in Australia, although firm data on the level of mortality and the effect of that mortality on crocodile populations are not available, as indicated by Webb *et al*. (1987) for the Northern Territory and Taplin (1987) for Queensland. For Western Australia, published references are limited to Messel *et al*. (1987) suggesting that commercial netting for barramundi in the 1978-84 period may have caused or contributed to a decline in *C*. *porosus* numbers in the Ord River system. G. Webb Pty Ltd (1989a) reported that a single professional fisherman stated in 1989 that he had accidentally drowned 50 *C*. *porosus* in nets in the King Sound area over the previous three years. It is known from reports received by DCLM that net entanglements and mortalities continue to occur, particularly with *C. johnstoni* in the Lake Argyle net fishery, where arrangements exist for reporting of incidental catches.

It is difficult to assess the level of mortality resulting from drowning in fishing nets and illegal shooting. Using only records based on carcasses that have been located or on reports that have been reliably substantiated, CALM's District Wildlife Officer stationed in Kununurra recorded five *C. porosus* drownings (including two in the Cambridge Gulf West Arm river systems) and 17 *C. porosus* shot (including 13 in the Ord River and two in the West Arm river systems) between April 1989 and 30 June 1994. In contrast, CALM's District Wildlife Officer in Broome received only one substantiated report of a *C. porosus* being shot between October 1988 and the 30 June 1994.

In addition, CALM receives reports that illegal shooting occurs from time to time. Such reports are investigated and action is taken where offenders can be identified.

POTENTIAL IMPACTS OF THIS MANAGEMENT PLAN

Potential impacts of this management plan are considered below for the activities of commercial harvest and management of crocodiles in National Parks and Nature Reserves. Management controls in place to minimize or monitor these impacts are also detailed.

Impacts on Crocodiles

Commercial harvest could potentially impact on crocodiles directly via harvest at unsustainable levels, or via demographic or genetic impacts on harvested populations.

- **Sustainability of Commercial Harvest**

  The following factors promote the sustainability of commercial harvest in Western Australia:

  1. Commercial harvesting limits are based on direct monitoring data of crocodile populations;
  2. Commercial harvest limits are set at levels that are considered ecologically sustainable for crocodile populations;
  3. Commercial harvest is patchy within crocodile habitat, leaving many areas of (unharvested) refuge habitat; and
  4. The size of the region harvested is modest in comparison to the large geographic distribution of crocodiles and the remoteness of much of that distribution.

  Management controls are in place within the commercial harvest limit setting system to ensure that harvest levels are sustainable. Annual monitoring allows for any other mortality agents acting on crocodile populations to be accounted for in the setting of harvest limits (e.g. animals lost through drought or disease).

  Numbers removed through non-commercial destruction are very low compared to that taken through commercial harvest. These figures are monitored and compiled regionally in harvest reports to the DEH

- **Demographic impacts of harvesting**

  Commercial crocodile harvest in Western Australia is biased towards hatchlings and eggs. Such a bias in the harvest will have no impact on wild stocks since the bulk of all eggs laid fail to result in an adult crocodile recruiting to the population. Webb (1989) estimates that the cumulative mortality for eggs thorough to five years of age for *C. porosus* is 99.2%, and 98.1% mortality for *C. johnstoni*. In contrast most efficient crocodile farms in Australia achieve much lower mortalilty rates, normally only 10%-30% (see Onions 1987).

  When harvesting live crocodiles potential changes to the sex and age structure of harvested crocodile populations could result, such as harvested populations having a female bias or a lower average age compared to unharvested populations.

  Intensive harvesting may change the age structure of crocodile populations at particular localities. However, the patchy nature and low level of the harvest will decrease the demographic impacts of harvesting on crocodile populations, due to rapid recolonization of harvested areas by immigrating crocodiles, the increased survivorship of hatchlings in areas where adult crocodiles have been removed and the presence of refugia for crocodiles in unharvested areas. Demographic impacts of commercial harvest are mirrored in unharvested crocodile populations following drought (e.g. adult-bias, fewer hatchlings).

Potential demographic impacts of commercial harvest on Western Australian crocodile populations are currently monitored through sex and size data provided on harvest returns. There is management control in place to ensure that there are no irreversible negative impacts on the sex or size structure of harvested crocodile populations.

- **Genetic impacts of harvesting**

There may be concerns that selective harvesting of crocodiles will lead to impacts on the genetic diversity and fitness of harvested populations. An understanding of crocodile mating systems would suggest that commercial harvesting at current levels has negligible impacts on the genetic diversity and fitness of crocodile populations, due to:

1. The size of crocodile populations in relation to the numbers removed through harvesting;
2. Large geographic ranges of genetic crocodile populations relative to the size of the harvested area. This is in part due to the migration of individuals across large distances; and
3. Patchiness of the commercial harvest, and immigration of new individuals into harvested areas.

