FRESHWATER TURTLES IN THE MARY RIVER, QUEENSLAND

Review of biological data for turtles in the Mary River, with emphasis on *Elusor macrurus* and *Elseya albagula*

September 2008

Queensland Government

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Executive summary

This report was prepared by the former Environmental Protection Agency in September 2008 as part of a review of the knowledge of Mary River turtles captured within the State Government's Queensland Freshwater Turtle database.

The Mary River is an iconic river for Queensland. It has high biodiversity (six species) and high endemicity (two locally endemic species) of freshwater turtles which include ancient lineages of turtles such as the Mary River turtle, *Elusor macrurus,* and the white throated snapping turtle, *Elseya albagula,* as well as ancient lineages of fish including the lungfish, *Neoceratados forestii*.

In the 1960s and early 1970s, *Elusor macrurus* was subject to a significant population decline because of excessive egg harvest for the pet trade. This pet trade and associated egg harvest ceased in 1974.

The long-term, pervasive and intense loss of eggs on nesting banks through predation is the most critical threat to the survival of the two listed freshwater turtle species in the Mary Catchment: *Elusor macrurus* and *Elseya albagula*. This resulting failure in recruitment of young turtles to the river has been in progress for at least one generation (15-20 years). Unless concerted action is taken to substantially reduce egg loss on the nesting banks and increase hatchling recruitment to the river, these species are unlikely to survive in the long term.

Elusor macrurus and *Elseya albagula* are cloacal ventilating species that rely on access to dissolved oxygen within the stream, are restricted to the flowing streams and shallow waters of large water bodies of the catchment. Small juveniles are identified as the component of the population that is at greatest risk if in-stream water quality deteriorates with reduced oxygen availability.

There has been limited opportunity to investigate the impact of impoundment infrastructure on the health of wild, free-ranging turtles in the Mary River Catchment. Based on present data, the highest frequency of turtles with fractures consistent with having been impacted on hard habitat occurs in the vicinity of Borumba Dam. A lower frequency of fractures occurs in populations well removed from impoundment infrastructure.

The occurrence of persistent *Elusor macrurus* and *Elseya albagula* populations in some of the water infrastructure impoundments in the Mary River should be a priority for investigation. This will provide better insights into the actual environmental conditions under which long-term viable populations of *Elusor macrurus* and *Elseya albagula* can be maintained in a progressively altering catchment.

Elusor macrurus and *Elseya albagula* are characterised by:

- slow growth of immatures and delayed maturity. First breeding is not expected until they are approximately 15-20 years old;
- most adult females breeding each year and breeding in successive years;
- females aggregating to breed at traditional nesting banks;
- most adult females laying only one clutch of eggs per year;
- a high hatch success if the eggs are not flooded or preyed upon.

These are slow-growing, delayed maturity, low-fecundity species.

Elusor macrurus lay their eggs in spring and early summer. *Elseya albagula* lays its eggs in autumn and early winter and these eggs have a long embryonic diapause. Hatching of eggs for both species occurs during summer in late November to early January.

Elusor macrurus and *Elseya albagula* nesting is not uniformly distributed within the Mary River.

- The best nesting aggregations continue to be identified at the traditional nesting banks near Tiaro.
- A series of nesting banks supporting a lower density of nesting has been identified in the upstream reaches between Traveston and Kenilworth.
- There are many sand banks along the Mary River that may appear to be "potential" nesting banks to the human eye but which are not used to any significant level for nesting by either *Elusor macrurus* or *Elseya albagula.*

For most investigated sites within the Mary River Catchment there is a deficiency of immature turtles in the populations. The populations consist primarily of aging adults, especially for *Elusor macrurus* and *Elseya albagula*.

- For the three species investigated, *Elusor macrurus*, *Elseya albagula* and *Emydura m. krefftii*, there was a general trend for increasing proportion of immature turtles in the population with progressive sampling from the downstream reaches below Tiaro to the upstream reaches near Kenilworth.
- The species with the poorest representation of immature turtles in the populations were, in general, the slow-growing, delayed maturity, low-fecundity species.
- Based on the limited size-class distribution of immature *Elusor macrurus* sampled, there is the possibility that there is a nett upstream movement of juvenile turtles from the Tiaro reaches with their associated traditional high density nesting aggregations to the mid to upper catchment reaches.

Several hypotheses are proposed to account for these observations of immature turtle distributions:

a. There has been an improvement in juvenile recruitment over the past decade;
b. There has been better juvenile recruitment in the upper reaches of the Mary River than in the middle to lower reaches, possibly because of active management of feral pests by farmers in the upper catchment;
c. Small immature *E. macrurus*, of about 3-4 years of age, migrate upstream from the vicinity of the principal nesting banks near Tiaro and accumulate in the middle to upper stream reaches of the Mary River when more than 4 years old.
d. The samples are biased by a combination of study methods and operator skills.

Management considerations:

- Designing effective conservation management for freshwater turtles within the Mary River Catchment is hampered by the continuing paucity of biological knowledge of these species and their ecological requirements.
- Loss of eggs through predation on the nesting banks is the most critical threat to the survival of the two freshwater turtle species in the Mary Catchment, *Elusor macrurus* and *Elseya albagula*. Unless concerted action is taken to substantially reduce egg loss on the nesting banks and increase hatchling recruitment to the river, these species are unlikely to survive in the long term.
- Construction of dams and weirs can be expected to cause some local reduction in suitable habitat for these species and associated reduction in population size within the foot print of the deep water habitats of the impoundment.

- Following the construction of dams and weirs, continued foraging and breeding by *E. albagula* and *E. macrurus* can be expected to occur within the slow-flowing, shallow, upstream reaches of impoundments.
- Construction of a dam should not result in the loss of populations of these turtles down stream of the impoundment infrastructure.
- The water released for stream flow volume and water quality down stream of an infrastructure is largely determined by the authorities managing the impoundment and its infrastructure. Therefore, the release of water from impoundments should be managed to enhance the quality of the down stream habitats for these threatened turtles.
- Impoundment infrastructure can cause injury and death of many turtles that aggregate at the infrastructure. Based on lessons learned at existing dams and weirs, through consultation with turtle biologists and engineers, dam/weir infrastructure design can be made more turtle-friendly to reduce turtle injury and mortality.
- More studies are required to design a mechanism whereby turtles can move safely upstream and downstream past impoundment infrastructures.
- If the survival prospects for these species are improved, there needs to be management actions to improve the riparian vegetation and broader catchment management, not just within the impoundments.

Given the existing significant threat to *Elusor macrurus* and *Elseya albagula* from predation of eggs and the potential for the construction of a major dam to further negatively impact on these species, it is considered imperative that a whole-of-Catchment approach be taken for developing a management plan for the maintenance of sustainable populations of freshwater turtles in the Mary River Catchment. All existing and potential threats to the species are amenable to mitigation with appropriate planning. Concerted action is needed to develop and implement an appropriate conservation management plan.

1. SPECIES DIVERSITY WITHIN THE MARY RIVER

Currently, eight genera of freshwater turtles from two families occur in Australia: Family Carettochyididae (*Carettochelys*) and Family Chelidae (*Chelodin*a, *Elseya*, *Elusor, Emydura*, *Pseudoemydura, Rheodytes* and *Wollumbinia*) (Cann, 1998; Wells, 2007). The Mary Catchment, which also has a high diversity of native freshwater fish (Lake, 1971), supports the highest biodiversity of freshwater turtles in Australia with six species from five genera of the chelid turtles occurring in the catchment (Legler and Georges, 1993; Cann, 1998) (Table 1). Only the Fitzroy River in central Queensland has a similar level of species diversity. The Mary Catchment also has one of highest levels of endemicity of freshwater turtles in Australia with two localised endemic species, *Elusor macrurus* and *Elseya albagula*. *E. macrurus* is endemic to the Mary Catchment while *E. albagula* is endemic to the combined Fitzroy-Burnett-Mary Catchments. Therefore the Mary Catchment is one of the most significant river systems in Australia with respect to conservation of biodiversity of Australian freshwater turtles.

These same species, *E. macrurus* and *E. albagula*, were identified as critical and high priority, respectively, during the government's Back on Track prioritisation framework for conservation management of Queensland's wildlife (BOT) in 2006. Both these species of critical and high conservation concern in the Mary Catchment are relatively new to science:

- *E. macrurus* was first described as a new genus and species in 1994 (Cann and Legler, 1994) and few publications on its biology have occurred since then.
- *E. albagula* was recently described in 2006 (Thomson et al. 2006). It is one of five species now recognised in the *E. dentata* species complex that spans coastal northern and eastern Australia from northern Western Australia to south Queensland. Few studies addressed the biology of *E. albagula* prior to 1998.

