Saltwater Crocodile *Crocodylus porosus*

Grahame J.W. Webb[1], S. Charlie Manolis[1] and Matthew L. Brien[2]

[1] Wildlife Management International, P.O. Box 530, Karama, NT 0813, Australia (gwebb@wmi.com.au, cmanolis@wmi.com.au)
[2] Department of Environment and Science, 5B Sheridan Street, Cairns, QLD 4870, Australia (crocmatt@hotmail.com)

Common Names: Saltwater crocodile, saltie, Estuarine crocodile, Indo-Pacific crocodile, Buaya muara (Indonesia), baya, pukpuk, kone huala (Papua New Guinea), Jara Kaenumkem (Thailand), ius (Palau)

Range: Australia, Bangladesh, Brunei, Cambodia (extinct?), China (possibly historically), India, Indonesia, Malaysia, Myanmar, Palau, Papua New Guinea, Philippines, Seychelles (extinct), Singapore, Sri Lanka, Solomon Islands, Thailand (extinct?), Vanuatu, Vietnam (extinct?)

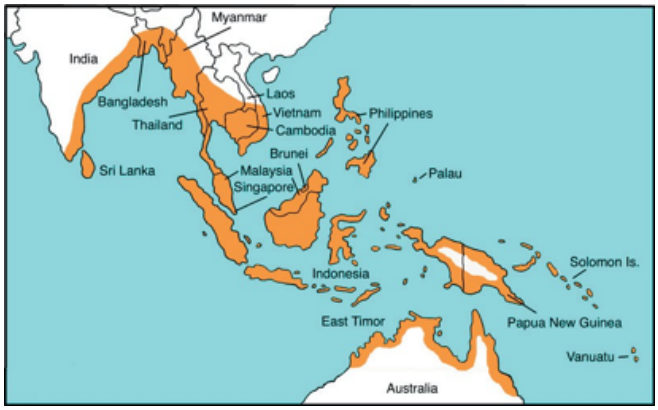

Figure 1. Distribution of *Crocodylus porosus*.

Conservation Overview

CITES:

- Appendix II: Australia and Papua New Guinea (unqualified listing)
- Appendix II: Indonesia [Ranching Resolution Conf. 3.15 (now Resolution Conf. 11.16 (Rev. CoP15)], with special conditions applying to Irian Jaya (now Papua and West Papua Provinces) pursuant to Resolution Conf. 8.22
- Appendix II: Malaysia (restricted to State of Sarawak, with zero export quota of wild specimens for States of Sabah and Peninsular Malaysia)
- Appendix I: All other Range States

CSG Action Plan:

- Availability of survey data: Variable, ranging from "good" in Australia, Malaysia (sarawak), limited in Papua New Guinea and Indonesia, and generally "poor" elsewhere.
- Need for wild population recovery: High in some countries, although constrained by high human population and low habitat availability.
- Potential for sustainable management: High in countries where sufficient habitat remains.

2018 IUCN Red List: Lower Risk/least concern. Global wild population is estimated to be in excess of 400,000 non-hatchlings, with secure populations in Australia, Papua New Guinea and Indonesia (mainly Papua and West Papua Provinces). Range is extensive, although seriously depleted in most other Range States, and considered extinct in the wild in Thailand, Cambodia, Vietnam and the Seychelles (last assessed in 1996; CSG 1996).

Principal threats: habitat destruction, illegal hunting, removal as pests and predators on people and livestock

Ecology and Natural History

Crocodylus porosus is considered the largest of the living crocodilians, with reported lengths of up to 6-7 m (Webb and Manolis 1989, 2009; Whitaker and Whitaker 2008; Britton *et al*. 2012a,b). Although accounting for less human fatalities than the Nile crocodile (Caldicott *et al*. 2005; Crocbite 2018), *C. porosus* prey on people when given the opportunity. It is one of the most widely distributed of all crocodilians, ranging from southern India and Sri Lanka, throughout southeast Asia, east through the Philippines to Micronesia, and down through Indonesia, Papua New Guinea and the Solomon Islands to northern Australia.

Figure 2. Adult male *C. porosus*. Photograph: Grahame Webb.

A great deal of ecological research was carried out in the 1970s and 1980s, particularly in Australia and Papua New Guinea. Despite its common name ("Saltwater crocodile"),

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implying a marine existence, the species inhabits non-tidal freshwater sections of rivers, and inland freshwater lakes, swamps and marshes. Indeed, it thrives in freshwater environments. In the marine environment it inhabits tidal rivers and creeks, where salinity changes with both season and distance upstream. They disperse from rivers and move around the coast between rivers, occupy offshore islands, and clearly make voyages at sea.

Figure 3. Tidal creek habitat of *C. porosus* in northern Australia. Photograph: Grahame Webb.

Long-distance sea journeys occur (Allen 1974; Manolis 2005), but with unknown frequency (eg Cox 1985; Jelden 1985; Webb *et al*. 1984, 1987; Messel and Vorlicek 1989; Webb and Manolis 1989, 2009). Some of the highest densities of *C. porosus* have been reported from heavily vegetated freshwater swamps without any tidal influence (Webb *et al*. 1977, 1984). Breeding and recruitment take place principally in rivers with significant freshwater input, or in freshwater swamps (Jelden 1981; Webb *et al*. 1983; Cox 1985).

Figure 4. Adult male *C. porosus*, Arnhem Land. Photograph: Tom Dacey.

In the tidal waterways of northern Australia the movement of *C. porosus* between river systems appears to be related to sex and ontogenetic changes in social status. Radio and satellite tracking of large, male *C. porosus* are now providing insights into the pattern of movement out of rivers onto the coast, between river systems, and within tidal and non-tidal habitats, including homing associated with relocated individuals (Campbell *et al*. 2010, 2013; Hanson *et al*. 2015; Read *et al*. 2007; Kay 2004; Brien *et al*. 2008; WMI *et al*. unpublished data).

In the Northern Territory of Australia, the recovery of wild *C. porosus* populations following protection (1971) was carefully documented, providing new information on population dynamics. Increasing numbers of large crocodiles over time have been accompanied by decreasing numbers of small crocodiles (Webb and Manolis 1992; Fukuda *et al*. 2011), which are predated or excluded from rivers and sometimes into marginal habitats, including upstream freshwater areas used for recreation by people (Letnic and Connors 2006). The possibility that significant numbers of dispersing *C. porosus* are lost through migration and predation at sea (Messel *et al*. 1981) cannot be discounted.

Figure 5. Aggressive social interaction between sub-adult *C. porosus*. Photograph: Grahame Webb.

Figure 6. Mud crabs are a common food item for *C. porosus* in tidal, saline areas. Photograph: Grahame Webb.

Female *C. porosus* mature at around 2.2-2.5 m (12+ years of age in the wild). In Australia female *C. porsosu* rarely exceed 3 m TL, but in Malaysia (Sarawak, Sabah) females reaching up to 4 m TL is relatively common. Females lay their eggs in a mound of vegetation during the annual wet season (October-May; Webb *et al*. 1977, 1983). Mean clutch size in Australia is around 50 eggs at 113 g per egg (Webb *et al*. 1983), whereas in Papua New Guinea it is around 60 eggs at 100 g per egg (Cox *et al*. 2006). Incubation is typically 80-90 days (depending on temperature).