- **Animal Welfare Concerns**

Allowing for a commercial harvest and non-commercial destruction of crocodiles from the wild has potential impacts on animal welfare. Animal welfare concerns are considered unlikely for actions conducted as part of this management plan, due to:

1. A good understanding of suitable capture, handling and husbandry techniques for crocodiles in Australia;
2. The enforcement of legislation as a condition of licence for Crocodile Takers and Farmers; and
3. The presence of a compliance program to maximize and monitor compliance with crocodile management legislation.

Impacts on Habitat

Impacts on habitat due to actions detailed within this management plan are likely to be non-existent. Crocodiles do not have any significant direct or indirect affect on vegetation in riparian systems.

Impacts on Ecosystems or Other Species

As top order predators, crocodiles are important for the maintenance of a balanced ecosystem. The low harvest level described in this plan is unlikely to result in any significant adverse impact due to the decline in natural predation exerted by crocodiles on other native species.

Table 1: Requirements of the *Environment Protection and Biodiversity Protection Act 1999.* Section 303FO – Approved Wildlife Trade Management Plan.

	Legislative Requirement	How Requirement is Addressed in this Management Plan
(1)	The export of a specimen is in accordance with an approved wildlife trade management plan	• This management plan is submitted for approval as an *Approved Wildlife Trade Management Plan.*
(3)(b)	There has been an assessment of the environmental impact of the activities covered by this plan, including an assessment of	
(i)	The status of crocodiles	• Conservation status of Saltwater and Freshwater crocodiles is detailed in p. 5 and Appendix 4. Ref: p.53.
(ii)	The extent of the habitat of *crocodiles*	• Distribution of crocodiles is detailed in Appendix 3. Ref: p.56. • Habitat will be mapped as part of Aim 1: Objective 3. Ref: p.17.
(iii)	The threats to crocodiles	• Threats to crocodiles are detailed in Appendix 3. Ref: p.59.
(iv)	The impacts of the activities covered by the plan on the habitat or relevant ecosystems	• Potential impacts of the activities are detailed in Appendix 3. Ref: p.60.
(3)(c)	The plan includes management controls directed towards ensuring that the impacts of the activities covered by the plan are ecologically sustainable to crocodiles, other taxa and ecosystems	• Ecological sustainable management is included within the goal of this management plan. Ref: p.7. • The harvest limits include management controls and performance measures to ensure that commercial harvest levels are sustainable in the long-term for crocodile populations. Ref: p.19. • Crocodile farms and processors are regulated to ensure that animals have been legally sourced (ie wild harvested crocodiles are not illegally entering the farms). Ref p 23-24
(3)(d)	The activities covered by the plan will not be detrimental to the survival of crocodiles, the conservation status of crocodiles, and any relevant ecosystem.	• Harvest levels are based on direct population monitoring. Ref: p.22. • Crocodile farms and processors are regulated to ensure that animals have been legally sourced (ie wild harvested crocodiles are not illegally entering the farms). Ref p 26-32
(3)(e)	The plan includes measures to:	
(i)	Mitigate and/or minimize the environmental impacts covered by this plan	• Effective licence procedures are in place to regulate the commercial harvest, farming and processing of crocodile products Ref: p.26-30. • Minimizing impacts is detailed in Aim 2: Objective 3. Ref: p.32.

(ii)	Monitor the environmental impact of the activities covered by this plan	• Crocodile populations are monitored regularly across the entire commercial harvest zone. Ref: p.9. • Harvest returns are collected to monitor characteristics of harvest. Ref: p.26-32. • Monitoring the impact(s) of harvest is detailed in Aim 2: Objective 3. Ref: p.32.
(iii)	To respond to changes in the environmental impact of the activities covered by the plan	• Harvest returns will be collated and submitted annually to the Department of Environment and Heritage. Ref: p.32. • An adaptive management approach will be promoted as part of this management plan. Ref: p.23-24, 32. • Management controls are in place for commercial harvest levels, along with performance measures and a mechanism to ensure that these are linked to future management actions. Ref: p.19, 31.
(3)(f)	The conditions applicable to the welfare of crocodiles are likely to be complied with.	• Aim 3 relates to ensuring that management actions conducted under this plan are humane to crocodiles. Animal welfare legislation is stated, and management actions are detailed. Ref: p.34. • Compliance with animal welfare legislation is enforced as a condition of permit. Ref: p. 28-29. • There is a compliance program in place to monitor and enforce compliance with animal welfare legislation. Ref: p.31.