In addition, both are among our more ancient lineages of freshwater turtles (Georges et al. 2006). These are specialist species with cloacal ventilation (Legler and Georges, 1993; Cann, 1998; Flakus, 2002; Limpus et al. 2002; FitzGibbon, 1998; Mathie, 2007) and slow growth with delayed maturity, taking 15-20 years before their first breeding (Flakus, 2002; Tucker, 2000; Hamann et al. 2004). These turtle species are among those most susceptible to the impacts of habitat change.

Like all Australian chelid turtles, the turtles within the Mary River are not characterised by temperature dependent sex determination (Georges, 1988; Thompson, 1988; Palmer-Allen et al. 1991). Nest temperatures do not determine hatchling sex ratios for these species. Any population anomalies for these species in this catchment cannot be attributed to temperature dependent sex determination.

In the absence of any pre-and-post construction studies to determine the impact of dams and weirs on turtle species in the Mary River, we rely on the Tucker (2000) study that indicates that some population change through either loss of habitat or reduction in population size can be expected to occur with each new impoundment. However, studies in the Burnett River (Hamann et al. 2004) and the Fitzroy River (Limpus et al. 2011) and the present evaluation of Mary River turtles indicate that the cloacal ventilating species can continue living and breeding within at least the shallow, up-stream reaches of impoundment areas for decades after their construction.

In the absence of any studies of impacts of over-topping events and water release events from dam and weir infrastructures in the Mary River, the Hamann et al. (2007)

and Limpus et al. (2011) studies in the Burnett and Fitzroy Rivers respectively provide a basis for identifying other likely negative impacts of dam and weir infrastructures on the health and mortality of turtles:

- Impoundment structures are barriers to the movement (migration) of turtles up and down the streams. In the long term this has the potential to limit gene flow within the population as a whole.
- No existing fishway has been proven suitable for enabling turtles to pass safely back and forth past impoundment infrastructures.
- Some turtles are significantly damaged or killed when they are washed over impoundment structures with flooding events and smashed on the concrete or rock structures at the base of walls or when they try to climb the walls and fall back onto the concrete or rock footings.
- Turtles are attracted to and aggregate within the low velocity stream flows associated with environmental flows from impoundment structures. Some of these same turtles are significantly damaged or killed when they are washed back with high velocity water releases through an impoundment wall, e.g. with agricultural flow releases.
- Filter systems which prevent trash entering and blocking water release intakes on the upstream side of impoundment infrastructures can trap large numbers of turtles and cause their death.

Within the current regime of impoundments within the Mary River, there is no indication that the presence of these impoundments threatens the survival of these species further downstream from impoundment structures. However, the concerns raised by Boardman (1996) regarding the potential for cumulative impacts of multiple impoundments on turtle populations to be non-sustainable should not be ignored in this regard.

It is presumed that land management over the past century-and-a-half within the Mary Catchment has had additional negative impacts on these species with reduction of riparian vegetation resulting in a reduction of fruits selected for food (fig, lillypilly, black bean) falling into the water, reduction in large log tangles as refugia and siltation/infilling of pools. There is a dearth of information on the impact on wild turtle populations of pesticide, herbicide, fertiliser and other chemical pollution runoff from farms, industry and urban development.

During dry seasons, agricultural demand for water is expected to result in the pools that are drought refugia for these turtles being drawn down to levels lower that would occur naturally.

Table 1. Freshwater turtles in the Mary Catchment, south Queensland. Recent taxonomic changes have separated *Elseya* latisternum and other closely related species to a new genus, *Wollumbinia* (Wells 2007).

Name	**Species**	**Endemicity**	**Threatened species status**	
			Commonwealth EPBC	**Queensland NCA**
Mary River turtles	*Elusor macrurus*	Occurs only in Mary Catchment, SE Qld	Endangered	Endangered, BOT = critical
White throated snapping turtle	*Elseya albagula*	Occurs in Mary, Burnet & Fitzroy Catchments, SE Qld	-	Common, BOT = high
Sawshell turtle	*Wollumbinia latisternum#*	Wide spread, northern NSW, QLD & eastern NT	-	Common
Krefft's short-necked turtle	*Emydura macquarii krefftii*	Wide spread, Mary River to Cape York Peninsula, Qld	-	Common
Broad-shelled river turtle	*Chelodina expansa*	Wide spread, SA-Vic-NSW-sth Qld	-	Common
Eastern snake-necked turtle	*Chelodina longicollis*	Wide spread, SA-Vic-NSW-sth Qld	-	Common

2. METHODS

Data sources and analysis

This report was initially commissioned by Queensland Water Infrastructure to review the knowledge of Mary River turtles captured within the government's Queensland Freshwater Turtle database. In response to the initial report, it was requested that more information be supplied on the sampling periods, sampling areas and methods used in gathering these data. This second edition of the report addresses these issues and has re-organised analysis and discussion of results while including some additional data gathered over the last year.

The study has collated data and summarises the knowledge gained from studies of freshwater turtles within the Mary Catchment. Tagging data from past studies are maintained within the Queensland freshwater turtle database maintained by the government's Turtle Conservation Project (QTCP). While no new field data was collected specifically during the present study, incidental data has continued to be recorded by staff and volunteers within the QTCP. Data has been sourced from the following studies:

- Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments, a QPWS study 1997 to 1999 (Tucker, 2000).
- S. Flakus M.Sc. studies, University of Queensland (Flakus, 2002).
- Tiaro community nest protection project (Tiaro and District Landcare Group Inc. 2005; Connell and Wedlock, 2006; van Kampen et al. 2003).
- Turtle studies by the former Environmental Protection Agency (EPA) in the Mary River:
    - o Dewatering the Borumba Dam plunge pool, collaborate project with Sunwater;
    - o Tagging-recapture studies in the Mary River collecting comparative *E. albagula* data for use in Burnett and Fitzroy Catchments studies (Thomson et al. 2006; Hamann et al. 2007; Limpus et al. 2007).
    - o Turtles supplied to post-graduate studies on *E. albagula* cloacal ventilation.
- Turtle studies of turtle mass mortality events by the former EPA.
- Data from other published studies.

New data collected by staff of the former EPA and QTCP volunteers that were added to the database during 2007-2008 include:

- Results of vessel based survey of turtle nesting banks along the Mary River during November 2006 from Kenilworth to Tiaro by Greening Australia, Tiaro.
- Snorkelling capture and tagging study by Craig Latta during April-May 2007 in the Mary River upstream of Traveston Crossing.
- Preliminary investigation of Obi Obi Creek, a mountain stream tributary in the extreme upper Mary River Catchment.

For statistical analysis, unless otherwise stated, means are presented with standard deviations. Statistical significance was accepted at $p < 0.05$.

Capture

Unless otherwise defined, the procedures described in Limpus et al. (2002) and Hamann et al. (2004) were used for the capture of turtles. Major sampling sites named in the text are shown in Figure 2.1. The sampling sites along the Mary River for which turtle data area available have been grouped into "sampling areas" shown as numbered sections in figure 2.1:

1. Within the Mary Barrage, downstream from Tairo.
2. Tiaro, adjacent to the traditional nesting banks identified by Flakus (2002).
3. Upstream and downstream of the highway bridge over the Mary River adjacent to the junction with Munna Creek.
4. Gunalda reaches.
5. Gympie reaches.
6. Upstream and downstream of Traveston Crossing.
7. Kenilworth area, downstream of Obi Obi Creek junction.

Data collected from tributaries are analysed for each of the respective tributaries.

The turtle capture data from each sampling area are summarised in Appendix 1.

Turtles were captured using four main methods:

- **Snorkelling:** Turtles were located visually by snorkelling along the sides and bottom of streams and captured by hand. Most snorkelling was by day (Figure 2.2a).
- **Trapping:** Various trap designs were used during 1997-2007 within the Mary River Catchment.
    - o Submerged trap: The original trap used was a submerged modified rectangular collapsible crab pots with two wide funnel openings and with a line to a surface marker.
    - o Floating trap: In some situations, the above collapsible traps were modified using internal styrofoam floats to produce a floating traps.
    - o Cathedral trap #1: Since 2003, the most commonly used trap was the "cathedral trap". These were modified submerged rectangular collapsible traps with an additional chamber above that was accessed via a vertical one-way entrance from the lower baited chamber. The trap was deployed so that the top of the upper compartment was positioned so that turtles could surface to breathe (Figure 2.2b).

