STATUS AND CONSERVATION OF *Crocodylus porosus* IN AUSTRALIA

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Following very severe exploitation for the skin trade during the 1950's and 1960's, the Australian population of *Crocodylus porosus* was very severely depleted by the start of the 1970's (Bustard 1970, Messel pers. obs.). A total import-export ban on crocodile skins and products by the Federal Government in 1972 effectively ended the period of intensive exploitation, though this had already happened in many areas due to numbers being too low for economic exploitation.

In 1971 the University of Sydney Crocodile Research Group commenced its study of *C. porosus* in northern Australia. The results of this lengthy and extensive study have appeared in numerous publications covering the physiology, nesting, growth, movement, mortality and population structure and status of *C. porosus* over much of the northern Australian coastline.

An important aspect of this work has been the development of systematic survey methods to enable the numbers of *C. porosus* on the tidal waterways to be estimated and the carrying out of surveys using these methods over a period of years to monitor the changes in the population. (A full description of the survey methods used and of the Project's aims may be found in Chapters 1 and 2, Monograph 1, Messel et al. 1979-1986). In this chapter we only summarize the results of some ten years of night-time crocodile surveys, involving well over 70,000 km of river travel, and discuss the results.

During the period 1975-1979, using a research vessel as a floating base, some 100 tidal systems (Fig. 1, and Figs. 1 to 9, Chapter 9, Monograph 1) were surveyed systematically and many of these were surveyed more than once. In the Northern Territory 3,998 km of tidal waterways were surveyed; in Western Australia 527 km and in Queensland 643 km. The detailed results of the study and the analyses of these results appeared in a series of 19 Monographs (Messel et al. 1979-1986) and 2 Western Australian Reports (Messel et al. 1977, Burbidge and Messel 1979) and a series of specialist papers. Intensive population surveys and studies were continued during 1980, 1981, 1982 and 1983 on some 330 km of tidal waterways centered on the Liverpool-Tomkinson and Blyth-Cadell Rivers Systems in northern Arnhem Land and on some 59.3 km of associated alternative habitat. These relatively undisturbed waterways constituted our population dynamics and status monitoring systems. In addition Ngandadauda Creek and the Glyde River with its associated Arafura Swamp were resurveyed twice in 1983. During June-July 1984 we resurveyed the 861.2 km of tidal waterways in Van Diemen Gulf which includes the Adelaide and Alligator Region River Systems and the Cobourg Complex. In September-October 1985 the major tidal waterways of the southern Gulf of Carpentaria were resurveyed. All these latter surveys are analyzed in great detail in Monographs 18 and 19 (Messel et al. 1979-1986) and were described in the population dynamics chapter.

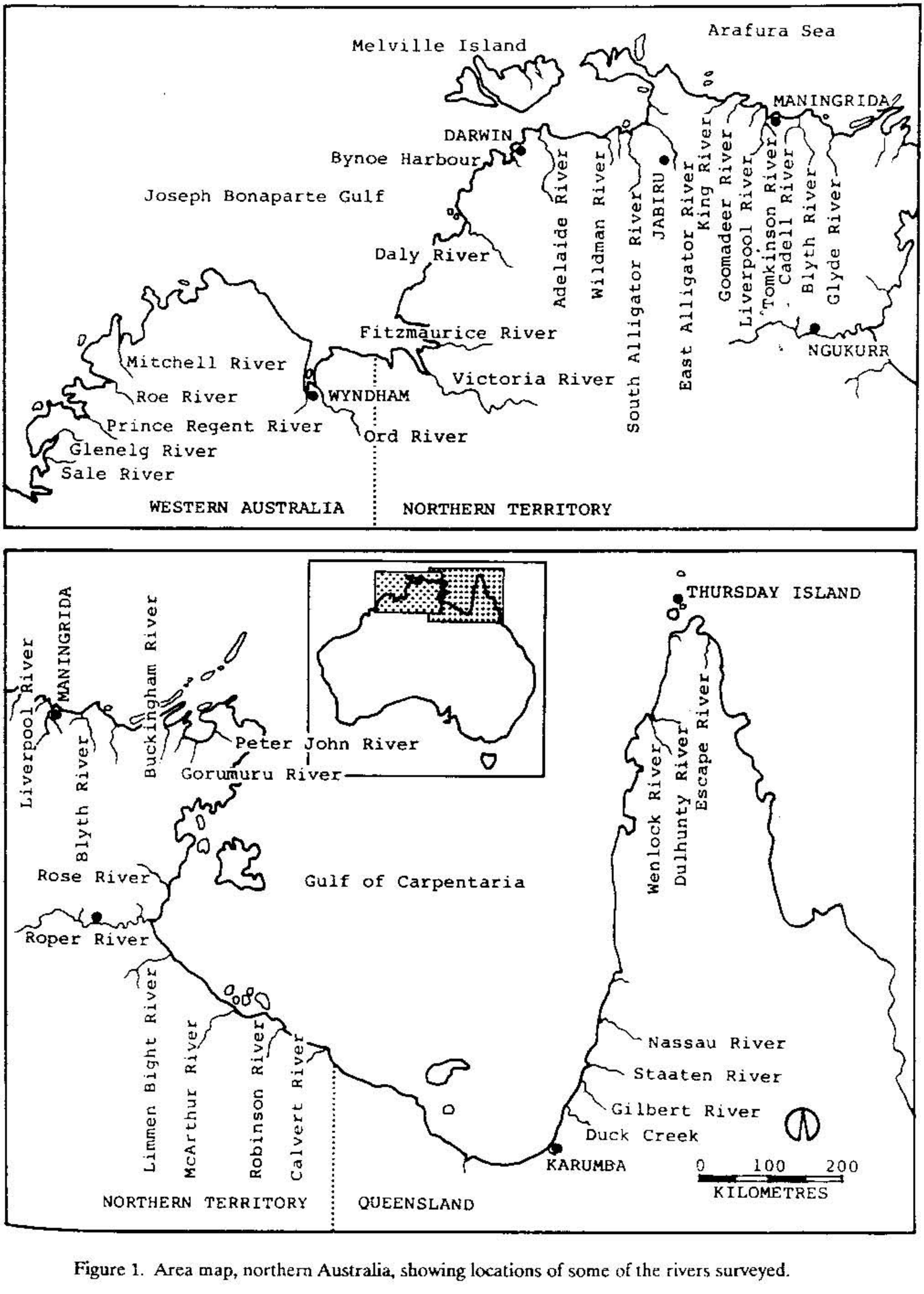

Figure 1. Area map, northern Australia, showing locations of some of the rivers surveyed.

The results of our surveys and studies have allowed a picture of *C. porosus* population dynamics in northern Australia to be developed and this picture was presented in some detail in our chapter on population dynamics. It enables us to account in a consistent fashion for the results of the surveys and to predict results to be expected on future surveys. The results also enable us to make an assessment of the overall status of *C. porosus* in northern Australia, and of the prospects for recovery of the population. Management implications of the results and population model are discussed also. The presentation here is necessarily very much abbreviated and the reader is referred to the 19 Monographs and 2 Reports for a wealth of supportive detail.

STUDY AREA AND METHODS

Study Area - Figures 1 to 9 in Chapter 9, Monograph 1, enable the locations of all waterways surveyed to be ascertained. The approximately 100 waterways surveyed extend from the Sale River (124°36'E, 15°58'S) at the top of Cape York Peninsula in Queensland. The only major area of coastal *C. porosus* habitat inadequately sampled is the eastern coast of Cape York Peninsular. The waterways of the Northern Territory have been most thoroughly surveyed, most of them having been surveyed at least twice. Each of the Monographs (except 15) deals with the waterways of a particular area and, besides the results of crocodile counts, gives details of salinity and temperature profiles, tidal patterns, ranges and delays and fringing riverside vegetation. Color photographs in each Monograph illustrate the nature of the waterways. Detailed river work maps (of all waterways surveyed) with mileages are collated in Monograph 15 and show channels and navigational hazards such as rock bars and sand and mud bars. Figures 1-6 in our Population Dynamics Chapter in the current volume show the monitored area, the Alligator Rivers Region and the Adelaide River in more detail.

Survey Methods - The methods used for surveying tidal river systems and their crocodile populations are described by Messel (1977), Messel et al. (1978) (also see for full details, Chapter 2, 4, 5 of Monograph 1). Particularly, it should be noted that these methods do not necessarily apply to non-tidal systems or swamp habitats.