As nesting is a wet season activity, loss of nests due to flooding is typically very high (Webb *et al*. 1983; Cox 1985). Some wild females actively defend their nests. Loss of eggs to non-human predators is exceptionally low. Lizards (varanids) take eggs, but usually when the eggs are dead and rotten, and can be located by smell. The loss of very small numbers of eggs to rodents has been recorded (WMI, unpublished data), and wild pigs have been reported to raid *C. porosus* nests, but the significance of this has not been demonstrated.

Figure 7. Female *C. porosus* at nest. Photograph: Grahame Webb.

Conservation and Status

Consolidating and improving the conservation and management of *C. porosus* in each Range State is a challenging problem. The species is both widely distributed and occupies a wide range of wetland habitats, from the sea (including thousands of islands) to hundreds of kilometres inland. Throughout most of this region, *C. porosus* are considered dangerous animals by those who share the environment with them. Quantifying status through regular surveys involves daunting logistics, beyond the reach of most national wildlife agencies. The species has the most commercially valuable hide of any crocodilian (Fuchs 2006), and was intensively hunting for skins historically throughout their range, particularly from the mid-1940s to the 1970s.

Depleted populations have the biological capacity to recover reasonably quickly if: (1) habitats are intact; (2) they are given the opportunity through effective protection; and (3) people are prepared to tolerate expanded populations. However, these three preconditions are rarely met. Habitat loss continues to be a major problem in many areas occupied by *C. porosus*, and they are frequently killed as pests regardless of whether their skin is used commercially or not. Unless incentives are provided, in most parts of their range people are not prepared to tolerate increases in *C. porosus* abundance, particularly the 20+-fold increases that are biologically achievable. Information on the current status of *C. porosus* in each Range State is summarized as:

- Australia: Surveys by Professor Harry Messel and colleagues established the baseline for crocodile monitoring in northern Australia in the early 1970s (eg Messel *et al*. 1978-1987). The population was protected (1970 Western Australia; 1971 Northern Territory; 1974 Queensland) after intensive unregulated hunting since 1945-46. The recovering Australian population was transferred to CITES Appendix II (for ranching) under Resolution Conf. 3.15 in 1985 (Webb *et al*. 1984), but since 1994 has had an unqualified Appendix-II listing under the original Berne Criteria. Resolution Conf. 9.24 (Rev. CoP17) was only agreed in 1994. Australia is considered the most secure long-term stronghold for *C. porosus* throughout its range.

- Northern Territory: Spotlight surveys carried out since the early 1970s indicate that in some rivers the population continues to increase, whereas in others numbers have stabilized (Fukuda *et al*. 2011), despite high levels of legal egg harvest (ranching program) in almost all river systems (Saalfeld *et al*. 2016). The size structure is now biased towards larger animals (>2 m), and total crocodile biomass continues to increase, even in rivers where numbers have stabilized (Fukuda *et al*. 2011). The total population in the Northern Territory is considered to be 80,000 to 100,000, near pre-exploitation levels (Webb *et al*. 2000; Fukuda *et al*. 2011; Saalfeld *et al*. 2016). A sustainable use program based on ranching of wild eggs forms the basis of management (Leach *et al*. 2009; Saalfeld *et al*. 2016). A program of problem crocodile removal (Fukuda *et al*. 2014), a limited wild harvest by landowners, and a public education to reduce HCC are all part of the NT management program. Eight farms are currently in operation. The degree to which introduced cane toads (*Bufo rhinella*) have impacted on *C. porosus* is unknown, but is not considered significant (Fukuda *et al*. 2016).

- Western Australia: Major *C. porosus* populations in the northwest of the state occur in protected areas. Between 1992 and 2012, the population monitoring program was based on an annual aerial survey in Cambridge Gulf (Ord River, West Arm), with spotlight surveys carried out less regularly in some areas (Mawson 2004). Regular monitoring is currently restricted to an annual spotlight survey of the King River, which has been surveyed fairly consistently since 1989 (1989-90, 1992-2015, 2017-2018).

  Helicopter count surveys, which target larger animals in the population, indicated mean rates of increase of 5.1% p.a. in the Ord River (2000-2008) and 4.1% in West Arm (1999-2008), with no signs that the populations were approaching stability. This is supported by spotlight surveys of the Ord River (1992-2019), which indicated mean rates of increase, based on all size classes, of 6.9% p.a. in the tidal section and 4.7% p.a. in the non-tidal section of the river. In 2015, spotlight surveys of the Prince Regent, Hunter and Roe Rivers confirmed healthy breeding populations, and a 300% increase in abundance since 1970 (Parke 2015). Cattle grazing is a potential threat to some nesting habitats, and some illegal harvesting of eggs is known to have occurred in 2009-2010.

The increasing *C. porosus* population has prompted authorities to implement a public safety program, similar to the "Be Crocwise" program that operates in the Northern Territory (Parke 2017). Legal harvesting of juveniles, sub-adults, adults and eggs was undertaken in West Arm between 1989 and 1994 to provide stock for crocodile farms. However, only one farm is currently in operation, in Broome, and it is based solely on captive breeding.

- Queensland: There is a high human population on the east coast of Queensland, and significant habitat alteration for agriculture. The abundance of *C. porosus* varies between river systems, with the highest densities reported from northwest Cape York Peninsula (Read *et al*. 2004a,b). Size structure varies between biogeographical regions. Recent surveys (2007) of 47 major waterways (767 km surveyed) along the east coast of Queensland revealed a relative density of 0.36 NH/km (Queensland Parks and Wildlife Service 2007). Crocodiles sighted ranged in size from hatchlings to 5 m, with the majority less than 2 m (61.6%). (excluding "eyes only" in surveys) . Hatchlings comprised 38% of all crocodiles sighted, while "eyeshines" comprised 27.7%. Conversely, surveys based on 10 key river systems in western Cape York Peninsula in 2008 showed a relative density of 0.85 NH/km with moderate breeding populations (Big Gecko, pers. comm. 2009). Identifiable threats to breeding include feral pests (toads) and invasive weeds.

  Based on comparisons with previous survey work (since 1996) in the same areas (Kofron and Smith 2001; Read 2002), the population of *C. porosus* on the east coast of Queensland has been increasing marginally since the 1980s for the majority of waterways north of Cooktown (Read *et al*. 2004). How this relates to the historical population remains unclear. In 2017, the Queensland Government embarked on a 3-year monitoring program involving systematic spotlight and helicopter surveys in carefully selected, previously surveyed river systems throughout the state. This is the most comprehensive program since 2003, and will be used to determine the distribution, abundance and size structure of the population and quantify changes over time. That the Queensand population is approaching carrying capacity in many areas cannot be rejected.

  Over the last few years authorities have been under increasing public pressure to deal with increasing numbers of problem crocodiles in urban areas, where the human population and general publicity are both increasing (Brien *et al*. 2017). Improved reporting through telephone and improved access to data through the CrocWatch website has resulted in a dramatic increase in the number of reports to the Department of Environment and Science, with a mean of 348 reports per year since 2011 (Brien *et al*. 2017).

  The current Queensland Crocodile Management Plan consists of six clearly defined zones, from Central to Far North Queensland, with management actions determined by the likelihood and risk of interactions between crocodiles and people. However, regardless of the zone, any *C. porosus* that poses a threat to human safety is removed by the Government. The number of crocodiles removed or relocated for management purposes (N= 608) has fluctuated widely each year (range 1-57; Brien *et al*. 2017).