  Submerged traps were checked every 1-2 hours depending on water temperature. Cathedral traps and floating traps were checked at least twice every 24 hours. Throughout this study a single bait type (beef heart) was used because of its attractiveness to a wide variety of turtle species and ease of handling.
- **Seine netting:** Seine nets 70 m or 30 m long and with mesh size of 5.5 cm were used singly or in combination in the open water habitats usually less than 2 m deep (Figure 2.2c). Most seine netting was conducted by day.
- **Muddling:** A line of people walking across a shallow pool, usually <50 cm deep, used their hands and feet to locate and catch turtles (Figure 2.2d).

Unless stated, each turtle was released at the point of its initial capture.

Distribution

An extensive range of habitats throughout the Mary Catchment has been sampled – from large reaches of the main river to farm dams; from permanent river reaches to drying waterholes in streams that do not flow year round. Where required, the Adopted Middle Thread Distance (AMTD) was used to reference capture sites, movement patterns of individual turtles and to describe the position of sites during the study. AMTD is defined as the distance, in kilometres, along the midline of the stream from the point of interest to the stream's mouth or confluence with the main watercourse (data was supplied by former Department of Natural Resources and Water). A GPS location (navigation set up WGS84) was recorded directly for each capture site or pool or the latitude and longitude for the capture site was estimated from GIS generated maps of the Catchment.

Morphological measurements and tagging

Morphological measurements were taken as described in Limpus et al. (2002). Two primary measurements were analysed during preparation of this report. Straight carapace length (SCL) was measured along the midline from the anterior end of the carapace to the posterior margin of the carapace at the junction between the post-ventral scutes. Tail length to carapace (TC) was the straight distance from the tip of the extended tail to the posterior end of the carapace.

Turtles captured within the Mary Catchment from 1996 until 2008 have been tagged using the standard methods used within the government's Queensland Turtle Conservation Project (Limpus et al. 2002). Each turtle was tagged with a self-locking, self-piercing monel tag in the webbing of a hind foot (Figure 2.3a) and/or coded with one or more notches in the marginal scutes (Figure 2.3b).

Sex, maturity and reproductive status

Life history stages are defined as follows.

Adult is defined as a turtle that is reproductively active for the current breeding season or one that has bred in the past.
Immature is defined as a turtle that has not completed development of its reproductive system and has not commenced breeding.
Hatchling is defined as a recently hatched young still associated with the nest or as a small juvenile turtle captured in the wild with an egg caruncle present and with an incompletely closed umbilical scar (Figure 2.4).

To determine gender, sexual maturity and breeding status, gonads were routinely examined either visually via laparoscopy following the methods of Limpus et al. (2002) and Hamann et al. (2007) (Figure 2.5a). Some gravid females carrying oviducal eggs were identified by palpation via the inguinal pocket.

The structure and development of the gonads and reproductive ducts of chelid turtles are, in principal, very similar to those previously described for marine turtles (Family Cheloniidae: Limpus and Limpus, 2003; Limpus, 1992) and have been described in part by Limpus et al. (2002), Hamann et al. (2007) and Limpus et al. (2011).

Females were assigned a maturity status based on ovarian and oviduct characteristics (After Limpus et al. 2011):
Immature: if the oviduct and ovary were not fully expanded (Figure 2.5b) or the ovary did not contain corpora albicantia, corpora lutea or mature ovarian follicles.
Adult: if the ovary contained one or more of the following characteristics; an enlarged, convoluted oviduct and expanded ovary with developing, mature or large atretic follicles, corpora lutea or corpora albicantia or oviducal eggs (Figure 2.5d,e,f,g). Adult female breeding status was defined using the following criteria:

- Corpora albicantia are characteristic of females that have ovulated in any previous breeding season (Figure 2.5f)
- Vitellogenic females preparing for the next breeding season had developing, vascularized yellow follicles larger than 0.5 cm in diameter that were distinctly larger than the previtellogenic follicles (Figure 2.5d).

- A female that had ovulated in the most recent breeding season was characterised by corpora lutea on the ovary (Figure 2.5c,d,e,f) and in some individuals, large ovarian follicles in atresia (Figure 2.5g).
- Female turtles breeding in consecutive seasons had either oviducal eggs or healing corpora lutea indicating that they had bred in the most recent breeding season and developing follicles in the ovary indicating that they were preparing to breed in the next breeding season (Figure 2.5g).

Males were assigned a maturity status based on testicular and epididymis characteristics (After Limpus et al. 2011):

Immature: if the epididymis was not fully distended from the body wall to be a pendulous structure adjacent to the testis (Figure 2.6a,b). Testis may be flat to ovoid in cross-section (Figure 2.6a).

Adults: if they had a fully pendulous epididymis extruding into the body cavity from the body wall (Figure 2.6c,d). Adult male breeding status was defined using the following criteria:

- Adult males within their spermatogenic phase were identified by the presence of a distinct white tubule in the epididymis (Figure 2.6d).
- Adult males also had visually distinct seminiferous tubules in the testes (Figure 2.6c).

Nests, eggs and clutches

Nest sites were located using a range of methods. At nesting time by day, stream margins were searched for tracks of nesting females to and from the water (Figure 2.7a). Known nesting banks were searched at night using spotlights to locate turtles ashore on nesting attempts. Some nesting turtles were encountered during daylight hours (Figure 2.7b,c). Stream margins were systematically searched in the vicinity of sand and loam banks for signs of nest sites and for broken eggshell from nests dug into by predators (Figure 2.7d).

Particular emphasis was given to searching stream banks between May and October for evidence of *E. albagula* nesting and during October-December for evidence of *E. macurus* nesting.

The nest location was recorded for distance (± 0.01 m) from water, height above water (± 0.1 m) and angle of slope of the bank from the water. Nests were excavated to record depth (± 0.5 cm) to top of eggs and to bottom of eggs. When eggs were in the nest they were removed with minimum of rotation for counting and each egg weighted on an electric balance (± 0.1g) and measured (± 0.01cm) for length and width using vernier callipers (Figure 2.8).

When intact or predated clutches were detected for which the nesting female had not been observed, species identification of eggs was made using measurements of the eggs or near-intact eggshells. Identification was assisted using a comparison of egg length and diameter for freshwater turtles that occur in the Mary Catchment (Figure 2.9). *E. albagula* lays the largest eggs (both width and length) for any species of freshwater turtles in southeast Queensland. Varanid (goanna) and agamid (dragon) eggs laid on the turtle nesting banks are distinguishable by their soft-shell even though they have measurements that occur within the range of the turtle eggs. One egg was taken from each wild clutch of eggs suspected to be *E. macrurus* and incubated in the laboratory at 29^{o}C to confirm species identification from the hatchling.

Where nesting and egg data are not available from the Mary Catchment, these data were derived from published accounts from other catchments where they are available.

Age and growth

Each growth layer (annulus) on a scute, not counting the initial hatchling scute, is assumed to represent a year of growth (Figure 2.10a). All available data for the Mary River Catchment has been included. Growth layers on the carapace and/or plastron scutes were counted to record the minimum age of individual turtles where the entire growth sequence from the hatchling scute or the 1st-year growth layer remained visible (Figure 210b). For example, if a turtle had seven growth layers separated by six rings, it was deemed to be in its 7th year of growth. However, the scutes on almost all adult turtles, and most large immature turtles were worn and an accurate age could not be determined for the majority of the turtles.

Mortality and injury

In response to the numerous fractured and dead turtles encountered associated with impoundment structures during studies in the Burnett River (Hamann et al. 2004), turtle populations throughout the Mary Catchment since 2003 were surveyed for injuries.