Night-time spotlight counts are normally conducted from two modified 5.5 m work boats, each with three or four staff members. A 3.5 m dinghy with a 9.9 HP motor is used for surveys of upstream areas, billabongs and small coastal creeks. The staff members include a spotter, driver and recorder/navigator.

Crocodiles can be located as the tapetum of their eyes reflects light and appears as a red glow in the beam of the spotlight. Counts can proceed when the tide leaves 60 cm or more of exposed bank (Plate 2.1,, 1, Monograph 1) on the sections to be surveyed. This means surveys must normally be carried out within 2-3 hours of low tide, depending upon the tidal pattern. Most crocodiles are spotted in the shallow water at the edge of the river; surveying when $\geq$ 60 cm of bank is exposed assures that a minimal number are missed because of screening by vegetation.

The location (±100 m) of each crocodile spotted is recorded. Whenever possible, the animal is approached to within 6 m and its size is estimated by an experienced observer, who also notes its situation on the bank or in the water. Measurements are also made, at 5 km intervals, of air and water temperatures, salinity and light level.

The survey methods outlined yield a distribution of crocodile numbers and size classes for the tidal system. The question then is: what relation do these numbers have to the actual number of crocodiles on the system? The Blyth River calibration survey study was initiated in 1976 to gain some insight into this difficult question (Messel 1977 and Monograph 1). Two 10 km calibration sections were surveyed 204 times.

It was shown in Monograph 1 that, providing surveys are made when EB $\geq$ 60 cm, in the manner indicated, there is no statistically significant variation in the fraction of crocodiles counted on surveys made during any time of the night and no significant variation between surveys made on incoming or outgoing tides. It was further shown that there is no consistent statistically significant variation between surveys carried out during different periods of the dry season.

In Monograph 1, it was also shown that the estimate for the actual number of crocodiles present on the river is approximated by the expression (aN ± b N), where N is the number of crocodiles sighted on a single survey (N to be > 10) and the coefficients 'a' (the inverse of the average fraction of crocodiles counted) and 'b' have different values for the various size classes, and b includes the confidence level factor. Values of a and b are given in the accompanying Table. For instance, for non-hatchlings the implication is that 95% of observations would fall in the interval (1.64N ± 2.01 N) and 99% of the observations in the interval (1.64N ± 2.64 N). For simplicity of interpretation, a difference between two counts will be called significant at the 95% (99%) level if the two counts do not overlap at their 95% (99%) confidence limits. These coefficients were derived on the basis that the counts were well described by the binomial distribution. Full details may be found in Chapter 5 of Monograph 1.

Size Classes	95% Confidence Level		99% Confidence Level	
	a	b	a	b
Hatchlings	1.59	1.89	1.59	2.49
Small (2-6')	1.49	1.68	1.49	2.21
Hatchlings plus small	1.52	1.73	1.52	2.28
Non-hatchlings	1.64	2.01	1.64	2.64
All crocodiles	1.59	1.89	1.59	2.49

RESULTS

The picture of the dynamics of *C. porosus* that has emerged from our studies and which is presented in our earlier chapter on population dynamics, shows that when discussing population increases or decreases, it is usually essential to consider not only results for individual waterways, but also those for broad groups of tidal waterways. We were able to show in Monographs 1, and 9 to 11, that a decrease in crocodile numbers in a TYPE 1 tidal waterway need not necessarily imply that the population of *C. porosus* is decreasing. The decrease may only imply that a fraction of the sub-adult *C. porosus* has been excluded from the system by breeding adults. Furthermore, the surviving fraction of the excluded sub-adults could give rise to a increase in population numbers in adjacent TYPE 2 and TYPE 3 waterways, and they could in due course return to the TYPE 1 system. Because *C. porosus* is known to travel long distances (Webb and Messel 1978), it is necessary first to consider small geographic subgroups and then larger groupings of tidal waterways covering broader geographic areas, if one is to appreciate the overall changes occurring in the populations of *C. porosus*. The tidal waterways considered in each Monograph normally form a natural geographic subgroup and these often contain a mixture of TYPE 1, TYPE 2 and TYPE 3 systems. For instance those in Arnhem, Buckingham and Castlereagh Bays form such subgroups. In particular it should be realized that repeated surveys of just one part of a waterway can be very limited value because of seasonal adjustments that occur in the distribution of animals on a complete waterway, as well as movements in and out of the waterway.

In Table 1 we present the following results up to the end of 1979 for each survey of the tidal waterways of the Northern Territory, Western Australia and Queensland: the number of *C. porosus* sighted within each size class, the midstream distance surveyed, density of non-hatchlings sighted and the 95% confidence level for the estimate of the actual number of non-hatchlings present. Also shown is the broad classification of tidal waterway TYPE as determined by the salinity signature of the waterway. It usually does not include the often differing TYPES of the waterway's sidecreeks; the dominant TYPE only is normally given. All crocodiles whose size class could not be determined positively (the EO, EO > 6' and EO > 6' classes) have been lumped together and shown in the EO size class. When it is necessary to allocate these crocodiles to various size classes, it is probably best to use the scheme outlined in Table 3 in the Population Dynamics Chapter.

Our results for the tidal waterways of the Northern Territory are presented in the same sequence as the Monographs. We then group and sum the results for the latest survey of each waterway, according to TYPE 1 (and waterway whose TYPE has a "1" in it), TYPE 2-3 (any waterway whose TYPE has a "2" but not a "1" in it) and TYPE 3. The summing of these three then yields the overall results for the Northern Territory. The percentage which each size class constitutes of the total number of *C. porosus* sighted is also shown. Next, we present the overall results for subgroups of waterways, grouped according to geographic proximity. Wherever possible, we show results for the 1975 and 1979 surveys so that increases or otherwise in population size for the geographic areas concerned may be examined. Finally the latest surveys (up to the end of 1979) of the tidal waterways of the Northern Territory are gathered and summed for the four large geographic areas:

1. Gulf of Carpentaria, which covers tidal waterways from the Queensland border of Gove (Figs. 5 to 7 Chapter 9, Monograph 1).
2. North Arnhem Land, which covers the tidal systems from the Burungbirinung River in the east to the King River in the west (Fig. 5 Chapter 9, Monograph 1).
3. Darwin eastward to the Cobourg Peninsula including Melville Island waterways (Fig. 4 Chapter 9, Monograph 1).
4. Darwin westward, from Port Darwin to the Victoria River near the Western Australian Border (Figs. 2 and 3 Chapter 9, Monograph 1).

The total number of *C. porosus* sighted, to the end of 1979, on the 3,997.6 midstream km of tidal waterways surveyed in the Northern Territory was 5,472, of which 1,293 were hatchlings. Since only some 50% of hatchlings survive from June of their first year to June of the next (Table 8.4.1, Monograph 1), they should not be included in any estimate of the viable population. We therefore usually give densities and estimates for the actual number of crocodiles present for the non-hatchling classes only. On this basis the overall density of th 4,179 non-hatchling crocodiles sighted is 1.0/km and the 95% confidence levels for the estimate of the number present is 6,724-6,984. This figure and corrections made to it for waterways which were not surveyed is discussed later, as are the results for Queensland and Western Australia.

The density figure of 1.0/km is of very limited value, for the density of non-hatchlings sighted in TYPE 1 and non-TYPE 1 systems is quite different. On the 2,175.5 km of TYPE 1 tidal waterways surveyed, the density of the (4,491-1,197 =) 3,294 non-hatchlings sighted was 1.5/km whereas on the TYPE 2.3 and TYPE 3 systems it was 0.5/km and 0.4/km respectively.

The size class structure of the crocodilians sighted in the TYPE 1, 2 and 3 systems also varies (Table 1). However, it should be cautioned that there can be considerable overlap and merging between the system TYPES. For instance large TYPE 1 tidal waterways such as the Adelaide and Liverpool River systems contain TYPE 2 to TYPE 3 systems as well. If these were subtracted from the systems, the difference would be further exaggerated. Table 1 also shows the percentage which each size class constitutes of the total number of crocodiles sighted. Thus in TYPE 1 systems some 27% of the crocodiles sighted are hatchlings, whereas in TYPE 2-3 systems this figure falls to 14% and in TYPE 3 systems down to 4%, showing a much decreased hatchling recruitment in non-TYPE 1 systems. In TYPE 3 systems the percentage of crocodiles in the hatchling, (2-3') and (3-4') size classes combined is some 11% whereas in TYPE 1 systems it is at least 52%. On the other hand the percentage of crocodiles in the ≥ (4-5') size classes is some 39% in TYPE 1 systems and 73% in TYPE 3 systems. These percentages do not take into account the EO class which amounts to 10%, 16% and 16% for TYPE 1, TYPE 2-3 and TYPE 3 systems respectively. However since large crocodiles are usually more wary than small ones (Webb and Messel 1979), any correction would tend to exaggerate further the differences between the TYPE 1 and non-TYPE 1 systems. It is likely that the difference between the figure of 10% for the EO size class in TYPE 1 systems and 16% for non-TYPE 1 systems is accounted for by the fact that there is a higher fraction of large crocodiles in non-TYPE 1 systems than in TYPE 1 systems. These results for size class structure indicate the utility and importance of our classification of waterways.