  The highest number of attacks, sightings, removals and relocations occurred along the populated east coast between Townsville and the Daintree River, during wet season months (November-February). There have been 35 crocodile attacks in Queensland in 1971-2015 (total 0.8 per year; fatal 0.3 per year), mostly involving local people or regular visitors (77.1%), specifically adult males (71.4%; mean age 44 y). There has been an increase in the rate of crocodile attacks over time, with an average of 1.3 per year since 1996, most of which were non-fatal (84%).

  The utilization of crocodiles on Queensland farms is currently restricted to captive breeding, with some farms importing large numbers of ranched eggs and hatchlings from the Northern Territory and Western Australia. The situation with wild egg harvesting is currently (2018) under review, with a pilot egg harvest program being considered for Pormpuraaw in Far North Queensland.

- Bangladesh: Saltwater crocodiles occur in the Sunderbans (Ganges delta). In 1982, four crocodiles and 20 tracks were recorded during surveys in 450 km (day) and 95 km (night). In 2016, 60 crocodiles and 31 tracks were recorded in 1893 km (day). Protected in 1974, the population was estimated to comprise 150-200 individuals in 1985, 250-300 adult *C. porosus* in 2000, and by 2012 it was considered to not exceed 100-150 adults (Rashid 2013). The reduction in the population is due to a variety of reasons, including an increasing human population, habitat alteration and illegal killing (eg fishermen believe crocodiles compete with them for fish; Manik 2009).

  The Karamjal Crocodile Breeding Centre was established in 2000, and in 2016 breeding stock consisted of two females and one male (Anon 2016a). In early 2017 total stocks comprised 215 crocodiles (Anon 2017). One of the goals of the KCBC is to make animals available for release into the wild, however by 2009 no crocodiles had been released (Manik 2009). In early 2016 about 19 *C. porosus* from KCBC were released into canals and rivers of the Sundarbans (Anon 2016b).

  In February 1999, 143,000ha (143 km^2) or 2.3% of the Bangladesh Sundarbans was declared a Wildlife Sanctuary where extraction/collection of wildlife resources was banned. However, after the devastating Cyclone Sidr in 2007, collection of 'golpata' (palm leaves) for housing and honey was allowed. The sanctuary includes Kotka-Kochikhadi in East Sundarbans, Notabele in West

Sundarbans, and Nikamol in South Sundarbans.

- Brunei: Little information is available on the status of *C. porosus* in Brunei. Cox (2006) reported low numbers in most rivers and creeks in Brunei Bay (relative density of 0.33 ind./km). Habitats are largely undisturbed, so the biological potential for recovery exists if incentives for the local population to accept increased numbers of crocodiles can be provided (Ibrahim and Cox 2006). There have been 8 confirmed attacks by *C. porosus* on humans since 2006 (CrocBite 2018).

- Cambodia: Saltwater crocodiles are considered to be extinct in Cambodia. It is believed that *C. porosus* was extirpated from Tonle Sap Lake about 30-50 years ago (Platt *et al*. 2006), but some individuals may possibly occur in coastal areas (Thuok and Tang 1994; Jelden *et al*. 2005; Ouk Vibol, pers. comm. 2017). Very few *C. porosus* are held on the 900+ crocodile farms in Cambodia (Jelden *et al*. 2005). Hybridization with *C. siamensis* in Cambodian farms is mainly with *C. rhombifer* (introduced from Cuba to Vietnam in 1985, and then from Vietnam to Cambodia more recently) rather than *C. porosus* (Starr *et al*. 2009).

- China: The original presence of wild *C. porosus* in southern China remains to be verified. None exist there in the wild today. Farming operations on the mainland and on Hainan Island may still have some *C. porosus*, imported from Range States such as Thailand (Chen 2001; Geng 2001; Li 2001).

- India: Saltwater crocodiles remain in the northeast coastal region of mainland India and the Andaman Islands (Kar 2013; Singh and Kar 2006). A "rear and release" program in Bhitarkanika National Park (BNP), Odisha State, has released more than 2950 captive-reared juveniles (approximately 1 m long) between 1977 and 2015. Some of these have matured, and several released females are now to be nesting successfully in the wild (Kar 2017). The *C. porosus* population in BNP has increased significantly since the reintroduction program started (Nayak *et al*. 2018), from 95 sightings in 1976/77 (relative density= 0.87/km) to 1682 sightings in 2017 (relative density= 13.4/km) (Kar 2017). The number of nests has increased from 5 in the mid-1970s, to 65 in 2009, and to 70 in 2017 (Kar 2009, 2017). BNP contains around 70% of the estimated total population of wild *C. porosus* in India.

The population increase in BNP has led to increased dispersal and HCC. A team of Crocodile Husbandry and Management staff at Dangmal/Bhitarkanika Research Facility are now engaged to capture problem *C. porosus* and relocate them back to suitable locations in BNP (see Anon 2008b). Recently, groups of captive-bred *C. porosus* were released by the Forest Department in the southern-most part of BNP, but primarily as a strategy for deterring human activities in the mangrove forest (Kar 2007).

Concerns about the potential impact of the Dhamara Seaport and Rengali Canal developments on BNP and its *C. porosus* population were raised previously (see Webb *et al*. 2010). However, Dhamara Seaport has now been in operation for five years, and does not appear to have had a detrimental effect on the crocodile population and its mangrove habitats. Studies conducted by Government and non-Government agencies on the impact of the Rengali Dam (upstream Brahmani River) on the flow of fresh water also highlighted negligible impact on mangrove ecosystems, including those in BNP - at present there appears to be sufficient freshwater flow from the Brahmani and other rivers (eg Baitrani and Kharasrota Rivers).

In the Indian portion of the Sundarbans in West Bengal, daytime surveys in January 2012 reported a relative density of 0.11 NH/km (1163 km), with a bias towards adults (49.3%), although this is typical of daytime surveys and is not considered to reflect the actual population size structure (Choudhury *et al*. 2012). As of March 2012,

Figure 8. *Crocodylus porosus*. Photograph: Grahame Webb.

more than 450 *C. porosus* had been bred at the Forest Department of West Bengal's farm in the Sundarbans, and released into the wild (Nagchoudhury 2012).

There are no recent data on the status of *C. porosus* in the Andaman Islands (Whitaker and Whitaker 1978; Andrews and Whitaker 1994), and although widely distributed, population expansion through intrinsic breeding appears to be constrained by the lack of suitable breeding habitat (freshwater swamps). Human occupation is displacing crocodiles (Andrews and Whitaker 1994) and HCC remains a serious concern in the area (Whitaker 2008, 2009; Giles 2015).

- Indonesia: An extensive survey program was conducted by FAO and the CITES Management Authority (PHKA - Direktorat Jenderal Perlindungan Hutan dan Konservasi Alam) in the 1990s, but it did not provide an estimate of the total population of *C. porosus* within Indonesia, nor its distribution across the archipelago nation. The stronghold for *C. porosus* is West Papua and Papua Provinces, particularly the Mamberano River drainage in the north. Past human exploitation and habitat alteration have reduced the population of *C. porosus* throughout much of Indonesian, although localities in Sumatra and the extensive rivers and lowlands of Kalimantan clearly support wild populations. With the exception of Papua and West Papua Provinces, captive breeding and ranching (subject to approval and population monitoring) of *C. porosus* is permitted elsewhere in Indonesia (eg Java, Sumatra, Kalimantan, Sulawesi), however ranching (collection of wild juveniles) appears to be widespread and commonplace in Sumatra and Kalimantan.