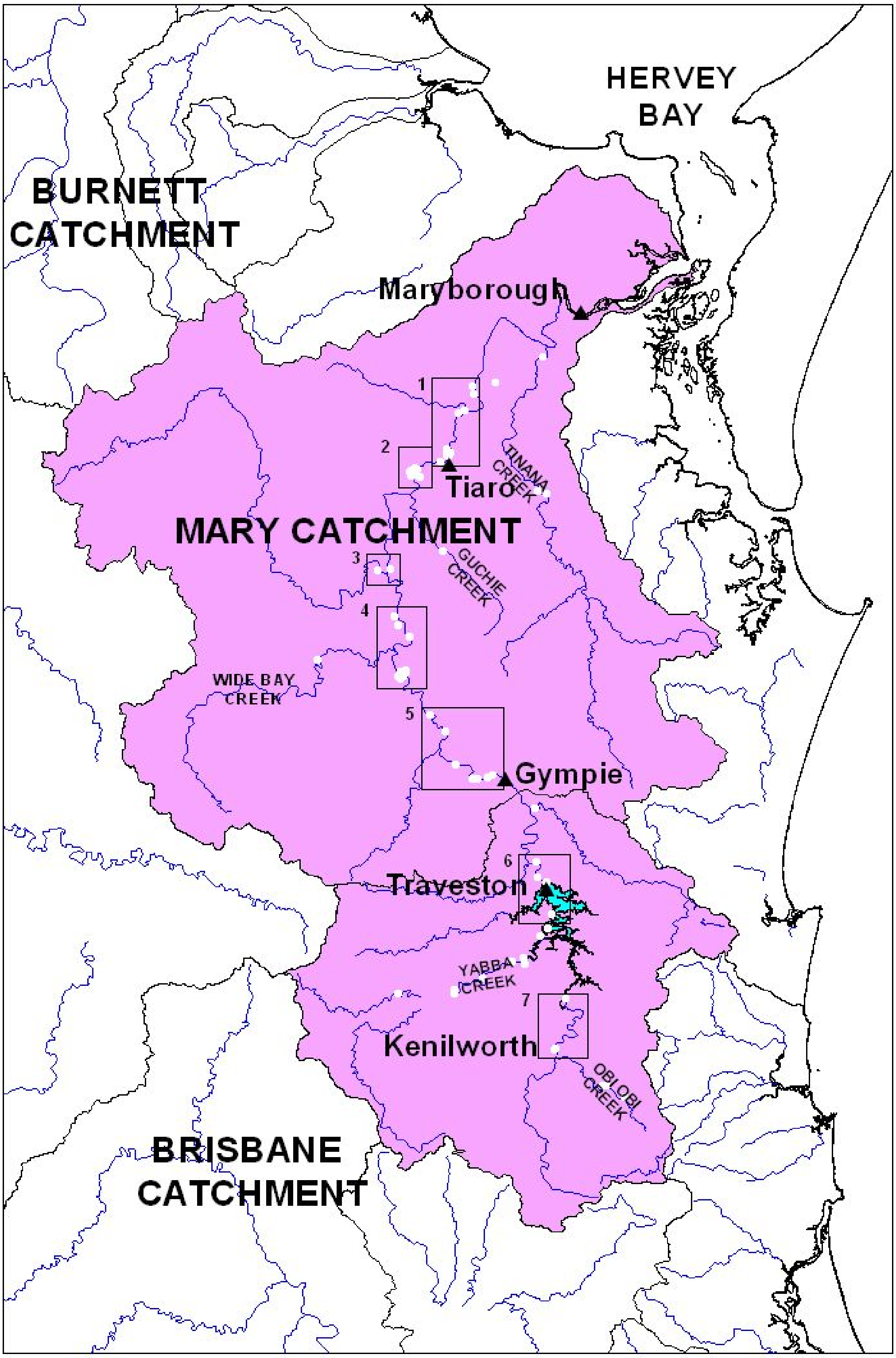


Figure 2.1. Primary sampling sites and impoundments within the Mary River catchment that are referred to in the text. See text for identification of the seven numbered sampling areas along the Mary River. White dots denote sampling sites represented in the database. The blue area denotes the approximate footprint of the proposed Traveston Crossing Dam.

2.2a. Snorkelling for Freshwater turtles.

2.2b. Cathedral trap.

2.2c. Seine netting for turtles, plunge pool below Borumba Dam, September 2003.

2.2d. Muddling for turtles during dewatering of the plunge pool below Borumba Dam, September 2003.

Figure 2.2. Capture methods.

2.3a. A monel, self-piercing, self-locking tag applied through the webbing of the left hind foot, *Chelodina expansa*, Borumba Dam.

2.3b. Notched marginal scale of an adult male *Elusor macrurus*), Mary River.

Figure 2.3. Tagging methods.

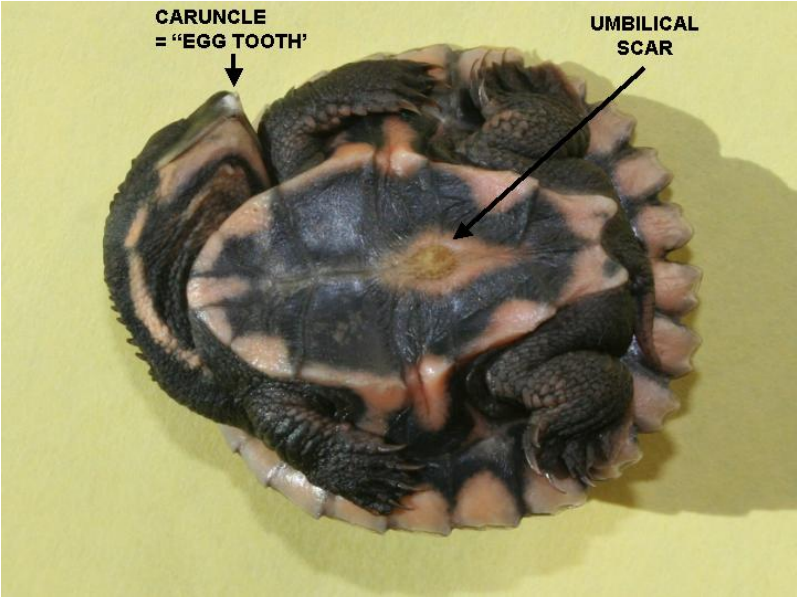
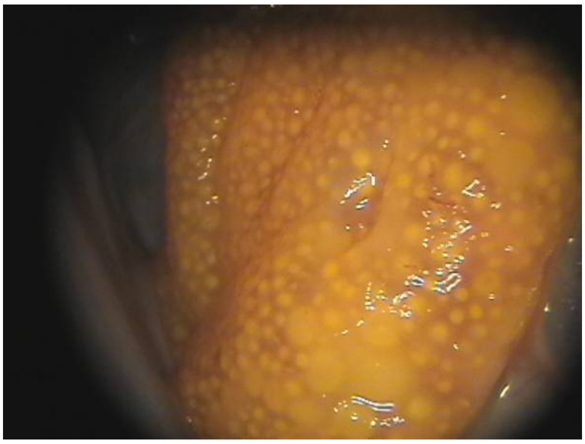
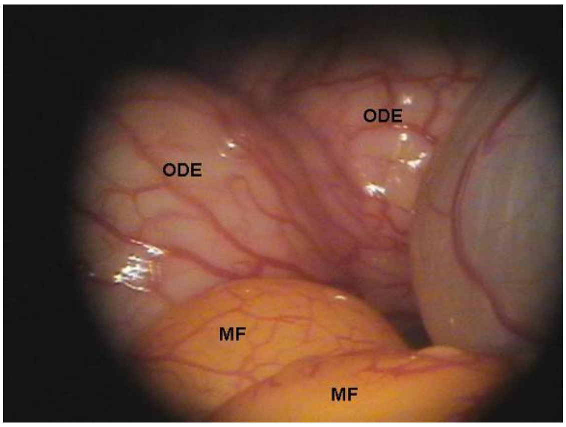


Figure 2.4. Morphological features defining the hatchling life history phase illustrated on a hatchling *Wollimbinia latisternum* from Buderim, May 2007.

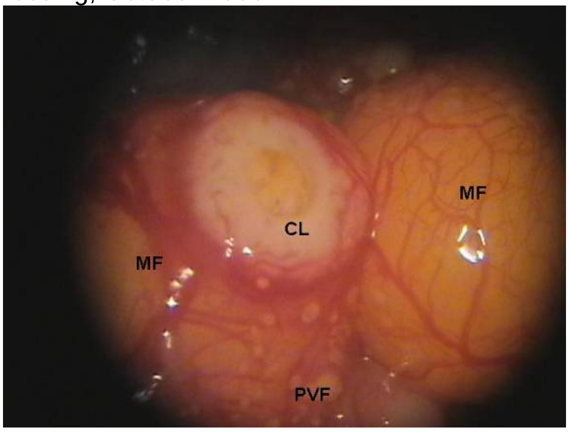
2.5a. Adult female *Elseya albagula* restrained for laparoscopic examination.



2.5b. Compact ovary with small yellow previtellogenic follicles characteristic of immature females; *Elseya albagula* (Tag: 5715), Glenroy Crossing, October 2006.