In Tables 1A and 1B of the Population Dynamics Chapter we give in the same format the results of surveys since 1979 in the monitored area, and in the Alligator Rivers Region and the Adelaide River. Table 2 of this Chapter gives the results for the resurveys of the waterways of the Gulf of Carpentaria carried out in 1985. For convenience, the earlier results for these latter systems are repeated in Table 2.

POPULATION STATUS

__1979 Estimate for the Northern Territory__ - On the basis of the surveys carried out up to and including 1979 we estimated in Monograph 1, Chapter 9, the total population of *C. porosus* in northern Australia. We now reproduce that estimate and the basis for it.

Of the 3,997.6 midstream km of tidal waterways surveyed in the Northern Territory in 1979, 54% (2,175.5 km) were TYPE 2-3 and 22% (883.7 km) were TYPE 3 systems. In making corrections for tidal waterways not surveyed, one should use the density appropriate to the waterway TYPE, because as we saw in the Results section the densities are quite different between the different TYPES.

Our estimate of the surveyable distances of tidal waterways not surveyed systematically in the Northern Territory is as follows:

	km
Melville and Bathurst Islands	330
Western Australian border to Gove	280
Gulf of Carpentaria	50
	660

Since practically all of these waterways are non-TYPE 1 systems, many being difficult to enter, and also since we had a very large sample of non-TYPE 1 waterways, it was thought not worthwhile endeavoring to survey them. During 1972 one of the authors (HM) had surveyed most of the waterways on Melville and Bathurst Islands which were omitted thereafter, and it was found than that these waterways contained even fewer *C. porosus* than those tidal waterways on Melville Island chosen for more intensive study (Monograph 6).

The shores of the coastline amounting to some 3,200 km were not surveyed either for a number of reasons. First there is the risk to life involved in trying to do so; secondly, on each occasion that we have surveyed long sections of bays and inlets at considerable cost and danger, we have sighted either no or only sporadic *C. porosus*. Though the density of *C. porosus* along the shores of the coastline may have been greater in bygone days, it is almost negligible at present and must be considerably less than 0.1/km (see Monograph 9). The reasons for this are probably many. The more important are that there are so few *C. porosus* and that they appear to dislike waves intensely (see Appendix A 1.2 of Monograph 1; wave action on the northern Australian coastline is high during much of the dry season). There is also little vegetation to provide cover along the long stretches of sandy and rocky foreshores.

In each tidal waterway surveyed, the survey boats proceeded as far upstream as depth of water would permit. In the case of non-TYPE 1 systems this constituted a much higher fraction of the overall waterway than in the case of TYPE 1 systems which have more extensive drainage courses. In most instances in non-TYPE 1 systems, the extreme upstream sections have no water in them near low tide and thus their omission yields almost negligible error in the estimate for the actual number of *C. porosus* present on the system. The case of TYPE 1 waterways is more complex, for here the waterway courses may have non-navigable (by survey boat) freshwater sections greater in length then the surveyed sections. These are usually beyond the tidal limit and often consist of intermittent waterholes with intervening sections which are dry during the dry season. *C. porosus* is known to inhabit the freshwater sections but its density is small. On these sections of the waterways *C. johnstoni* appears to be the main species (Monographs 2, 3, 12, 13 and 16). The Roper River is an example of such a river system, as are the McArthur, Adelaide, Alligators, Prince Regent, Mitchell, Ord and Victoria River systems. A pointed out in Chapter 6 of Monograph 1, in our discussion of the distributional pattern of *C. porosus*, the number of *C. porosus* sighted int he freshwater section of the Blyth River falls quickly and drastically as one proceeds further upstream. The same phenomenon was discussed again at some length in Monographs 10 and 12, where it was cautioned that care must be taken when comparing non-hatchling *C. porosus* densities of one waterway with another. By including long freshwater sections one can bring down the density figure to very low values. For instance on the Roper River we found a non-hatchling density of 1.14/km. The density of the 20 non-hatchlings sighted on the 68.5 km of freshwater sections above km 85 was only 0.3.km. During the calibration surveys on the Blyth River, the average density of non-hatchlings sighted on the first purely freshwater (km 40-45) section was only 1.1/km compared to at least 2.7/km for the whole river system. The density falls rapidly as one proceeds upstream of km 45. On the basis of the above discussion, one could perhaps add some 1,000 km of TYPE 1 river distance to the 2,175.5 km surveyed, but the density of *C. porosus* on these unknown sections is unlikely to be more than 0.2/km. During 1972 we systematically surveyed waterhole after waterhole on the sections of the Goyder River upstream of the Goyder crossing and sighted only 2 *C. porosus*. The Goyder River runs into the Arafura Swamp which is known to be one of the few large remaining freshwater swamp areas in northern Australia.

The relatively few freshwater swamps both large and small in the Northern Territory are known to contain populations of *C. porosus*, but these have not been inventoried systematically and the present extent of the populations in them remains unknown. However, from the many casual observations already made, we believe it is likely to prove to be considerably less than 20% of the population sighted in tidal river systems.

On the basis of the above and with due reservations being made, our generous estimate for the number of sightings of non-hatchling *C. porosus* in the Northern Territory which were omitted from our tidal river survey is:

Unsurveyed tidal waterways (660 km x 0.5/km)	330
Unsurveyed freshwater sections of TYPE 1 systems (1,000 km x 0.2/km)	200
Unsurveyed foreshores of coastline (3,200 km x 0.05/km)	160
Freshwater swamps, taking 20% of the number sighted in tidal systems	836
	1,526

If one applies the same confidence limits for these 1,526 non-hatchlings as we have for our surveys (this procedure for the assumed 836 non-hatchlings in freshwater swamps is dubious, but is as valid an assumption as any other at present!) then there could be between 2,424 and 2,582 non-hatchlings additional to the 6,724-6984 derived from the surveys. Thus using (4,179 + 1,526 =) 5,705 non-hatchlings, there could be between 9,204 and 9,508 non-hatchling *C. porosus* in the Northern Territory as of October, 1979. We feel it would require unrealistic assumptions to carry this figure much above 10,000. We even retain some doubts about the maximum figure of 10,000; it may well be a substantial overestimate. On the other hand, we do feel that our estimate of 6,724 to 6,984 is a reliable lower one for the actual number of non-hatchling *C. porosus*, for this figure is based upon careful and systematic observations made over a period of almost 5 years and some 50,000 km of waterway travel.

Western Australia in 1978 - Tidal river systems in the Kimberley were chosen for survey by the Department of Fisheries and Wildlife, Western Australia (Messel et al. 1977, Burbidge and Messel 1979). It is believed that the majority of the large Kimberley tidal waterways were surveyed; the only significant areas not surveyed are the Walcott Inlet-Secure Bay area and the West Arm of the Cambridge Gulf, with their associated rivers and creeks. It is also believed that small populations occur in such areas as the mouth of the Drysdale River. Commonly, small coastal rivers and creeks in the Kimberley have short surveyable tidal sections which are terminated by rocky ledges and often by waterfalls.

We believe that we examined more than half of the better *C. porosus* habitat in the Kimberley. In the 527.3 km surveyed, 898 crocodiles were sighted of which 227 were hatchlings. The 671 non-hatchlings yield a density of 1.3/km and the estimate for the actual number of non-hatchlings present, at the 95% confidence level, is 1,048-1,152. Assuming that the number of non-hatchlings which would be sighted in the areas not surveyed is also 671 we obtain lower limits of 2,127-2,275 for the number of non-hatchlings remaining in the Kimberley as of July 1978. One can extend this estimate (of say 2,500) almost without limit if one cares to make what we feel would be unreasonable assumptions.