  In July 2007 there were 15 registered farms in Indonesia (Manolis 2007; Manolis and McInnes 2007), and this is now reduced to xxx in 2017. The last intensive review of crocodile conservation and management in Indonesia was in the early 1990s (Webb and Jenkins 1991), although some aspects of management were addressed by a CSG mission in 2014 (Brien *et al*. 2014).

  Despite a self-imposed hunting moratorium between 1994 and 1996, it seems that by 1997 many crocodile farms in Papua Province had stockpiles of wild *C. porosus* skins collected during this time. Based on these stockpiles, the management plan was revised in 1997 (Directorate General of Forest Protection and Nature Conservation 1997) (Hellen Kurniati, pers. comm. 2009). A system of ranching (juveniles) and wild harvest (sub-adults), similar to that established in neighbouring Papua New Guinea, is now well established in West Papua and Papua Provinces.

  Annual export quotas are established by the CITES Scientific Authority (LIPI - Lembaga Ilmu Pengetahuan Indonesia) based on monitoring results, and the CITES Management Authority (PHKA) regulates the quotas. Spotlight surveys, which form the basis for monitoring the wild *C. porosus* population (Kurniati and Rumbarar 1999), were not undertaken between 1998 and 2008, and a zero export quota for the species was put in place. However, in 2007, it was reported that about 10,000 hatchlings were taken through ranching (Hellen Kurniati, pers. comm. 2009). Industry was also interested in an egg harvest, which was undertaken on a trial basis with C. novaeguineae in the early 1990s under the FAO project (Manolis and McInnes 2007), but costs of collection in the remote swamps of West Papua and Papua Province are prohibitive.

  Industry recently raised concerns that the harvest quotas in Papua Province could be increased, and that the system of allocation of quotas between farms may not be equitable (Manolis and McInnes 2007). Although minimum and maximum size limits for wild *C. porosus* skins (25 cm and 51 cm belly width respectively) are established, large skins are still purchased illegally by buyers. It is difficult for hunters to distinguish between the two species of crocodiles around the maximum size limit

  It is widely recognized that the crocodile industry in Indonesia (as in Papua New Guinea) is an important, and sometimes the only, source of cash income for many rural communities in remote areas.

- Malaysia: The Malaysian population of *C. porosus* was transferred to CITES Appendix II in 2016, mainly to allow the State of Sarawak to implement a wild harvest and ranching program to address increasing levels of HCC (see below). A zero export quota for wild specimens of *C. porosus* applies to Peninsular Malaysia and Sabah.

  - Peninsular Malaysia: *Crocodylus porosus* is considered to be relatively rare, although they are now sighted more regularly throughout Peninsula Malaysia (eg Klang River; Kwan 2017). In July 2013, a large *C. porosus*, estimated to be around 6 m long, was found dead on the banks of the Kuala Selangor River, at Bukit Belimbing, Kuala Selangor - a sack and plastic bag in its stomach suggested that pollution may have been implicated in its death (Chen 2015). Sebastian (1993) listed 10 localities where *C. porosus* had been reported and suggested that the Setui-Chalok-Bari basin on the east coast near Trengannu may contain the most significant population, but this has not been confirmed with surveys. A preliminary survey of *C. porosus* in Rembau Estuary in 2009 indicated a relative density of 2.9 NH/km; the presence of hatchlings indicating successful nesting the previous season (Nazli and Hashim 2009).

  - Sabah: Surveys of the *C. porosus* population have been undertaken irregularly over time in Sabah. Stuebing and Mohammed Sah (1992) surveyed the Klias River and found a small but viable population of around 50 individuals, while Cox and Gombek (1985) reported uniformly low densities throughout Sabah. Kaur (2006) reported the relative density of *C. porosus* in the Segama River had increased from around 0.04 ind./km in 1981 (Whitaker 1984) to 1.42 ind./km in 2005. Stuebing *et al*. (2002) reported a mean density of 1.1 NH/km in Sabah rivers - 22 times that reported by

Whitaker in 1984 (0.05 NH/km). A 3-year State-wide survey program across 11 of Sabah's largest rivers, selected on the basis of historical data and incidence of HCC, was initiated in 2017 to assess status and population trends. Preliminary results from 6 of those rivers indicated a mean relative density of 0.50 NH/km (+ 0.12) - results for the remaining 5 rivers will be available by end of December 2017 (Sabah Wildlife Department, pers. comm. 2017). Notwithstanding that the preliminary mean density reported in 2017 is lower than that reported by Steubing *et al*. (2002), there is little doubt that the *C. porosus* population in Sabah has recovered significantly over the last 20+ years due to: legal protection (since 1982); a decline in the timber industry which decreased habitat/river disturbance; siltation leading to the alteration of downstream river habitats; stabilization of oil palm estates and secondary growth along river banks; opening of closed canopy swamp and riverine forest; the El Niño-Southern Oscillation episode of 1997-98 which reduced flooding of nests and led to high recruitment that year; and, a dramatic decline in the harvest of wild crocodiles for skins during the late 1990s due to both lower prices and the implementation of CITES (Steubing *et al*. 2002).

The increase in HCC in recent years is of major concern to authorities (Webb 2008a), with 34 attacks (19 fatal, 15 non-fatal) reported between 2000 and 2011 (2.8 attacks/y) (Andau *et al*. 2004; Sabah Wildlife Department 2011) and 61 attacks between 2012 and 2017 (10.2 attacks/y; Lading 2018). Problem crocodiles have been captured and removed to farms (Look Fook Soon Trading, unpublished data), although some individuals are shot due to their proximity to human habitation. The current statewide survey program will inform a new management plan to be drafted in 2020.

- Sarawak: Saltwater crocodiles occur in most major rivers in Sarawak, and large individuals are sufficiently common to be a serious threat to people. Surveys undertaken in the early 1980s found uniformly low densities of crocodiles throughout Sarawak (0.05 NH/km; Cox and Gombek 1985), but recent surveys indicate that numbers have increased markedly since that time. Surveys conducted in 2012-2014 indicated densities of 0.68 NH/km (Sarawak Forestry Department) and 0.83 NH/km (Sarawak Forestry Corporation), and the population was estimated to be around 12,000-13,500 individuals (MCMA 2016).

  The size structure of the population, with a high proportion of large individuals, is considered to have contributed to high rates of HCC. Attacks on humans in Sarawak increased over time (1.85/year 1980-1999, 4.3/year 2000-2009, 8.5/year 2010-2017; MCMA 2016; CrocBite 2018; Lading 2004). Sarawak has established the Swift Wildlife Action Team (SWAT) to respond to wildlife issues, including human-crocodile conflict, focusing on handling crocodile attacks, removal of crocodiles in "Crocodile Removal Zones" and nuisance crocodiles, as well as promoting awareness on "living with crocodiles".

  Sarawak recently published a 5-year "Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak 2016-2020" (R. bin Ahmad, pers. comm. 2018). The plan is wide-ranging, covering conservation, sustainable use, public awareness, scientific research and tourism products.

- Myanmar: Once widely distributed throughout all coastal areas, *C. porosus* is now largely restricted to the lower Ayeyarwady (= Irrawaddy) River, and coastal Rakhine and Tanintharyi States. The only viable population is in Meinmahla Kyun Wildlife Sanctuary (MKWS) and adjacent forest reserves of the Ayeyarwady Delta, where nesting and recruitment were documented in 1999 (Thorbjarnarson *et al*. (2000) and 2003 (Thorbjarnarson *et al*. 2006). The sanctuary was surveyed again in January 2017, and the numbers were comparable to the 1999 survey (S. Platt *et al*. unpublished data). It is speculated that this population may function as a source population for coastal regions in southern Myanmar, including offshore islands in the Myeik Archipelago, and it represents one of the only significant populations of *C. porosus* remaining on mainland Southeast Asia. Reports of crocodile attacks (CrocBite 2018) indicate that *C. porosus* is present in the Myeik Archipelago, albeit at low densities. MKWS could also be the source of crocodiles that recently turned up near Phuket Island, Thailand.