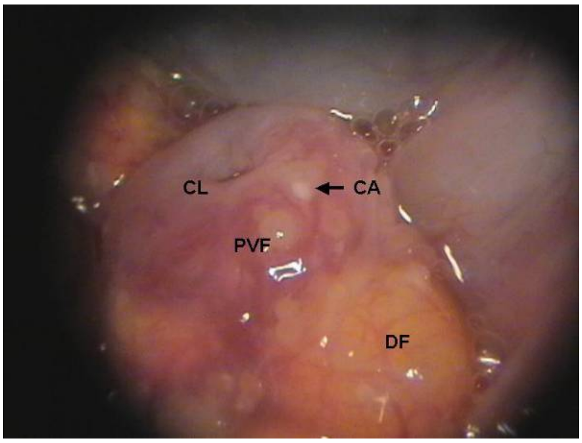


2.5c.i. Hard-shelled oviducal eggs, mature follicles

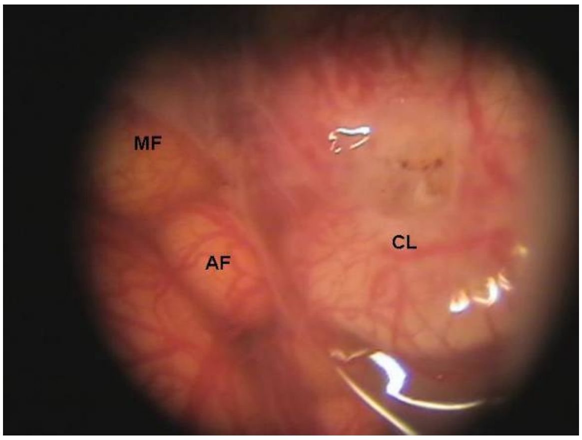


2.5c.ii. Corpus luteum and mature follicles for an additional clutch.

2.5c. Adult *Wollumbinia latisternum* (Tag: 19095), carrying oviducal eggs for her 1st clutch for the season and mature follicles for an additional clutch(es), Glenroy Crossing, October 2006.

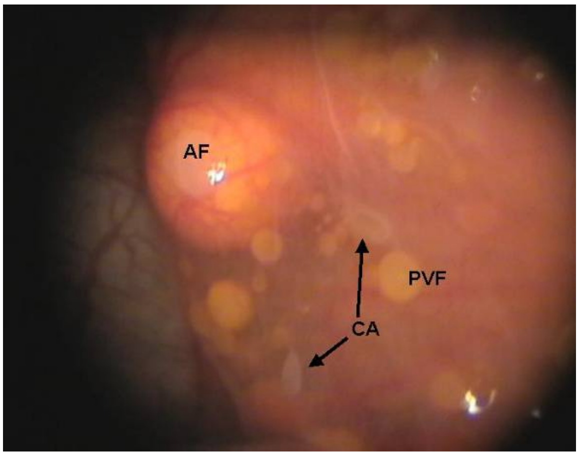


2.5d. Adult *Emydura m. krefftii*, corpus luteum, developing follicle, previtellogenic follicle, corpus albicantium, Fitzroy Barrage, October 2006.

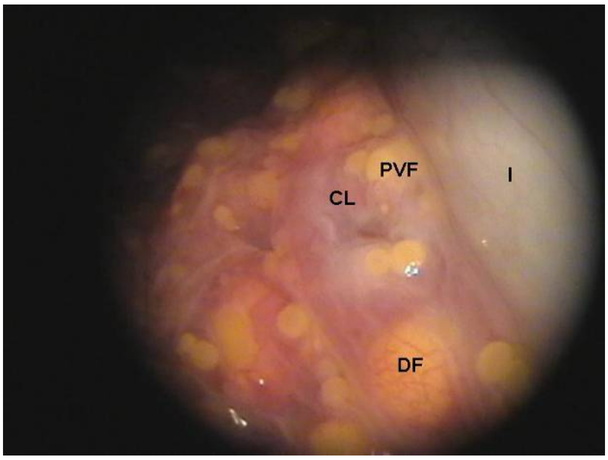


2.5e. Adult *Rheodytes leukops* (tag = 24790), mature follicle, corpus luteum and small vascularized developing follicle, Cardoan, Connars River, 27 September 2005.

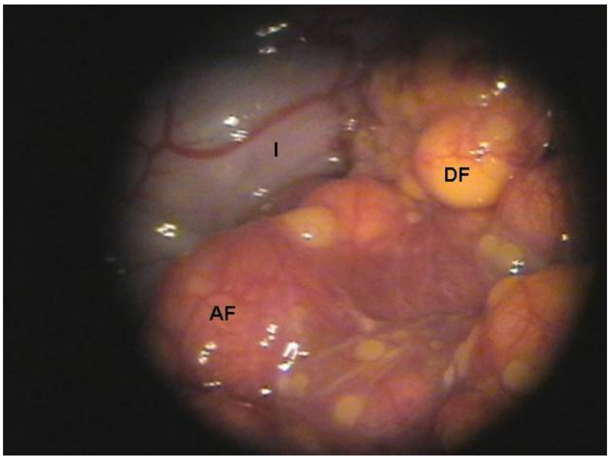
Figure 2.5. Visual examination of freshwater turtle ovaries and oviducts using laparoscopy. MF = mature follicle; DF = developing follicle; AF = atretic follicle; PVF = previtellogenic follicle; CL = corpus luteum; CA = corpus albicantium; I = intestine.



2.5f. Adult female *Rheodytes leukops* (tag: 5719), small atretic follicle, previtellogenic follicles and corpora albicantia, Glenroy Crossing, October 2007.



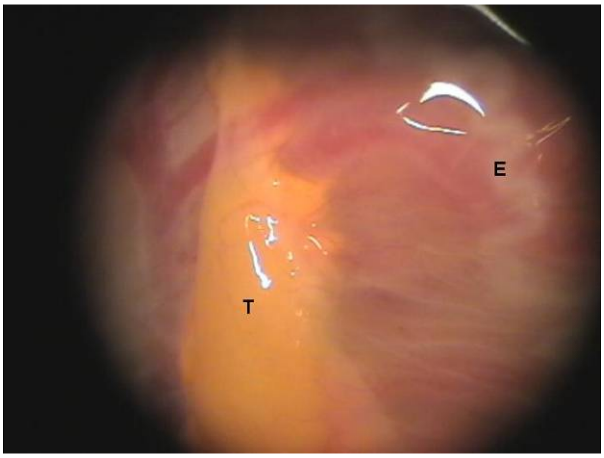
2.5.i. Healing corpus luteum and small vascularized developing follicles



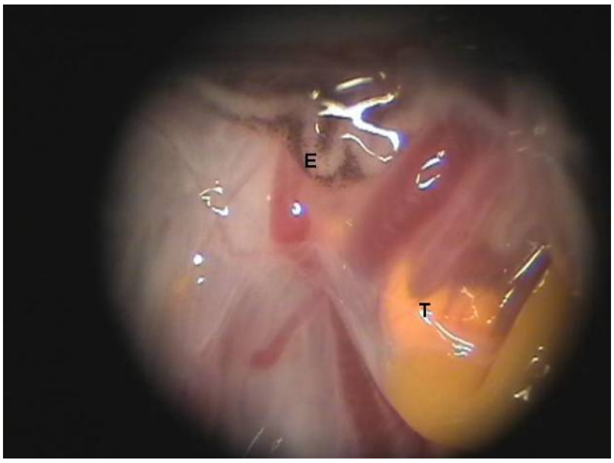
2.5g.ii. Large atretic follicle and small vascularized developing follicle.

2.5g. Adult female *Elseya albagula* (tag: 5778), Glenroy Crossing, 9 October 2006.

Figure 2.5 Continued.

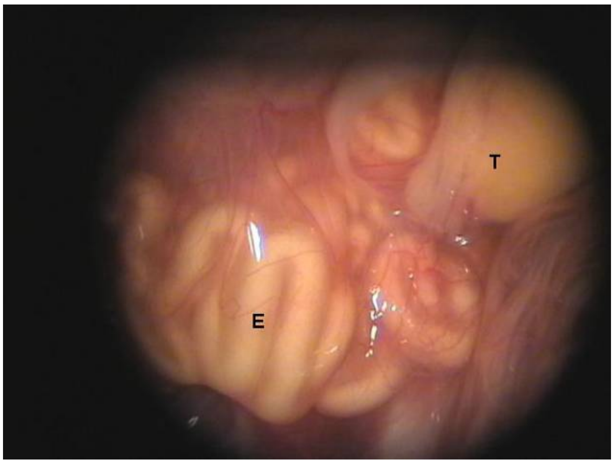


2.6a. Prepubescent male *Emydura m. krefftii* (Tag: 4890), with non-pendulous epididymus within the body wall, Fitzroy Barrage, 24 September 2005.



2.6b. Pubescent male *Emydura m. krefftii* (Tag: 29685), with epididymus partly distending from the body wall, Fitzroy Barrage, 24 September 2005.