Queensland in 1979 - A sample of four major tidal waterways on the west coast of southern Cape York Peninsula, which were known to have contained some of the best populations of *C. porosus* during the 1950's and 1960's, was chosen by the Queensland National Parks and Wildlife Service for survey. In addition the Port Musgrave area, containing what is believed to be the best remaining tidal waterway habitat for *C. porosus* in Queensland, and the Escape River on north-eastern Cape York Peninsula, were also chosen for survey. As seen in Table 1, the results for the Port Musgrave area and the other areas were quite different. Whereas the non- hatchling density was 1.8/km for the 241.0 midstream km surveyed on the Port Musgrave waterways, the non-hatchling density for the groups of waterways on south-western Cape York Peninsula (359.7 km) was only 0.4/km surveyed) is 0.9/km and the estimate at the 95% confidence level for the actual number of non-hatchlings present is 945-1,043.

What estimate can one make for the number of non-hatchling *C. porosus* in overall northern Queensland? The lengths of the remaining waterways on the maps look large, but most of the rivers have relatively short navigable sections. Without carrying out further surveys one can only make a broad estimate; it would be surprising if non-hatchling *C. porosus* densities on them were as high as the 0.4/km we found for the southern waterways surveyed. Erring on the generous side, we estimate that there are probably a further 2,400 km of waterways not surveyed. Using a non-hatchling density of 0.4/km this would yield a further 960 crocodiles which would be sighted. On this basis, the estimate at the 95% confidence level for the actual number of non-hatchling crocodiles present, using the (606 + 960 =) 1,566 value, is 2,488 to 2,648 or say 3,000. However, without further surveys one is unable to substantiate this number.

<u>Northern Australia in 1979</u> - We now have estimates for the populations of non-hatchling *C. porosus* in the Northern Territory, the Kimberley of Western Australia and northern Queensland. However only the figures for the tidal waterways surveyed may be deemed to be reliable; the remainder are probably upper limits and may be over-estimated considerably. With this warning in mind our upper estimates for the non-hatchling *C. porosus* populations were:

Northern Territory	10,000
The Kimberley	2,500
Northern Queensland	3,000
	15,500.

<u>'Dry Wet' Seasons in estimating population status</u> - 'Dry wet' seasons play a very important role in the dynamics of *C. porosus* populations, and it was the continuing of the surveys after 1979, in the monitoring area, that allowed us to unravel this as we described in our Population Dynamics Chapter--see Tables 1A and 1B of the same Chapter. By a 'dry wet' we mean a west season which has considerably less than the usual amount of rainfall and thus does not give rise to extensive flooding of the tidal upstream sections of the waterways. The wet season of 1978-1979 was an exceptionally dry one and those of 1981-1982 and 1982-1983 were also dry ones. As is evident from the Tables, there was in 1979 an increase in the number of sightings in the tidal waterways, right across the Northern Territory. At the time we interpreted this increase as a sign of the expected recovery of the population. Now, however, we believe this interpretation may have been too optimistic. To account for the results in our monitoring area, the only reasonable explanation we are able to give, which is in accord with the observations made during the 1979, 1982 and 1983 surveys following 'dry wet' seasons, is that the Arafura Swamp is acting both as a breeding system (during normal wet season periods) and as a rearing stockyard of varying extent, for sub-adult crocodiles from Arnhem Bay in the east to the King River in the west. The Blyth-Cadell System is a very important component of this. During a severe 'dry wet' season as in 1978-1979, the water levels in small and large swamps fall drastically and crocodiles inhabiting these have no choice but to leave. They can only return to the tidal waterways, both TYPE 1 and non-TYPE 1, and this they do--as they did in 1979 and 1982. Many animals frequenting the alternative freshwater habitat must have come from TYPE 1 tidal breeding systems and hence, as the swamps dry, some of the sub-adult animals probably return to the tidal system from whence they originally came, the others apparently have to frequent non-TYPE 1 tidal systems--even though temporarily--until they can go back to the swamp rearing stockyard or a TYPE 1 system. Some of the returning large animals appear successful in establishing a territory for themselves (and perhaps a few of the 3-6' animals also); the others appear to be excluded yet again-- and specially the 3-6' and sub-adult large

animals--on the commencement of the breeding season. When the next 'dry wet' arrives [if there has been the usual wet season(s)], large and sometimes 3-6' animals again are excluded from the swamps and the degree of the process must depend upon just how 'dry' the wet season is--upon how much the swamp water levels fall. The whole process is superimposed upon the normal exclusion and re-entry of animals which takes place in usual years and which accounts for most of the sub-adults sighted in non-TYPE 1 systems. Thus, whether 'dry wet' seasons are the proximal factor involved or not, they are certainly associated with the major influxes of large and sometimes 3-6' animals sighted on the tidal waterways during surveys made in June-July, after a 'dry wet'. Thus 'dry wets' appear to play a very important role in the dynamics of *C. porosus* populations.

As we have said, the influxes of large and sometimes small animals in 1979 were in fact a general phenomenon on the tidal waterways of the Northern Territory (Table 1). It was especially marked on the waterways of the Alligator Region (on the Wildman, for example, 21 large animals were sighted in September, 1978 and 56 were sighted in August, 1979). Both these systems have fairly extensive associated freshwater complexes. Increases also occurred on non-TYPE 1 systems with little associated freshwater complexes, for example on the TYPE 3 waterways of the Milingimbi Complex the number of animals ≥ 4-5' increased from 29 to 63 between 1975 and 1979. In the latter cases the animals could only have come from further afield (in the Milingimbi case, from the Arafura Swamp via the Glyde River). A very interesting exception to the general pattern was the waterways of Arnhem Bay. There was no increase in the number of large animals sighted between 1975 and 1979, and this could be connected with the relative lack of swamp associated with this whole area and the somewhat wetter climate there.

1985 Update - Our estimate of 15,500 for 1979 was based, as discussed earlier, on counts carried out in a year when most crocodiles were concentrated into the tidal waterways. Our allowance for the numbers in the relatively scarce swamp areas was very likely too generous; it is hard to know with certainly as systematic and reliable surveying of such freshwater habitat has not been carried out extensively and usually requires methods quite different from those applicable on tidal waterways. In October, 1983 we surveyed the largest remaining open body of water in the Arafura Swamp (the old Arafura billabong) and sighted 70 animals including 32 ≥6', concentrated into its 2 km. Taking into account the few remaining open water billabongs and low water level in the swamp, we estimated 400 as a generous upper limit to the number of crocodiles in the swamp at that time.

Our results in the monitored area between 1979 and 1983 (see Tables 1A and 1B of the Chapter on Population Dynamics and the "Overview" paper in Monograph 18) gave no reason for modifying the 1979 estimate by much to obtain the 1983 population.

Though there appears to have been no sustained significant increase in the number of non-hatchling crocodiles sighted on the tidal waterways of the Maningrida area since our surveys started in 1974, the size structure of the animals sighted appears to have been changing slowly. Notwithstanding substantial fluctuations, the ratios of small (2-6') to large (≥6'), and 3-6' to large animals was decreasing on the Blyth-Cadell, may have been decreasing on the Liverpool-Tomkinson and was decreasing overall on the tidal waterways of the Maningrida monitoring area. Thus there was some indication of the commencement of a slow recovery phase.

In the case of the tidal waterways of the Alligator Region and the Adelaide River System, we were able to show (Population Dynamics Chapter), as expected from the model, an important and apparently continuing recovery was underway; that the Adelaide River System was recovering faster than the rivers of the Alligator Region. The tidal waterways in the Alligator Region indicate the potential for recovery , at a rate equal to or even better than that found for the Adelaide System. However, at present too many crocodiles are being killed in fishing nets so the potential cannot be realized until the commercial net fishing for barramundi is halted in these rivers, all of which are in Australia's Kakadu National Park. Restoration of habitat after eradication of the feral water buffalo will also aid the full recovery of the population (both in the Alligator Region and the Adelaide River). The Adelaide however does not have the protection of being in a national park.

The present results for the 787 km of tidal waterways resurveyed in the southern Gulf of Carpentaria (Table 2) shows that the *C. porosus* population in this area remains as severely depleted today as it was in 1979. There has been no significant change in this population, however there is some hint, from the smaller numbers sighted in the TYPE 3 creeks, that it is dropping even lower. There can be little hope for these populations in the southern Gulf if barramundi netting in the area is not severely curtailed. Even the *C. porosus* population in the Roper River System is in great danger, if netting is allowed to continue well upstream--to the km 61.5 point. This ensures that the major fraction of the *C. porosus* population in the System is within the netting limit (see Fig. 12.31 Monograph 12). If the Roper System is depleted then there will be little hope for the long term survival of the remnant *C. porosus* population in the other tidal systems in the southern Gulf of Carpentaria, such as the Limmen, Towns, Yiwapa and Nayarnpi nearby. These systems depend to a large degree on animals excluded from the Roper System. They cannot rely on animals excluded from the large McArthur System, for it is already as depleted as they are.