  Platt *et al*. (2015) surveyed Lampi Marine National Park in Tanintharyi Region of Myanmar and found no evidence of an extant crocodile population. The area now encompassed by the National Park harbored a population of *C. porosus* as recently as the 1990s. Local extinction is attributed to direct persecution, egg harvesting (for domestic consumption and sale), and capture of crocodiles to sell to buyers from crocodile farms in Thailand. The park is a suitable site for reintroduction of *C. porosus*. It is also possible the island group could be recolonized by crocodiles dispersing from MKWS or elsewhere on the mainland.

  A small population of *C. porosus* (said to number about 20 adults) is also known to occur in Ban Pone Chaung, a mangrove wetland on the mainland near Ywa Thit Village in southern Tanintharyi Region (Platt *et al*. 2014). A few crocodiles reportedly still occur in the Tanintharyi River, although these probably do not constitute a viable population (Platt *et al*. 2012). Other small populations of questionable viability are rumored to be scattered along the coast, from Ywa Thit northwards to Myeik, but the veracity of these reports has not been confirmed (Platt *et al*. 2014).

  Hatchlings from the MKWS were collected for captive rearing and released back to the wild when up to 1.2 m TL; 68 were released between 1998 and 2001 (Thorbjarnarson *et al*. 2006). A farming-ranching program was implemented

by Government in 1978, and Thaketa Farm was established in 1979 (Aung Moe 1994). Juvenile *C. porosus* collected from the wild (4097 between 1978 and 1999) and captive-bred individuals (3087 hatchlings between 1983 and 1999) were used to stock the farm. Exports were mainly of live animals to Thailand and Singapore, but since 1990 have been minimal. The farm remains in operation, but continues to be poorly managed (Platt *et al*. 2013), and suffers from a range of technical problems (Thorbjarnarson *et al*. 2006). Efforts to register it as a CITES captive breeding facility in early 2008 were unsuccessful. In 2013, the farm maintained 500-600 crocodiles, ranging in size from hatchlings to large adults. Hatching success is poor and may be related to the nutritionally inadequate diet of marine fish and fish skins (obtained from a nearby fish processing facility) provided to adult breeders.

During the 1970s, the Government of Cambodia presented three Siamese crocodiles (*C. siamensis*) to General Nwe Win, the former ruler of Myanmar. The Siamese crocodiles can no longer be accounted for, and it is unknown if these hybridized with the more numerous *C. porosus* in the farm. Platt *et al*. (2013) recommended "that henceforth the Thaketa Crocodile Farm concentrate solely on public education for it is within this arena the farm is most likely to make a significant contribution to regional crocodile conservation". Furthermore, these authors stated "it is imperative to reconsider our earlier recommendation to augment *C. porosus* populations in protected areas of the Ayeyarwady Delta with captive-bred juveniles (Thorbjarnarson *et al*. 2000). Given the possibility of hybridization with *C. siamensis*, under no circumstances should any crocodiles from the farm be released into the wild without prior genetic screening to identify and eliminate hybrid individuals. To do otherwise risks contaminating a genetically pure population of *C. porosus* with *C. siamensis* genes."

- Palau: Crocodiles were extensively hunted in Palau for their skins between the 1960s and 1980s. The first systematic survey of crocodiles, undertaken in 1991 by Messel and King (1992b), recorded 42 crocodiles in 112 km of waterway, concentrated in two small populations at North Estuary on Belilou and Ngerdok Lake on Babeldaob. Brazaitis *et al*. (2009) estimated the total population to be 500-750 individuals, based on a 2003 survey. The Bureau of Marine Resources carried out annual surveys in 2005-2008, with the most recent ones revealing relative densities of 0.41-1.48 ind./km in coastal mangrove habitat and 0.41-2.81 ind./km in creeks - the majority of individuals were estimated to be 0.6-3.0 m TL. However, no surveys appear to have been carried out since 2008. The available data suggest that the population had not increased significantly since the early 1990s, and at least up until 2008 was considered to be stable. Interviews with 46 past/present crocodile hunters in 2002-03 suggested that there were more crocodiles at that time than there were 5, 10 or 50 years prior to 2002 (Matthews 2003, 2005).

  Two crocodile attacks have been reported in Palau, the first in 1965 (fatal) and the most recent in 2012 (non-fatal) (see CrocBite 2018). The Palau program has focused on 'problem' crocodile complaints and public awareness, with 21 problem crocodiles reported between 2005 and 2008, mostly from the north of the country (Joshua Eberdong, pers. comm. 2009). A few adult *C. porosus* were maintained in Koror, and some captive-bred hatchlings have been released back into the wild.

  Despite concerns about the genetic integrity of *C. porosus* in Palau due to past importation of different crocodile species (*C. novaeguineae*, *C. mindorensis*, *Alligator mississippiensis*; Brazaitis *et al*. 2009), an analysis of 39 blood samples from wild *C. porosus* confirmed no hybridization (Russello *et al*. 2007). A CSG review in 2005 highlighted the fact that crocodiles are not currently protected by law, and the public generally "dislike" them and consider them pests (Anon 2006). At times crocodiles are killed and eaten as food.

Figure 11. Female *C. porosus* with hatchlings. Photograph: Grahame Webb.

- Papua New Guinea: *Crocodylus porosus* is widely distributed throughout the lowlands of Papua New Guinea and on the islands of New Britain, New Ireland, Bougainville and Manus. Current management of the wild population involves ranching (eggs, hatchlings, juveniles) and wild harvest (with size limits to protect breeding stock). A monitoring program has included regular nest surveys of representative habitats in the middle Sepik River since 1982, with a review of the program carried out in 1995 and subsequent revision of nesting indices (Manolis 1995). Nesting surveys indicate that the *C. porosus* population is healthy (Solmu *et al*. 2014). Increases in nesting in the Sepik River area were attributed in part to a conservation awareness campaign and conservation incentives generated from an expanded *C. porosus* egg harvest (Wilken and Langelet 2004; Sine and Kula 2006; Solmu *et al*. 2014). The increasing involvement of local communities in the egg collection program has helped turn a HCC problem into an economic opportunity that supports the conservation of *C. porosus* (Solmu *et al*. 2014). However, increasingly

strict skin grading standards in the international market have resulted in reduced purchases of ranched juveniles by farms, leading to a reduction in price for wild skins, and thereby threatening the incentives that have been created in some remote areas through the program (E. Langelet, pers. comm. 2018).

Introduced fish [Pacu (*Piaractus brachypomum*), Java carp (*Puntius gonionotus*)] continue to degrade nesting habitats (Cox *et al*. 2006; G. Solmu, pers. comm. 2018), although other factors (eg climate change) may also be implicated. Consideration is currently being given to size and quality of current remaining habitats, land tenure and land use, presence of other fauna and expansion into new areas in which the Sepik Wetlands Management Initiative (formed in 1998) is working.