2.6c. Adult male *Chelodina expansa* (tag = 4607) in approximately stage 1-2 of the spermatogenic cycle, testis with distinct seminiferous tubules and translucent white epididymis, Yabba Creek, September 2003.



2.6d. Adult male *Rheodytes leukops* (tag = 29942) in approximately stage 7-8 of the spermatogenic cycle, distended opaque white epididymis adjacent to a yellow testis, Glenroy Crossing, October 2006.

Figure 2.6. Visual examination of freshwater turtle testis and epididymus using laparoscopy. T = testis; E = epididymus; L = lung.

2.7a. *Elusor macrurus* tracks on nesting bank, Tiaro. Photograph by Sam Flakus.

2.7b. *Emydura macquarii krefftii* nesting within a suburban garden.

2.7c. Elseya albagula nesting, May 2008 beside Baxter Creek, a tributary of Obi Obi Creek. Photograph by Dennis Woodford.

2.7d. Broken *Elseya albagula* egg shells at nest dug into by a monitor lizard, *Varanus varius*, 4 September 2003, Obi Obi Creek.

Figure 2.7. Freshwater turtle nests.

Figure 2.8. Weighing and measuring turtle eggs from a natural nest after the female had completed oviposition, nesting bank 1 within the Fitzroy Barrage, 22 September 2005 (Female tag: 4803).

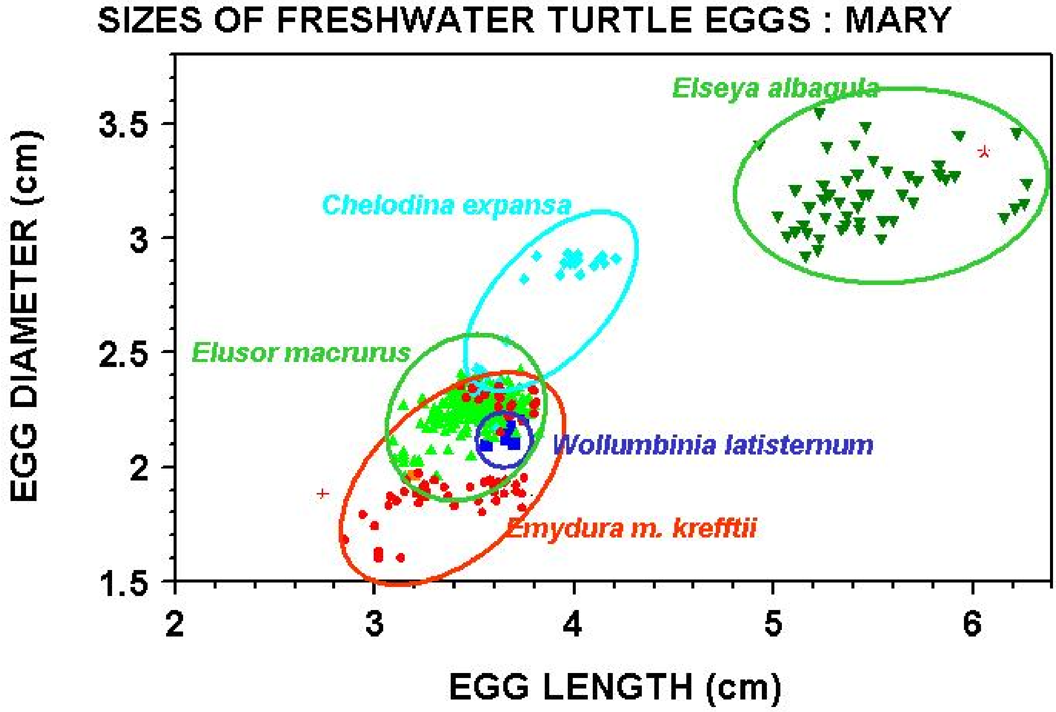


Figure 2.9. Comparison of egg measurements for the freshwater turtle species in the Mary Catchment. The lace monitor, *Varanus varius*, has soft-shelled eggs (denoted by *) of comparable size to the hard-shelled eggs of *Elseya albagula*. Water dragon, *Physignathus lesueurii*, eggs (denoted by +) are of comparable size to the eggs of *Emydura m. krefftii*.

2.10a. 8mth old captive reared juvenile displaying one growth layer outside of the hatchling scute for each scute. This turtle is scored as being in its 1st year of growth.

2.10b. Carapace of immature male in its 7th year of growth, Glenroy Crossing, October 2006 showing visible annuli. Hatchling scute still visible within each scute.

Figure 2.10. Growth layers in scutes of *Elseya albagula*.

3. MARY RIVER TURTLE, *Elusor macrurus*

E. macrurus (Figure 3.1) is the sole survivor of one of the more ancient lineages of Australian freshwater turtles (Georges and Thomson, 2006). The species is also one of the largest freshwater turtles in Queensland. Yet, it has been one of the more recent turtle taxa described for Australia (Cann and Legler, 1994). The species was identified as "short-neck alpha" in the scientific literature before 1994. It displays atypical chelid sexual dimorphism with the adult female being smaller than the adult male. With reversed sexual dimorphism, this species has the largest males amongst chelid turtles in Australia. Adult males also have extremely large tails compared to those of other species. The species is iconic, being one of five Queensland species of turtle with well developed bimodal ventilation – using gas exchange from the air by the lungs and from the water by an elaborate cloacal gill system.

E. macrurus was subject to intense egg harvest for producing hatchling turtles, "penny turtles", for the pet trade in the 1960s through to 1974 when the species was protected under the *Fauna Act 1974* with a corresponding cessation of the trade (Cann, 1998; Flakus, 2002). The eggs were collected from the traditional nesting banks near Tiaro. Flakus (2002) through interviews with the egg collector has provided a minimum estimate of egg production in the 1960s and compared this with the observed nesting rates in the late 1990s. She estimated that there had been an approximately 95% decline in the size of the annual nesting population at the main Tiaro nesting banks from the 1960s to the late 1990s (Figure 3.2). This population decline has been attributed to the long term consequence of many years of excessive egg harvest. As a result of this population decline, *E. macrurus* has been listed as an endangered species under the Queensland *Nature Conservation Act 1992* and the *Environmental Protection and Biodiversity Conservation Act 1992*.

These are the only long term census/trend data available for any freshwater turtle population in Queensland.

Distribution

E. macrurus is found naturally only in the Mary Catchment. It occurs primarily in the mainstream Mary River and major tributaries, including Tinnana Creek, Yabba Creek and Obi Obi Creek (Figure 3.3). It occurs from the downstream freshwater limits within the Mary River Barrage up into the upstream mountain reaches above Kenilworth in the upper Catchment. It has not been recorded from any temporary wetlands or farm dams and other man-made water bodies within otherwise ephemeral stream areas within the catchment. This is a turtle that occurs in the permanent stream and large pool habitats of the Mary Catchment.

While the entire Mary Catchment has not been systematically surveyed for turtle distribution and abundance, it has been sufficiently surveyed to enable a number of generalities to be made with confidence.

- *E. macrurus* occurs within the area of the Mary River that will be flooded if Traveston Crossing Dam is constructed.
- *E. macrurus* occupies habitat within existing impoundments in the Mary Catchment:
    - It has been captured in and recorded breeding from within the Mary River Barrage impoundment in the lower catchment.
    - It has been recorded within the Tallegalla Weir impoundment, Tinnana Creek.

    - It has been captured in and recorded breeding from within the Imbil Weir impoundment, Yabba Creek in the upper catchment.
- *E. macrurus* occurs within Yabba Creek downstream of Borumba Dam.
- *E. macrurus* has not been recorded within the Borumba Dam impoundment or further upstream in Yabba Creek.
- *E. macrurus* has been recorded in upper mountain stream habitats of Obi Obi Creek.

Although long overlooked by the scientific community, the species is surprisingly prominent with both adult and immature *E. macrurus* regularly basking along with other turtle species on logs, rocks and banks throughout the Mary River (Cann, 1998; Flakus, 2002).

E. macrurus have been recorded washed downstream over the Mary River Barrage into the estuarine waters. It appears unlikely that they can return back upstream past the barrage wall. The fate of these turtles has not been determined.

Population structure and dynamics

Figure 3.4 summarises the size class distribution by species, sex and maturity for *E. macrurus* within the Mary River. Hatchlings have a mean SCL of approximately 3.3 cm. The sizes of adult turtles of confirmed sex and maturity are

females: SCL = 31.72 cm (SD = 1.917, range = 27.22 – 34.78, n = 28);
males : SCL = 37.47 cm (SD = 2.552, range = 28.70 – 42.02, n = 25)

Large male *E. macrurus* are the largest turtles in this catchment.