During the past three dry seasons we have resurveyed some 2,111 km of tidal waterways in the Northern Territory as follows:

		km
1983	Northern Arnhem Land, Maningrida area	462.9
1984	Alligator Region - Adelaide River Systems and Cobourg Complex	861.2
1985	southern Gulf of Carpentaria	787.0
		2,111.1

This constitutes more than 50% of the some 4,000 km of tidal waterways surveyed to the end of 1979 in the Northern Territory.

On the basis of the data we have gathered on our resurveys between 1979 and 1983, and during 1983, 1984 and 1985, we can now update our 1980 estimate for the non-hatchling *C. porosus* population in the Northern Territory (Chapter 9 Monograph 1). Keep in mind that such a large portion of the hatchlings are lost each year that they are not a good indicator of population trends. Hatchling numbers may increase dramatically during the hatchling season and decrease during the rest of the year; they are also very variable from year to year. If a census were taken later in the year after many hatchlings have been lost, the same population would be smaller. This is why crocodilian monitoring programmes all over the world, e.g., North America, India, Africa, focus on non-hatchlings. Our 1980 estimate was 10,000 non-hatchlings and allowing for the recovery of the population on the Adelaide and Alligator Rivers we found in 1984, we feel that estimate might be increased by up to 20 percent, perhaps to a figure of some 12,000 non-hatchlings now. One cannot be more precise about such an estimate.

The probability of the *C. porosus* populations in the Kimberley of Western Australia recovering over a period of several decades is fair, especially in the George Water, St. George Basin, Roe-Hunter and Ord River waterways where barramundi net fishing in the rivers is minimal and there is no destruction of nesting habitat by feral water buffaloes. We will be resurveying areas in Western Australia in 1986.

The same cannot be said for most of the tidal waterways in northern Queensland, especially in the light of our resurveys of the southern Gulf of Carpentaria. In these, the density of *C. porosus* is probably already at dangerously low levels and recruitment is minimal. Barramundi net fishing which is allowed in the rivers is not only quickly exhausting the rapidly dwindling barramundi resource but is drowning a substantial fraction of the few remaining large *C. porosus*. It is likely that, with the exception of the Port Musgrave area, the population of *C. porosus* in northern Queensland is still falling and is well on the road to exhaustion.

MANAGEMENT OF THE *C. porosus* POPULATION

What are the management implications of our results? We are not management authorities, but are aware that a multitude of factors--some of them political--must be taken into consideration. For example, for reasons based on public safety, Australian society could decide that all waterways utilized for business and/or pleasure or which had settlements near them, should be cleared of *C. porosus* and the *C. porosus* should be allowed to exist and perhaps recover, only in a number of designated parks and/or reserves used for scientific and/or tourism purposes (we have suggested some suitable areas in Chapter 9, Monograph 1, p. 439). Such a decision would result in the removal of *C. porosus* from many of the waterways in northern Australia and could have far reaching ecological consequences, many of which probably could not be foreseen beforehand. Based on examples from elsewhere in the world, we know that the removal of a predator from the top of a complex food chain cannot occur without some major consequences. The Australian people would have to decide whether the unhindered enjoyment of the waterways of northern Australia is worth the risk of possibly disastrous consequences to the whole ecology of the waterways. The fishing industry is one group that readily springs to mind as a possible sufferer.

Or it might be decided to encourage the establishment of a commercial *C. porosus* skin industry based upon the wild population. Since some 70% of the 3-6' animals are lost--and these are the most valuable ones commercially--one is tempted to believe that their removal beforehand would yield a valuable resource without harming it. But one must proceed with extreme caution before embarking upon such an enterprise. Undoubtedly the exclusion and/or loss of some 80% of the 3-6' animals is an integral part of the vital process of sorting out the successful from the less successful, or sorting out the stronger and more dominant component of the population. Removing a given fraction of the population might very well remove the stronger component and thus over the long term set the population on a declining course. We simply do not know. On page 15 of Monograph 1, we proposed in 1981 a critical experiment to test the effect of removing a given fraction of the (3-6') *C. porosus* population and proposed that some 25 to 40% of the (3-6') animals be removed annually for a period of 4 to 5 years from the downstream sections of the Adelaide River to see what effect if any this had upon the population in that river. For the experiment to be meaningful, one had to monitor the population changes on another set of control tidal waterways in which the *C. porosus* population remained untouched. The University of Sydney financed the costly monitoring of a control group of waterways for 4 years and this work has now been completed successfully. Though the proposed experiment had very important ramifications for the management and ranching of the *C. porosus* resource, no financial support had been forthcoming, from relevant authorities, for the other half of it. The original opportunity has been lost, but the experiment still must be done (though at much greater cost) so that important management decisions can be made on an adequate data base.

We have already mentioned two very important factors affecting any possible *C. porosus* recovery, that can be influenced by correct management. The first of these is prevention of further destruction to habitat by the feral water buffalo and a program to allow recovery of already damaged habitat. The second factor is the continuing loss by drowning in fishermen's nets of hundreds of large crocodiles per year (see Monograph 1:437-438). Some of these nets are set legally. Our results show that over 80% of the 3-6' animals are excluded from many TYPE 1 waterways and that this exclusion also involves large animals; that there is great and continuing movement of these animals into and out of the river systems. Allowance of net fishing in or at the mouths of rivers, specially the TYPE 1 waterways is certain to remove an important component of the large animals and could well ensure that the population in those waterways never recovers or even declines. For instance, we believe that the decrease in the number of large animals sighted on the West Alligator and Wildman Rivers shown in Table 9 of the Population Dynamics Chapter is probably due to the continuing heavy commercial net fishing in those rivers. The total lack of any recovery over six and a half years in the waterways of the southern Gulf of Carpentaria, described earlier, is also undoubtedly due to continuing net fishing.

Undoubtedly economic and political considerations are involved in arriving at a reasonable compromise in relation to the matter of commercial net fishing in tidal waterways. We have no desire whatever to become involved in argumentation about it. At the very minimum it is suggested that all net fishing be definitely phased out over a period of two years in rivers included in national parks (it is still legal to set nets in the tidal waterways of Kakadu National Park). The continued loss of very valuable large crocodiles in the quest for the rapidly dwindling barramundi resource should be stopped.

Crocodile farming should be encouraged and removal of eggs from the wild from nests which are known to be flooded during the January-March period might be considered on certain selected tidal waterways. Early November nests or March-April late nests must not be robbed. Because of the heavy losses of hatchlings and 3-6' animals, we feel that release of such animals into TYPE 1 systems, except in cases of very depleted systems, is purely cosmetic and a waste of effort. If restocking is to be considered then TYPE 2-3 or TYPE 3 systems and freshwater complexes should be uses, and only ≥4' size classes should be released. Even then, many uncertainties remain about the success of such a restocking policy.

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Table 1. Number of *C. porosus* sighted within size class on tidal waterways of the Northern Territory, Western Australia and Queensland during night time spotlight surveys[a].

System	Date	Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
							MONOGRAPH 1							
BLYTH-CADELL	Oct. 74	387	89	81	147	58	6	2		4	91.9	3.2	454- 524	1
	Nov. 75	353	50	106	81	72	23	4	2	15	94.9	3.2	462- 532	
	Sept. 76	348	82	63	104	46	14	7	6	26	92.0	2.9	403- 469	
	Nov. 76	307	61	61	103	47	10	4	2	19	92.0	2.7	371- 435	
	Apr. 77	327	72	70	108	48	10	2	4	13	92.0	2.8	386- 450	
	May 77	333	88	60	94	55	13	4	1	18	92.0	2.7	370- 432	
	June 77	365	108	36	102	69	13	10	3	24	90.5	2.8	389- 453	
	Sept. 77	386	105	45	132	47	17	4	4	32	90.5	3.1	427- 495	
	Oct. 77	360	112	68	83	47	18	8	3	21	90.5	2.7	375- 439	
	June 78	432	173	65	81	67	15	6	4	21	90.5	2.9	393- 457	
	Sept. 78	399	155	60	79	56	18	8	6	17	90.5	2.7	369- 431	
	June 79	465	123	91	93	59	31	16	26	26	94.5	3.6	524- 598	
							MONOGRAPH 2							
VICTORIA	Aug. 78	139	13	8	21	22	26	8	13	28	229.1	0.6	184- 230	1
FITZMAURICE	Aug. 78	79	9	5	13	25	6	4	11	6	146.6	0.5	98- 132	1
							MONOGRAPH 3							
ADELAIDE	July 77	417	48	24	88	116	47	35	33	26	226.3	1.6	566- 644	1
	Sept. 78	381	62	24	71	90	43	33	32	26	221.0	1.4	487- 559	
	Sept. 79	374	53	8	46	75	58	47	64	23	231.6	1.4	490- 562	
DALY	Aug. 78	115	5	7	16	25	21	11	18	12	90.0	1.2	159- 201	1
MOYLE	Aug. 78	16			1	4	2	1	2	6	10.0	1.6	18- 34	1
							MONOGRAPH 4 (14)							
MURGENELLA	Oct. 77	95	1	1	8	33	13	6	18	15	45.9	2.0	135- 173	1
	June 78	173	48	16	4	17	24	23	30	11	44.9	2.8	183- 227	
	Aug. 79	198	47	24	12	22	24	27	26	16	45.6	3.3	223- 273	

Table 1. cont.