Given the very large area of inaccessible and undeveloped habitat and the incentives for local traditional landowners to maintain crocodiles, *C. porosus* appears secure in Papua New Guinea. Reports from New Britain suggested that increasing numbers of attacks on people and livestock were due to increasing numbers of *C. porosus* (PNG National Newspaper, 28 August 2009). However, attack data reported by CrocBite (2018) for the country as a whole suggest that the frequency of attacks by *C. porosus* has remained somewhat stable over the last 15 years (5.6 per year; range 1 to 11).

- Philippines: Saltwater crocodile populations and habitats are reduced throughout the Philippines and no large populations of *C. porosus* remain (Ortega *et al*. 1994). Today they exist as a few single individuals, small groups, and some iconic populations scattered through remaining wetland habitats. Areas with the highest numbers of *C. porosus* are thought to be on the island of Mindanao (eg Ligawasan Marsh), rivers and estuaries around southern Palawan, Sulu Archipelago in southwestern Philippines, northeastern Mindanao and some part of northeastern Luzon. A recent survey (Manalo 2012) found evidence of basking areas that are potential nesting sites in the Agusan River basin but no large viable population of *C. porosus* is known to exist.

  The Balabac Group of Islands in southern Palawan had high numbers compared to other areas in the Philippines. Recent data reflects that the population in the southern portion of Palawan is higher than previously thought (Manolo *et al*. 2016) and the causes of historical decline appear to be reversible. Populations of *C. porosus* in Sulu Archipelago, Zamboanga Peninsula and Siargao Island are still viable and locally protected. Although both *C. porosus* and *C. mindorensis* co-exist in Ligawasan Marsh, interviews with local residents in 2007 suggested that *C. mindorensis* is much more commonly sighted than *C. porosus* (Pomares *et al*. 2009). However, local poaching for trade has indicated a viable population in the marsh. It is publicized locally that the increased conversion of wetland into agriculture has threatened the crocodile habitat in Ligawasan Marsh. To date, no surveys have been undertaken to quantify the abundance of both species.

  The northern Sierra Madre National Park in Isabela may also be home to a small population of *C. porosus* (Rainier Manalo, pers. comm. 2018), but they are threatened by killing as pests, by-catch in fishing nets, and by agricultural encroachment into the remaining habitats (Manalo 2004). Palawan and Mindanao are known strongholds of *C. porosus* in the Philippines. The connectivity of these islands in the northeast coast of Borneo suggests a shared crocodile population and genetic studies may be needed to investigate this possibility.

  In the late 1980s and early 1990s, the majority of the remaining wild adult *C. porosus* population on Palawan (141 individuals) and Mindanao (115 individuals) were caught and/or acquired from private collectors, and relocated to the Crocodile Farming Institute (now Palawan Wildlife Rescue and Conservation Center), where they formed the nucleus of a captive breeding population. The progeny of these animals were later relocated to private establishments, some of which have begun commercial farming based on captive breeding (Mercado 2007).

  Of the 26 recorded cases of crocodile attack on humans in the 2000-2015 period, 20 occurred in southern Palawan (Corvera *et al*. 2017). Crocodiles that threaten the safety of people and livestock are sometimes killed, but in most cases communities that practice their cultural beliefs toward crocodiles and their habitats have positive attitudes towards crocodiles.

  In February 2007, a forum convened to address conservation, management and sustainable use of crocodiles in the Philippines (Anon 2007). This led to an exchange of information and experience between organizations in Luzon (Mabuwaya Foundation) and Mindanao (University of Southern Mindanao; Pomares 2007) (USM Crocodile Research Team 2007; Mabuwaya Foundation Inc. 2007), and closer collaboration with the crocodile farming industry (Crocodylus Porosus Philippines Inc.). In 2015 the Philippine Government reconstituted the Philippine Crocodile National Recovery Team (PCNRT), to be known as the National Committee for the Conservation of Crocodiles (NCCC). The NCCC developed the "Conservation and Management Plan for the Crocodile Species in the Philippines" that would serve as guiding framework for both species of crocodiles in the country. Establishment of sanctuaries, enhancing social understanding and acceptance, implementation of protocols in managing human-crocodile conflict, and effective monitoring and management of wild and captive populations were the identified goals and strategies. A second Forum on Crocodiles in the Philippines was convened in March 2019 (Manalo and Mercado 2019).

- Seychelles: Crocodiles were noted when the first Europeans visited the Seychelles in 1609. Re-examination of skeletal material suggests that the species that occurred there at the time of European discovery, and subsequently extirpated

by the early 1800s, was *C. porosus*, and not *C. niloticus* as previously assumed (Gerlach and Canning 1993).

- Singapore: Considered to have been extinct in Singapore, Saltwater crocodiles have been present in Sungei Buloh Wetland Reserve, on the northwest coast of Singapore, since around 2004. Around 130 ha in size, the reserve was listed as an ASEAN Heritage Park in 2003. Breeding is known to occur in SBWR (nests and hatchlings observed). Given the high rate of local and international visitation to SBWR, the potential for HCC is of concern to authorities, and barriers have been constructed along some walkways that are close to where crocodiles regularly bask, to mitigate HCC (Beng Choo How, pers. comm. 2017). CrocBite (2018) reports 26 attacks in 1842-1957, and the two most recent attacks occurred in 1974 and 1989 respectively. Individual *C. porosus* have been reported in other parts of Singapore, and the population was previously estimated to comprise around 15 adults, but this number can vary from year to year - in 2017 only 5-6 adult *C. porosus* were regularly sighted. The source of the *C. porosus* population in Singapore is considered to be Peninsular Malaysia, which is around 1 km from Singapore. One crocodile tagged with a location device by Singaporean authorities regularly travelled every few days between the two countries.

- Solomon Islands: The only survey of crocodiles in the Solomon Islands was undertaken in 1989 by Messel and King (1990), who identified survey sites based on knowledge from local people and crocodile hunters. Suitable habitat is restricted by the terrain and further reduced by human occupation and agriculture, and most sightings were from three localities - Lauvi Lagoon (Guadacanal), Lake Tatae (Russell Islands) and Ghahirahobo (Santa Isabel). With the cessation of hunting for skins in 1989, the *C. porosus* population has increased, resulting in increased HCC and fatalities in different parts of the country. The situation has been exacerbated by the banning of firearms following civil unrest and the arrival of the Australian-led Regional Assistance Mission (RAMSI) in 2003, such that local people were unable to deal with problem crocodiles themselves. In early 2018, the Government secured funding for expert consultants to carry out surveys, develop public awareness materials, facilitate training of staff, and develop a management program, based on sustainable use (J. Hurutarau, pers. comm. 2018).

- Sri Lanka: The status of *C. porosus* in Sri Lanka varies between locations, although how current abundance in different areas compares to historical abundance is unknown. A breeding population is known to exist in Muthurajawela Swamp (Devapriya 2004; Jayawardene 2004), although sporadic breeding is occasionally reported at other locations (eg De Silva and de Silva 2008; Gramentz 2008). Surveys in 2007-2008 in the Bentota River revealed a small breeding population, with the population size structure strongly biased towards hatchlings (35 cm TL) and yearlings (<70 cm TL) (93%) (Gramentz 2008), which is indicative of a depleted population attempting to recover. Devapriya (2001, 2004) observed 20 individuals along a 2.8-km stretch of the Dandugam Oya and 2-9 individuals in 1.7 km of adjacent marsh. *Crocodylus porosus* were reported in the Madu Ganga (De Silva and De Silva 2008). De Silva (2008) reported an estimated population of 50 individuals in a 5-km stretch of the Nilwala River. Samarasinghe and Chandrasiri (2013) reported a relative density of 5.1 ind/km in Bellanwila-Attidiya Sanctuary in 2013.