The limited data available for *E. macrurus* with readable growth layers indicates that the species is slow growing with delayed maturity (Figure 3.5). It is expected that the species takes more than 15 years before either sex will commence breeding.

The size frequency data by sex and maturity indicate that there was a general paucity of large immature *E. macrurus* (greater than 4 years old) in the population in the late 1990s within the lower to middle Mary River (Appendix 1, Figure 3.4a-b). At the same time, the data indicate that there was a modest proportion of small immature *E. macrurus* (less than 4 years old) within the population. Overall, immature turtles comprised only 35% of the lower Mary River population in the late 1990s. This is an unsatisfactory low proportion of immature turtles in the population. The measured sample examined in the vicinity of Traveston, in the upper Mary River, during 2007 also displays an unsatisfactory population structure (Figure 3.4c) with a poor representation of large immature turtles but a higher proportion of medium-sized immature turtles (estimated age > 4 years old). Collectively these data (Figure 3.4) indicate a general trend for increasing proportion of immature turtles in the population with sampling further upstream (34% immature in lower Mary; 38% in middle Mary; 75% in upper Mary) (Figure 3.6).

Because most of the sampling during the late 1990s was undertaken downstream from Gympie to the upper reaches of the Mary River Barrage and then up stream of Gympie during 2007-2008, caution should be exercised in extrapolation of these conclusions. There are several possible hypotheses that could account for the differences identified with these data:

e. There has been an improvement in juvenile recruitment over the past decade;
f. There has been better juvenile recruitment in the upper reaches of the Mary River than in the middle to lower reaches;

g. Small immature *E. macrurus*, of about 3-4 years of age migrate upstream from the vicinity of the principal nesting banks near Tiaro and accumulate in the middle to upper stream reaches of the Mary River when more than 4 years old.
h. The samples are biased by a combination of study methods and operator skills.

Other population data that have a bearing on population function include:

- Among the 29 adult females examined for breeding status, none were females in their first breeding season. This indicates that the species has a very low recruitment to the adult life history phase, with the population composed mainly of aging adults.
- Of adult females whose breeding status was examined, 86% were breeding within the year during which they were examined. Most adult females bred in successive years.

Reproduction

The species aggregates for nesting on traditional nesting banks that are revisited for nesting across decades (Cann, 1998; Flakus, 2002). The distribution of known nesting sites within the Mary River are illustrated in Figure 3.3b. While there are numerous sand banks occurring through out the Mary Catchment, no nesting has been recorded at the majority of recorded sand banks (Figure 3.3b).

The Tiaro based community group continues to identify turtle clutches found after females have returned to the river following laying on the nesting banks near Tiaro during late October to December (Flakus, 2002; van Kampen et al. 2003; Tiaro and District Landcare Group Inc. 2005; Connell and Wedlock, 2006). Their species identification has been very accurate. This is based on identification of hatchlings from representative eggs incubated at the government's Mon Repos laboratory: 95-100% of the yearly sample of clutches were correctly identified to *E. macrurus*.

The limited radio tracking data (Flakus, 2002) indicates that *E. macrurus* will migrate variable but short distances from a foraging area to aggregate at traditional nesting banks – and return to the same foraging areas after the breeding season. For the majority of the nesting, *E. macrurus* lays its eggs into alluvial deposits of sand or loam, usually within 6 m of the water (van Kampen et al. 2003). These alluvial banks are reworked with each significant flooding event.

Nesting is not uniformly distributed with the Mary River. The present day nesting distribution down stream from Gympie (Flakus, 2002; van Kampen et al. 2003; Tiaro and District Landcare Group Inc. 2005; Connell and Wedlock, 2006) resembles the nesting distribution described for the early 1960s when there was a commercial egg harvest occurring (Flakus, 2002) – but with at least one to two orders of magnitude lower nesting density occurring now (Figure 3.2).

- Low density nesting occurs at several sites along the reaches below Tiaro. This area is now contained within the Mary Barrage.
- The most abundant nesting found in recent years continues to occur within the lower reaches of the river at the traditional nesting banks immediately upstream from Tiaro.
- There continues to be a paucity of identified nesting as one continues upstream towards Gympie.

Another cluster of low-density nesting banks has been identified in the upper Mary River in the reaches between Traveston Crossing and Kenilworth (Figure 3.3b).

E. macurus is a spring-summer (October-December) nesting species (Flakus, 2002; van Kampen et al. 2003). Laparoscopic examination of adult females has not identified any turtle producing more than a single clutch for the breeding season. As each female lays her clutch for the season she has already commenced enlargement of the small developing follicles in preparation for her clutch in the next breeding season. Contrary to previous reports (Cann, 1998), the great majority of *E. macrurus* will lay only one clutch of eggs per year. They average 14.7 eggs per clutch (van Kampen et al. 2003). These eggs are of intermediate size and overlap in size with *E. m. krefftii*, *W. latisternum* and small *C. expansa* eggs (Figure 2.9). The embryos have a short post-oviposition embryonic diapause and hatchlings emerge from nests in mid summer during December and January (Cann, 1998; Flakus, 2002). Legler and Georges (1993) give an incubation period of 56 days.

When eggs are left undisturbed and protected on the nesting banks, a high proportion of eggs hatch (81.6%), with 78.4% of eggs resulting in hatchlings leaving the nest to head for the water (van Kampen et al. 2003). *E. macrurus* is laying viable clutches of eggs.

The collective data on incubation success of eggs in natural nests on nesting banks within the lower Mary River indicates that an excessively high proportion of eggs are destroyed by predators (Feral: fox, dog and pig. Native: goanna and water rat) or trampling by cattle (Flakus, 2002; Tiaro and District Landcare Group Inc. 2005; Connell and Wedlock, 2006; van Kampen et al. 2003; unpublished data from the former EPA). These studies indicate that, in the absence of nest protection, approaching 100% of eggs will be destroyed by predators or trampled by cattle, at least in the mid to lower Mary River Catchment.

Diet

There has been no in-depth study of the diet of *E. macrurus*. From the limited sampling, it is clear that adults are primarily herbivorous (Tucker, 2000). They feed on a range of macrophytes as well as the fallen fruits of riparian trees including figs, lillypilly and black beans (Flakus, 2002).

Injuries and mortality

In other catchments, turtles are injured and killed as they attempt to pass upstream past impoundment structures and pass down over impoundment structures at flood time (Hamann et al. 2007). Many are also killed on the trash filter screens fitted to water outlets of dam and weir walls (Limpus et al. 2011). *E. macrurus* has not been exposed to significant mortality and injuries from these sources because of the general absence of substantial dams and weirs within the Mary Catchment and the lack of records for this species in the immediate vicinity of Borumba Dam. In the vicinity of Munna Bridge in an area without significant impoundment infrastructure, 13% of E. macrurus were recorded with fractures to the carapace and/or plastron. Some of these fractures were compressed fractures consistent the turtles having been trampled by cattle rather than fractures from impact with a hard substrate.

E. macrurus is one of the turtle species less frequently hooked on lines by recreational fishers. It has been recorded ingesting hooks baited with worm in Obi Obi Creek.

Discussion

The endangered Mary River turtle, *E. macrurus*, has to be regarded as the most threatened species of freshwater turtle in Queensland and one of the most threatened species in Australia. It was subjected to intense excessive egg harvest to supply hatchling turtles into the pet trade during the 1960s and up to 1974. It has been previously presumed that this egg collection caused the 95% decline in the breeding population that we observe today in the lower Mary Catchment (Flakus, 2002). However, there is no evidence that the population is in a recovery mode from that cessation of intensive egg harvest some three decades ago.

Based on the population structure of the wild, free-ranging populations that occur widely throughout the permanent stream and large pool habitats of the Mary Catchment, *E. macrurus* is recognised as having very low recruitment to the adult life history phase. The population is composed mainly of aging adults. In addition, even though most females breed each year, producing viable eggs, almost no eggs are hatching. This failure in hatching success is the result of intense predation of eggs on the nesting banks by a range of feral (particularly dogs and foxes) and native (goannas and water rats) predators. Based on the reports of the egg collectors in the 1960s and early 1970s, egg predation was not intense in those times (Flakus, 2002). Indeed, fox predation of turtle eggs may have emerged as a regional problem only since the 1960s (Flakus, 2002; Limpus, 2008). Therefore it is concluded that egg depredation has prevented the recovery of this severely depleted species since the egg harvest ceased in 1974. In the absence of nest protection actions, the continuing excessive loss of egg through predation is now the critical threat to the survival of this species.