System	Date		Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
						Numbers in size class									
EAST ALLIGATOR	Oct.	77	318	53	18	37	57	41	40	34	38	114.9	2.3	402- 468	1
	June	78	329	39	14	63	51	42	31	51	38	118.9	2.4	442- 510	
	Aug.	79	393	53	30	44	58	28	58	64	58	119.2	2.9	521- 595	
SOUTH ALLIGATOR	Oct.	77	142			12	24	24	25	31	26	113.8	1.2	209- 257	1
	July	78	157	6	3	4	14	43	24	38	25	113.2	1.3	223- 273	
	Aug.	79	164	4	1	4	12	24	31	51	37	114.0	1.4	237- 287	
WEST ALLIGATOR	Oct.	77	83	9	2	14	14	15	10	10	9	42.2	1.8	104- 138	1
	July	78	85	23	5	12	9	13	10	6	7	40.4	1.5	86- 118	
	Aug.	79	96	12	9	13	14	7	12	14	15	42.2	2.0	120- 156	
WILDMAN	Sept.	78	118	53	16	6	8	10	9	7	9	33.5	1.9	91- 123	1
	Aug.	79	155	21	34	15	14	7	17	31	16	33.5	4.0	197- 243	
								MONOGRAPH 5							
GOOMADEER	Aug.	75	46		27	7	5	4			3	45.3	1.0	61- 89	1
	Sept.	76	52	18	5	8	5	1	3	3	9	45.3	0.8	44- 68	
	June	77	50	2	9	13	10	6	2	1	7	45.3	1.1	65- 83	
	July	79	90	29	14	7	14	10	6	1	9	45.3	1.4	84- 116	
KING	Aug.	75	17	3	3	3	2			4	2	52.0	0.3	15- 31	2
	Aug.	76	37	12	8	7	1	1	1	4	3	52.0	0.5	31- 51	
	June	77	38	18	4	5	5	1		1	4	48.7	0.4	24- 42	
	July	79	48	3		11	10	9	2	5	8	48.5	0.9	61- 87	
MAJARIE	Aug.	75	12	1	1	2	2	1	1	2	2	20.1	0.5	11- 25	3
	Aug.	76	7			3					4	20.1	0.4	7	
	July	79	18			1	7	4	1	3	2	24.1	0.7	21- 39	
WURUGOIJ	Aug.	75	4				3	1				16.4	0.2	4	3
	Aug.	76	1								1	16.4	0.1	1	
	July	79	9					2	2	4	1	16.4	0.5	9	
ALL NIGHT	Aug.	75	3					2	1			9.1	0.3	3	3
	Aug.	76	0									9.1	0.0	0	
	July	79	6		1				1		4	9.1	0.6	6	

System	Date		Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
					Numbers in size class										
								MONOGRAPH 6							
ANDRANANGOO	June	75	40	14	2	5	6			2	11	47.8	0.5	33- 53	1
	Nov.	75	17		1	4		1	2	2	7	47.8	0.4	20- 36	
	Aug.	76	41	7	1	8	10	3	3	1	8	47.8	0.7	44- 68	
	June	77	43	7	1	5	9	4		3	14	47.8	0.8	47- 71	
	Oct.	79	56	4	1	3	9	7	6	10	16	48.4	1.1	71- 99	
DONGAU	Oct.	72	15	2	2		3			8		22.4	0.6	14- 28	2-3
	July	75	10	4			1	4		1		22.4	0.3	6	
	Nov.	75	2				2					22.4	0.1	2	
	Aug.	76	17	3	2	3		1	1	5	2	22.4	0.6	15- 31	
	June	77	17	5	1	3	3	1	1	3		22.4	0.5	13- 27	
	Oct.	79	15				3	3	2	5	2	22.4	0.7	17- 33	
JOHNSTON	Oct.	72	4								4	30.0	0.1	4	2-3
MAINSTREAM	June	77	17					3	3	7	4	30.0	0.6	20- 36	
	Oct.	79	14				1	4	4	1	4	36.3	0.4	15- 31	
OVERALL JOHNSTON	Oct.	79	20			2	1	5	5	2	5	89.8	0.2	24- 42	
BATH	Oct.	72	0									15.0	0.0	0	2-3
	July	75	0									12.0	0.0	0	
	Oct.	79	5		1		1	1		1	1	14.5	0.3	5	
TINGANOO	Oct.	72	0	(however, 2 large slides seen)								14.5	0.0	0	
	July	75	1					1				14.5	0.1	1	
	Nov.	75	0									14.5	0.0	0	
	Aug.	76	1							1		14.5	0.1	1	
	Oct.	79	6				1	2	1	1	1	14.5	0.4	6	
								MONOGRAPH 7							
LIVERPOOL-TOMKINSON	July	76	228	19	39	56	27	13	3	3	68	152.2	1.4	314- 372	1
	May	77	245	40	6	51	59	30	13	5	41	145.1	1.4	307- 365	
	Oct.	77	228	56	7	39	62	24	9	1	30	123.4	1.4	256- 308	

Table 1. cont.

System	Date	Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
					Numbers in size class									
LIVERPOOL-TOMKINSON	Sept. 78	233	37	18	37	65	19	14	8	35	141.4	1.4	293- 349	
	July 79	515	289	11	39	43	34	29	20	50	150.0	1.5	341- 401	
	Oct. 79	355	161	16	36	37	29	17	23	36	141.1	1.4	290- 346	
NUNGBULGARRI	Aug. 75	29		4	11	3		1		10	15.0	1.9	37- 59	2
	July 76	15	2		3	5	1	1		3	13.6	1.0	14- 28	
	June 77	14	2	2		6	1	1		2	13.6	0.9	13- 27	
	July 79	35	10		4	4	6	5	2	4	14.8	1.7	31- 51	
							MONOGRAPH 8							
ROSE	Oct. 78	7				2		3		2	23.5	0.3	7	1
MUNTAK	Oct. 78	3				1				2	6.7	0.4	3	2
HART	Oct. 78	4				1				3	7.5	0.5	4	2
WALKER	Oct. 78	15	1		4	2	1	2	1	4	24.4	0.6	15- 31	1
KOOLATONG	Oct. 78	5					1	2	1	1	11.0	0.5	5	1
							MONOGRAPH 9							
BENNETT	Sept. 75	3			1	1		1			17.6	0.2	3	3
	June 79	10			1	1	3	2	3		53.0	0.2	10- 22	
DARBITLA	Aug. 75	13		1		5	3	2	1	1	34.8	0.4	14- 28	2-3
	June 79	19		2		2		3	3	9	35.7	0.5	22- 40	
DJIGAGILA	Sept. 75	8		1	1	5	1				23.0	0.4	8	3
	June 79	23	1			2	6	5	4	5	25.0	0.9	27- 45	
DJABURA	Sept. 75	3			1	2					21.6	0.1	3	3
	June 79	14	1		1	7	3	1		1	25.7	0.5	14- 28	
NGANDADAUDA	Sept. 75	19	3	2	5	1	1	2	1	4	22.6	0.7	18- 34	3
	June 79	21			2	3	3	4	4	5	23.9	0.9	25- 43	
WOOLEN	Sept. 75	31	5	2	5	3	1	3	6	6	80.4	0.3	33- 53	2
	July 79	57	14	3	6	10	4	2	12	6	102.5	0.4	58- 84	
GLYDE	Sept. 75	28			3	6	2	1	4	12	45.9	0.6	35- 57	1
	July 79	100	36	9	10	9	10	6	6	14	45.9	1.4	89- 121	

Table 1. cont.