  Major threats to the species include the destruction of eggs, killing, fishing and habitat loss (eg urban encroachment, sand mining, conversion for aquaculture, tourism and agriculture) and pollution (De Silva 2008; Samarasinghe and Chandrasiri 2013; Amarasinghe *et al*. 2015; Madawala *et al*. 2017; Pethiyagoda *et al*. 2015). Killing of crocodiles is sometimes as "revenge" after attacks on humans, but in some cases crocodiles are taken by villagers/fishermen as a source of meat (Madawala *et al*. 2013; Amarasinghe *et al*. 2015). Local communities along the rivers use now a variety of crocodile exclusion enclosures for bathing, washing, etc., in response to attacks by *C. porosus* (De Silva 2008). The current practice of relocating "problem" *C. porosus*, sometimes into Mugger (*C. palustris*) habitats, is not considered to be a good long-term strategy, which is exacerbated by authorities lacking expertise with regard to the capture and transport of crocodiles (Amarasinghe *et al*. 2015).

  Despite these anthropogenic impacts on the *C. porosus* population, it is considered to have increased significantly since the late 1970s (De Silva 2013). The total population was estimated to be around 375 non-hatchlings in 1978, with the majority (70%) confined to the southwest coast of the island (Whitaker and Whitaker 1979). More recently, Amarasinghe *et al*. (2015) conservatively estimated the *C. porosus* population to be around 2000 non-hatchlings.

- Thailand: Saltwater crocodiles are effectively extinct in Thailand. Surveys undertaken in the early 1990s revealed sightings of one or two *C. porosus* on Phuket Island (Ratanakorn *et al*. 1994), but the majority of suitable habitat in this area has now been destroyed or occupied by people. Occasional reports of crocodiles by local fisherman in the Ranong River, adjacent to the Myanmar border, and a report of a newly hatched clutch in 2010 (TCMA 2013), suggest a few individuals may still exist in this area. Temsiripong (2012) reported a small remnant population at Samaesarn Island on the southeast coast, and two female *C. porosus* (2.43 and 2.5 m TL) were captured, marked and released in April 2012. Ao Bandon, the largest mangrove inlet on the east coast, may still support a number of *C. porosus* (Ngampongsai and Nabhitabhata 1987), but this remains to be confirmed. TCMA (2013) estimated the wild population of *C. porosus* to comprise around 200 individuals.

  As of 31 December 2016 some 156,000 *C. porosus* were held in crocodile farms (Manolis 2017), of which 16 were registered as CITES captive breeding operations at the end

of 2017. Farms contain mainly *C. siamensis*, and hybrids between *C. siamensis* and *C. porosus*, but some produce exclusively *C. porosus*.

- Timor Leste: The population status of *C. porosus* in Timor Leste is unknown, but it is considered to have increased significantly since the country achieved independence in 2002. The largest population exists in Lake Iralalaro (Nino Konis Santana National Park, Posto administrative Lautém). In addition, various waterbodies, mainly lagoons and billabongs along the coast, contain crocodiles including Be Malae (Bobonaro), Ai Parapa, Hera, Christo Rei (all Dili), Naktuka and Citrana (all Oecusse), Loes (Liquica), River Irabere and Maurei, Waibani Waiwai, Rubinaha Wai, Matahoi, Luca (all Viqueque), Namalutu, Urunami and Lapalapa, Werukoco, Raumoco (all Lautém), Kasalac, Hasan Foun, Onu Bot, Beco, Raimea no Leolima, Tashilin & Raimea (all Cova Lima), Modomahut (Manufahi), Seical, Vemase (all Baucau), Ribeira Manatuto (Manatuto) and Bican Tidin (Ainaro) (Crocodile Task Force Timor-Leste 2017).

  The Timorese Government has set up warning signs at sights known to have crocodiles, and is regularly visiting affected communities to raise public awareness. At least 5-10 fatal attacks are reported each year, but under-reporting of non-fatal attacks is believed to be high. Crocodiles are culturally very important to local people, and *C. porosus* is the national animal (Anon 2008c). Some coastal communities hunt crocodiles for meat. A considerable number of *C. porosus* are held in captivity in the capital, Dili. Government has constructed a crocodile enclosure in Hera, near Dili, to enable the removal and housing of problem crocodiles. Community-based monitoring was conducted in various communities in Lautém and Viqueque to assess data on crocodile habitat and attacks, integrating the knowledge of local stakeholders.

  Local authorities raised the concern that crocodiles dispersing from Australia could be responsible for the increase in crocodile attacks. Future research and management focuses on testing the dispersal hypothesis and on the implementation of sophisticated regimes to remove problem crocodiles from areas where crocodile habitat and human activity frequently overlaps, as well as on developing an ecotourism strategy including crocodile watching.

- Vietnam: Saltwater crocodiles persisted in southern Vietnam and the Mekong delta until 20-25 years ago, but extensive habitat degradation and the direct capture and killing of crocodiles greatly reduced the population. By the mid-1940s no more than 100 *C. porosus* were thought to survive in the wild (Cuc 1994), and no viable wild populations are known to exist today. A re-introduction and recovery program for *C. porosus* in remaining suitable habitat was proposed by a CSG review mission (Jelden *et al*. 2008), but no progress has been made to date. Very few *C. porosus* are on crocodile farms (Jenkins and Sung 1998; Jelden *et al*. 2008; H. Jenkins, pers. comm. 2018). Nonetheless, hybridization of *C. porosus* with either *C. siamensis* or *C. rhombifer* (imported into Vietnam from Cuba in 1985) occurs (Jelden *et al*. 2008).

- Vanuatu: The eastern-most population of *C. porosus* is recorded from eastern Vanua Lava in Vanuatu (New Hebrides and Banks Islands). The area was surveyed in 1992 by Messel and King (1992a), who concluded that crocodiles were on the verge of extinction there. Only two adult crocodiles were seen in the wild and the population was no longer breeding. In 2003, Australia Zoo was asked by the Vanuatu Government to capture and relocate a 3.6 m *C. porosus* from the heavily populated island of Maewo to Vanua Lava, where it is believed to have originated.

Figure 10. *Crocodylus porosus* in tidal, coastal habitat. Photograph: Grahame Webb.

- Other: Stray *C. porosus* have been encountered considerable distances from their normal range. For example:

  - In 1971, a 3.8 m *C. porosus* was captured in southern Pohnpei, Eastern Caroline Islands, around 1360 km from the nearest population (Allen 1974; Buden and Haglelgam 2010).
  - Around 1959, a 1.0-1.5 m long crocodile, assumed to be *C. porosus*, was killed at Eauripik Island, Yap State. Although not reported in the literature, many residents sighted the animal after it was killed and buried (Buden and Haglelgam 2010). In late 1986, a crocodile, assumed to be *C. porosus*, was reported from Woleai Atoll, Yap State (Eldredge 1994; Buden and Haglelgam 2010).
  - Takashima (1955) reported three crocodiles from Japanese territory; one from Iwo Jima (in 1744), one from Amami- Oshima at the northern end of the Ryukyu Islands (in 1800), and a third from Toyama Bay, on the main Japanese island of Honshu. All three were presumably specimens of *C. porosus*.
  - A vagrant crocodile was reported on Nauru Island, 1160 km from the nearest *C. porosus* population (Webb 1994).
  - In October 2004, an individual *C. porosus* was captured in the Marshall Islands, some 2000 km from the nearest *C. porosus* population in Papua New Guinea (Manolis 2005).