System	Date		Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
CADELL								(not used)							
CREEKS	Sept.	75	4		1		1	1			1	7.0	0.6	4	3
HUTCHINSON	Sept.	75	25	6	5	3	4	1	3	2	1	58.3	0.3	22- 40	3 &
	July	79	56	10	3	5	9	13	6	1	9	78.5	0.6	61- 89	mini 1
KALARWOI	Sept.	75	82	38	15	17	3	4		4	1	38.9	1.1	59- 85	1 &
	June	79	132	45	7	16	19	11	16	7	11	40.1	2.2	124- 162	2-3
BUCKINGHAM	Sept.	75	100	10	42	8	14	8	1	3	14	31.1	2.9	129- 167	2
	June	79	101	16	7	24	17	9	8	4	16	35.3	2.4	120- 158	
WARAWURUWOI	Oct.	75	18		1	3	5	4	1	2	2	28.8	0.6	21- 39	3
	June	79	34			1	4	3	7	9	10	37.0	0.9	44- 68	
KURALA	Oct.	75	16			3	5	2	1	2	3	27.8	0.6	18- 34	3
	June	79	26				6	7	3	6	4	36.4	0.7	33- 53	
SLIPPERY	Oct.	75	9			2	1	2	1		3	11.0	0.8	9	3
	June	79	20		2	5	7	2	4			10.7	1.9	24- 42	
								MONOGRAPH 11							
BURUNGBIRINUNG	Oct.	75	13	9	2			2				13.0	0.3	4	2
	May	79	37	3	8	7	8	3	3		5	11.7	2.9	44- 68	
PETER JOHN	Oct.	75	142	27	58	17	23	7	3	4	2	41.5	2.8	167- 211	1
	May	79	300	136	60	48	21	11	5	3	16	42.1	3.9	243- 295	
CATO	Oct.	75	108	59	6	19	10	9	1	3	1	23.5	2.1	66- 94	1
	May	79	89	34	19	19	5	3		4	5	23.0	2.4	75- 105	
DARWARUNGA	Oct.	75	15		1	4	7	1	1	1		47.8	0.3	17- 33	2-3
	May	79	34	1	1	6	10	5	2	2	7	45.0	0.7	42- 66	
HABGOOD R.	Oct.	75	101	13	24	14	25	10	2	4	9	22.0	4.0	125- 163	1
	May	79	111	23	15	23	23	15	3	2	7	22.1	4.0	125- 163	
HABGOOD CK.	Oct.	75	6			1	2	1			2	4.4	1.4	6	3
	May	79	4				3				1	3.4	1.2	4	
BARALMINAR	Oct.	75	15			1	6	4	1	3		25.2	0.6	17- 33	2-3
	June	79	30			5	13	4	3		5	26.4	1.1	38- 60	

Table 1. cont.

System	Date		Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels		Type
				Numbers in size class												
GOBALPA	Oct.	75	15	2		3	6	2	1		1	19.3	0.7	14-	28	2-3
	June	79	17			3	5	3	2	4		21.3	0.8	20-	36	
GOROMURU	Oct.	75	299	128	95	37	14	7	6	6	6	44.3	3.9	254-	306	1
	June	79	410	134	58	139	31	10	5	7	26	48.0	5.8	420-	486	
								MONOGRAPH 12								
LIMMEN BIGHT	May	79	19	1	1		3	8	3	2	1	127.3	0.1	21-	39	2
TOWNS	May	79	55	28	1	6	7	7	2	3	1	57.2	0.5	34-	54	2
ROPER	May	79	430	126	67	41	86	39	34	26	20	262.8	1.2	477-	549	1
YIWAPA	May	79	9				4	2	3			14.6	0.6	9		3
MANGKURDUR-RUNGKU	May	79	2					2				6.5	0.3	2		3
								MONOGRAPH 12								
CALVART	Apr.	79	2					1	1			38.4	0.1	2		2
EINSTEIN	Apr.	79	1								1	6.6	0.2	1		3
MAXWELL	Apr.	79	0									2.0	0.0	0		3
SCHRODINGER/ FERMI	Apr.	79	1							1		2.0	0.5	1		3
ROBINSON	Apr.	79	0									35.9	0.0	0		2
FAT FELLOWS	May	79	1				1					11.0	0.1	1		3
GALILEO	May	79	0									8.0	0.0	0		3
ARCHIMEDES	May	79	3					1	1		1	6.4	0.5	3		3
PLANCK	May	79	1				1					15.1	0.1	1		3
WEARYAN	May	79	4	2				1	1			34.4	0.1	4		2
FARADAY/DAVY	May	79	1				1					10.5	0.1	1		3
COULOMB	May	79	0									13.3	0.0	0		3
McARTHUR	May	79	28			2	3	6	4	5	8	232.6	0.1	35-	57	1
								MONOGRAPH 14								
SALTWATER	Aug.	79	29		1	1	6	4	6	9	2	14.1	2.1	37-	59	3

Table 1. cont.

System	Date	Total	H	2-3	Numbers in size class 3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
MINIMINI	Aug. 79	11			1	4	3	1	2		43.8	0.3	11- 25	3
MIDDLE ARM	Aug. 79	6				3	2	1			28.5	0.2	6	3
IWALG	Aug. 79	10				3	1	2	2	2	53.5	0.2	10- 22	3
ARM A	Aug. 79	5				3		1		1	26.7	0.2	5	3
ARM B	Aug. 79	3				1		1	1		15.0	0.2	3	3
ARM C	Aug. 79	7				3	1	1		2	29.3	0.2	7	3
ARM D	Aug. 79	9				1		3	2	3	19.8	0.5	9	3
ILAMARYI	Aug. 79	16				3	4	3	3	3	44.4	0.4	18- 34	3
							MONOGRAPH 17							
PORT DARWIN	Sept. 79	80	4	8	6	8	8	9	16	21	148.6	0.5	107- 143	2-3
PORT PATTERSON	Sept. 79	10			1	1	2	2	1	3	59.9	0.2	10- 22	3
PORT HARBOUR	Sept. 79	24	2	1	1	4	4		9	3	109.5	0.2	27- 45	3
							LATEST SURVEY ONLY							
Total TYPE 1		4491	1197	478	629	597	392	353	413	432	2175.5	1.5	5287-5517	1
% of total			27	11	14	13	9	8	9	10	54			
Total TYPE 2-3		591	82	32	80	105	79	54	62	97	938.4	0.5	790- 880	2-3
% of total			14	5	14	18	13	9	10	16	23			
Total TYPE 3		390	14	8	20	88	72	61	64	63	883.7	0.4	578- 656	3
% of total			4	2	5	23	18	16	16	16	22			
Overall total		5472	1293	518	729	790	543	468	539	592	3997.6	1.0	6724-6984	1 to 3
% of total			24	9	13	14	10	9	10	11				
							MONOGRAPHS 4 & 14							
ALLIGATOR REGION	77	638	63	21	71	128	93	81	93	88	316.8	1.8	895- 991	1
EXCL. WILDMAN	78	744	116	38	83	91	122	88	125	81	317.4	2.0	980-1080	
	79	851	116	64	73	106	83	128	155	126	321.0	2.3	1151-1259	
ALLIGATOR REGION	78	862	169	54	89	99	132	97	132	90	350.9	2.0	1084-1190	1
	79	1006	137	98	88	120	90	145	186	142	354.5	2.4	1366-1484	

System	Date	Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
					Numbers in size class									
							MONOGRAPH 14							
COBOURG COMPLEX & SALTWATER	79	96		1	2	27	15	19	19	13	275.1	0.3	137- 177	3
ALLIGATOR REGION COBOURG COMPLEX & SALTWATER	79	1102	137	99	90	147	105	164	205	155	629.6	1.5	1521-1645	1 & 3
							MONOGRAPH 6							
ANDRANANGOO,	75	51	18	2	5	7	5	3	11		84.7	0.4	42- 66	1 to 3
DONGAU & TINGANOO	79	77	4	1	3	13	12	9	16	19	85.3	0.9	103- 137	
MELVILLE I.	79	102	4	2	5	16	18	14	19	25	189.6	0.5	141- 181	
							MONOGRAPH 5 & 7							
NUNGBULGARRI TO	75	111	4	35	23	15	8	3	6	17	162.2	0.7	154- 196	1 to 3
KING	79	206	42	15	23	35	31	17	15	28	158.2	1.0	243- 295	
							MONOGRAPH 1, 5 & 7							
BLYTH TO KING BUT	75	712	73	180	162	116	46	13	11	111	416.0	1.5	997-1099	1 to 3
USING LIVERPOOL '76 FOR '75	79	1186	454	117	155	137	96	62	61	104	402.7	1.8	1146-1254	
							MONOGRAPH 9							
CASTLEREAGH BAY	75	130	14	11	19	27	9	12	14	24	304.2	0.4	168- 212	1 to 3
& HUTCHINSON STR.	79	300	62	17	25	43	42	29	33	49	390.2	0.6	359- 421	
							MONOGRAPH 10							
BUCKINGHAM &	75	225	48	58	33	28	20	4	11	23	137.6	1.3	263- 317	1 to 3
ULUNDURWI BAYS	79	313	61	16	46	53	32	38	26	41	159.5	1.6	381- 455	

Table 1. cont.

System	Date	Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
							Numbers in size class							
							MONOGRAPH 11							
ARNHEM BAY	75	714	238	187	96	93	43	15	21	21	241.0	2.0	737- 825	1 to 3
	79	1032	331	161	250	119	54	23	22	72	243.0	2.9	1097-1203	
							MONOGRAPH 1, 5, 7 TO 11							
NORTH ARNHEM LAND TO KING	75	1781	373	436	310	264	118	44	57	179	1098.8	1.3	2234-2384	1 to 3
	79	2831	908	311	476	352	224	152	142	266	1195.4	1.6	3066-3242	
							MONOGRAPH 12 & 13							
GULF SOUTH COAST	79	116	31	2	8	16	24	12	11	12	600.7	0.1	120- 158	1 to 3
GULF SOUTH COAST EXCL. TOWNS	79	61	3	1	2	9	17	10	8	11	543.5	0.1	80- 110	1 to 3
ROPER SYSTEM & COASTAL CREEKS	79	450	126	67	41	90	43	37	26	20	283.9	1.1	495- 567	1 to 3
							MONOGRAPH 8							
GULF WEST COAST	78	34	1		4	6	2	7	2	12	73.1	0.5	42- 56	1 to 2
							TOTALS							
GULF OF CARPENTARIA	78, 79	600	158	69	53	112	69	56	39	44	957.7	0.5	683- 767	1 to 3
NORTH ARNHEM LAND	79	2831	908	311	476	352	224	152	142	266	1159.4	1.6	3066-3242	1 to 3
DARWIN EASTWARD TO COBOURG INCL. MELVILLE	79	1578	194	109	141	237	181	225	288	203	1050.8	1.3	2195-2345	1 to 3
DARWIN WESTWARD	78, 79	463	33	29	59	89	69	35	70	79	793.7	0.5	663- 747	1 to 3
NORTHERN TERRITORY	78, 79	5472	1293	518	729	790	543	468	539	592	3997.6	1.0	6724-6984	1 to 3

Table 1. cont.

System	Date	Total	H	2-3	Numbers in size class 3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
					WESTERN AUSTRALIA - Reports 24 & 34									
LAWLEY	July 77	44	13	1	4	6	8	5	3	4	37.0	0.8	40- 62	2
MITCHELL	July 77	50	8	1	9	12	8	3	6	3	47.7	0.9	56- 82	1
ROE	July 77	176	52	40	27	22	14	8	6	7	68.6	1.8	181- 225	1
HUNTER	July 77	47	11	7	5	10	6	4	2	2	39.3	0.9	47- 71	2
ST. GEORGE BASIN ARMS	July 77	72	10	1	2	18	10	15	13	3	(estimate) 36.0?	1.7	86- 118	2 to 3
PRINCE REGENT	July 77	74	15	4	25	12	8	5	1	4	58.6	1.0	82- 112	1
GEORGE WATER & GLENELG	July 78	213	73	33	26	33	18	12	12	6	96.3	1.4	206- 254	1 to 3
ST. GEORGE BASIN ARMS	July 78	97	25	3	1	13	12	14	25	4	(estimate) 72.0?	1.0	101- 135	2 to 3
PRINCE REGENT	July 78	92	31	11	17	11	8	6	6	2	68.0	0.9	84- 116	1
ORD	July 78	179	14	17	39	50	19	11	8	21	98.4	1.7	245- 297	1
TOTAL LATEST SURVEYS		898	227	113	128	157	93	63	68	49	527.3	1.3	1048-1152	1 to 3
% OF TOTAL			25	13	14	17	10	7	8	5				
					QUEENSLAND - MONOGRAPH 16									
NASSAU	Apr. 79	103	4	27	30	23	7	5	3	4	146.3	0.7	142- 182	1
STAATEN	Apr. 79	20		6	3	2	2	3	3	1	74.5	0.3	24- 42	1
GILBERT	Apr. 79	8				1	3	1		3	65.2	0.1	8	1-3
DUCK	Apr. 79	27		2	5	5	3	6	4	2	73.7	0.4	34- 54	1-3
TOTAL		158	4	35	38	31	15	15	10	10	359.7	0.4	228- 278	1 to 3
WENLOCK	Nov. 79	311	83	67	65	44	8	8	4	32	103.7	2.2	344- 404	1
DUCIE	Nov. 79	201	28	52	48	40	16	3	2	12	109.9	1.6	258- 310	1
DULCIE	Nov. 79	1					1				3.5	0.3	1	1
PALM	Nov. 79	9	1		2	1	1			4	6.0	1.3	8	1
NAMALETA	Nov. 79	14		1		7			1	5	17.9	0.8	15- 31	3

Table 1. cont.

System	Date	Total	H	2-3	3-4	4-5	5-6	6-7	>7	E.O.	Kilometers surveyed	Density	95% levels	Type
					Numbers in size class									
PORT MUSGRAVE	Nov. 79	536	112	120	115	92	26	11	7	53	241.0	1.8	654- 736	1 & 3
ESCAPE	Nov. 79	31	3			5	6	2	7	8	42.0	0.7	35- 57	1
TOTAL QUEENSLAND	79	725	119	155	153	128	47	28	24	71	642.7	0.9	945-1043	1 & 3
& OF TOTAL			16	21	21	18	6	4	3	10				

[a] The midstream distance surveyed and density of non-hatchling crocodiles sighted on it is shown, as are the 95% confidence limits for the estimate of the actual number of non-hatchlings present. The TYPE classification of each waterway is given also (see text).

Table 2. Number of *C. porosus* sighted within each size class on tidal waterways of the southern Gulf of Carpentaria during night-time spotlight surveys carried out during 1979 and 1985.

System		H	2-3	3-4	4-5	5-6	6-7	>7	EO			95% Levels	TYPE
		Numbers in size class											
MONOGRAPH 12													
Limmen Bight													
May 79	19	1	1		3	8	3	2	1	127.3	0.1	21- 39	2
Oct. 85	31[a]	2	1				4	7	17[a]	127.3	0.2	37- 59	
Towns													
May 79	55	28	1	6	7	7	2	3	1	57.2	0.5	34- 54	2
Oct. 85	28		1	1	5	9	2	7	3	57.2	0.5	35- 57	
Nayarnpi													
Oct. 85	5							2	3	17.9	0.3	5	3
Roper													
May 79	439	126	67	41	86	39	34	26	20	262.8	1.2	477-549	1
Sept. 85	405	44	134	43	52	31	34	37	30	262.8	1.4	554-630	
Yiwapa													
May 79	9				4	2	3			14.6	0.6	9	3
Sept. 85	5				1		1	3		14.6	0.3	5	
Mangkurdurrungku													
May 79	2					2				6.5	0.3	2	3
Sept. 85	0									6.5	0	0	
MONOGRAPH 13													
Wearyan													
May 79	4	2				1	1			34.4	0.1	4	2
Sept. 84	5			1			1		3	34.4	0.1	5	
Fat Fellows													
May 79	1			1						11.0	0.1	1	3
Sept. 85	1							1		11.0	0.1	1	
Galileo													
May 79	0									8.0	0	0	3
Sept. 85	0									8.0	0	0	
Archimedes													
May 79	3					1	1		1	6.4	0.5	3	3
Sept. 85	0									6.4	0	0	
Faraday/Davy													
May 79	1				1					26.2	0.04	1	3
Sept. 85										26.2	0	0	
McArthur													
May 79	28			2	3	6	4	5	8	232.6	0.1	35- 57	1
Sept. 85	48	2	14	1	3	1	5	9	13	232.6	0.2	61- 89	

[a] Treat with caution as this number probably includes *C. johnstoni*.