- The first reported *C. porosus* captured in the Maldives was in 1998, and the animal was placed in a local zoo (Ali 2015). In 2007, a crocodile, assumed to be *C. porosus*, was captured, and in April 2009 suspected crocodile tracks were investigated at Gaafu Alifu Atoll (Anon 2009). In January-February 2015 more than 10 Saltwater crocodiles were reportedly sighted (Ali 2015), and a 3.1 m individual was captured near L. Isdhoo (Fayaz 2015). The closest population of *C. porosus* is in India, some 430 km away (Bindloss 2015).

Saltwater crocodile populations are legally protected in most countries, but protection alone may be ineffective. Management programs based on sustainable use (ranching, wild harvest, captive breeding) have been successfully implemented in Papua New Guinea, Australia and Indonesia (Table 1), the three countries that contain the majority of the global population of the species, and programs in Malaysia and the Solomon Islands are being developed on the basis of sustainable use.

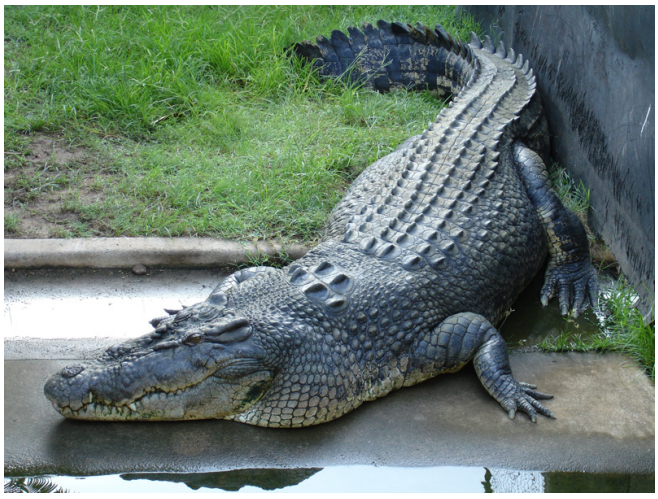

Figure 13. Captive breeding based on *C. porosus* is carried out in many Range States where the wild populations are depleted. Photograph: Grahame Webb.

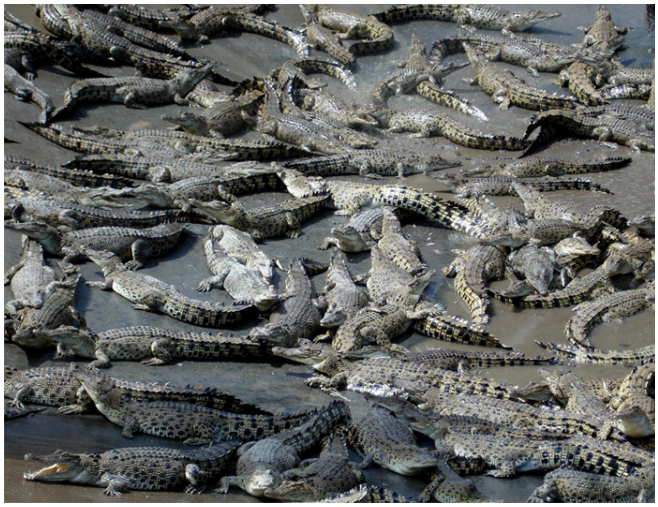

Figure 14. Sustainable use programs have created positive incentives for the conservation of *C. porosus*. Photograph: Grahame Webb.

In the remaining Range States, populations have been greatly reduced as a result of historical hunting and ongoing habitat loss. Nonetheless, protection has resulted in population increases in a number of countries, to the extent that attacks on humans have increased and become a serious problem. Protection alone is unlikely to offer long-term security in these cases, because if it works, and wild populations increase, crocodiles attack people again, increasing efforts to eradicate them. Management options that allow recovered populations to be used sustainably, for the commercial benefit of landowners have particular utility with *C. porosus*.

Farming of *C. porosus*, based on captive breeding is undertaken in Bangladesh, China, Thailand, Singapore, Malaysia, Myanmar, Philippines, Indonesia, Papua New Guinea and Australia. Stocks produced through captive breeding is supplemented significantly through ranching programs (eggs, hatchlings and/or juveniles) in Indonesia, Papua New Guinea and Australia. Ranching is not possible in much of the former range of *C. porosus* because wild populations are severely depleted or extinct.

As a species, the global population of *C. porosus* is secure, because of large populations, extensive habitat and effective management in Australia, Papua New Guinea and to a lesser degree Indonesia. There are increasing *C. porosus* populations in the Solomon Islands, Sarawak and Sabah, due to effective protection measures, and management may require incentives derived from sustainable use to counter negative public attitudes towards them. Reintroduction and protection efforts in Bhitarkanika National Park, India, have been successful to the point that increasing HCC is being reported. Re-establishment of large populations in India outside protected areas may never be possible due to the large human population and lack of suitable habitats. Likewise, re-establishment of wild populations of *C. porosus* in Thailand, Vietnam and Cambodia, where the species is essentially extinct, is unlikely, although in some cases it may be possible in pockets of protected areas.

Priority Projects

High priority

1. **Status surveys**. Recent quantitative and qualitative assessments of the current status of wild *C. porosus* populations in the majority of Range States are lacking. Status overviews are required for most countries, but in some even basic data are missing [eg Brunei, Cambodia, Timor Leste, Indonesia (outside Papua and West Papua Provinces), Vietnam].

2. **Management**. Population surveys planned for Sabah (Malaysia), the Solomon Islands and Timor Leste, where all indications are that the wild populations of *C. porosus* are increasing, are needed to better inform management. The conservation problem appears to have been largely solved (depleted populations are now increasing). However, as a consequence HCC is on the increase, and if realistic management programs tailored to local

circumstances are not developed and implemented, there will be no public or political will to tolerate the expanded population. Sustainable use may be one means through which economic incentives can be generated (eg Whitaker 1984), but the probability of success depends on many factors.

3. **Crocodile management in Indonesia**. Population monitoring of *C. porosus* in Papua and West Papua Provinces has not been undertaken since 1998 (Kurniati and Rambarar 1999), but may restart in 2009/2010 (Tonny Soehartono, pers. comm. 2009). Although wild harvest quotas have been reduced because of no survey data, the allocation of the quota among licensed farms located in Papua Province, Sumatra and Java, is of concern to some operators (see Manolis and McInnes 2007). The regulatory system may benefit from external review by the CSG or other competent groups. Protection is nominally afforded to *C. porosus* in areas other than Papua Province (ROI 1994), but it seems ranching is occurring in Sumatra, Kalimantan and perhaps other locations. If so, it needs to be sanctioned by CITES, through a proposal to the CITES Secretariat.

4. **Increased regional cooperation in Southeast Asia**. The close association between production and trade in crocodilian products (including *C. porosus* but mainly *C. siamensis*) between Cambodia, Vietnam, Thailand and China indicates that management, conservation and regulatory activities need to be coordinated in this sub-region (see Jelden *et al*. 2005, 2008). Technical exchange (eg training), surveys, development of management programs and mutually supporting regulatory structures (eg enforcement, Customs) are recommended.

Moderate Priority

5. **Crocodile conservation program in India**. An evaluation of restocking and the identification of additional release sites are in need of review. There are excess animals now in captivity and insufficient release sites to take them. The issue of HCC in Bhitarkanika National Park and adjacent areas needs to be assessed in view of the increasing attacks on local people.

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