Recovery of the species is also being compromised by the paucity of knowledge of the biology of this species in the wild. There is a lack of sound data regarding the habitat requirements of juvenile turtles, including their dietary requirements. Past and present assessment of growth and age to maturity has been based on very sparse data. The essential temperature and moisture regimes required for maximising incubation success remain undescribed. When linked to the sparse data on nest site selection for the species, it is not possible at present to define the optimal nesting banks required for enhancing the recovery of this species and hence clearly define the rejuvenation processes for the nesting banks that occur with significant flooding events. It also follows that attempts to restore riparian vegetation along the degraded margins of the streams may adversely impact on the availability of nesting habitat and the associated breeding success of this species.

E. macrurus is one of three species of freshwater turtles in the Mary catchment that has a significant reliance on extracting dissolved oxygen from the water using cloacal ventilation (Chapter 6). The diving physiology and diving behaviour studies indicate that the small juveniles have the greatest requirement for access to water with a reasonable dissolved oxygen content. This is undoubtedly the principal factor that contributes to the distribution of the species being limited to the flowing stream and permanent large water bodies within the catchment. As a consequence, in the absence of appropriate management of stream flow from impoundments, *E. macrurus* is identified as a turtle at high risk from the existing and planned changes to the in-stream habitat and flow regimes from the long past pristine conditions in this river.

E. macurus because of its unusual biology and its restriction to a single small river system with a highly modified catchment presents major challenges for conservation management. Climate change with the anticipated reduction in rainfall and hence alteration in stream flow for the Mary Catchment is adding additional significant elements into the complexity of maintaining viable populations of this unique cloacal ventilating species.

The occurrence of persistent populations in some of the water infrastructure impoundments in the Mary River warrant a priority for investigation to provide better insights into the actual environmental conditions under which long term viable populations of *E. macrurus* can be maintained in a progressively altering catchment.

Given the existing significant treat to the species from predation of eggs and the potential for the construction of a major dam to further negatively impact on the species, it is considered imperative that a whole-of-Catchment approach be taken for developing a management plan for the maintenance of sustainable populations of *E. macrurus* in the Mary River Catchment. All of the existing and potential threats to the species are amenable to mitigation with appropriate planning. Concerted action is needed to develop and implement an appropriate conservation management plan.

3.1a. Sexual dimorphism: small adult female on the left, larger adult male on the right.

3.1b. Adult male, illustrating the very large tail characteristic of the species.

3.1c. Head

3.1d. Ventral view, adult female

3.1e. Hatchling, newly hatched, dorsal view

3.1f. Hatchling, newly hatched, ventral view

Figure 3.1. Mary River turtle, *Elusor macrurus*

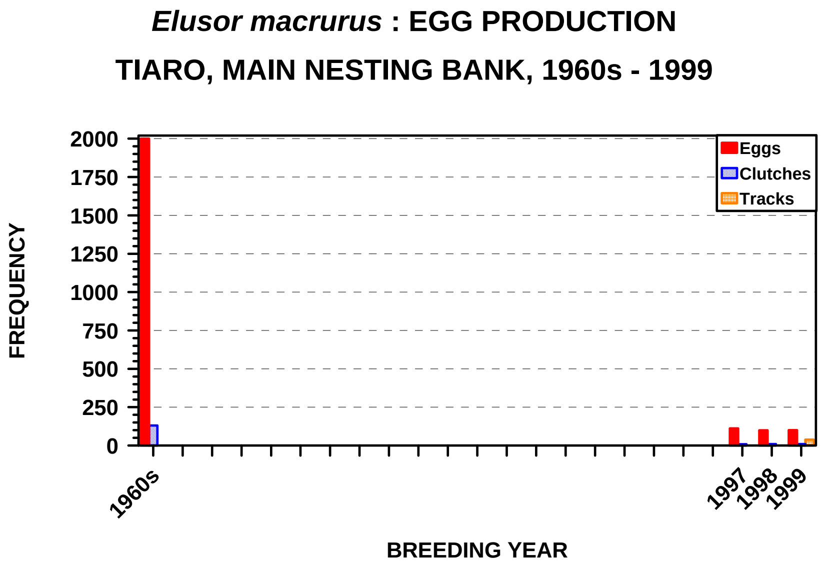


Figure 3.2. Comparison of estimated annual *Elusor macrurus* egg production from the main nesting bank at Tiaro from the 1960s with quantified annual egg production in the late 1990s (After Flakus, 2002).

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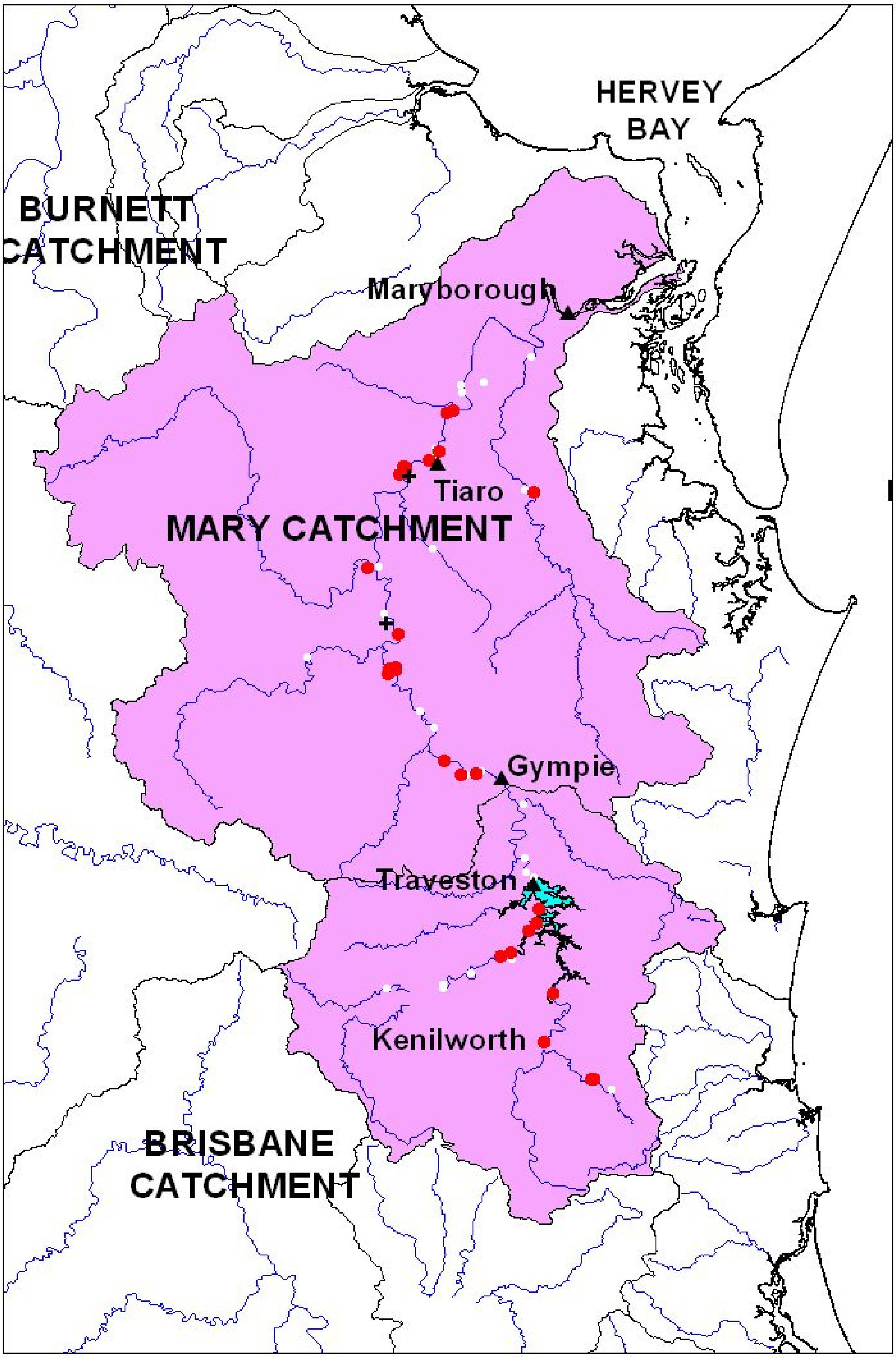


Figure 3.3a. Mary River turtle, *Elusor macrurus*: Distribution of recorded sites in the Mary River Catchment. Red dots denote capture and/or observation records. White dots denote sites examined where the species were not recorded. Black crosses denote type specimen localities. These records were extracted from the freshwater turtle research database of the former EPA Queensland.

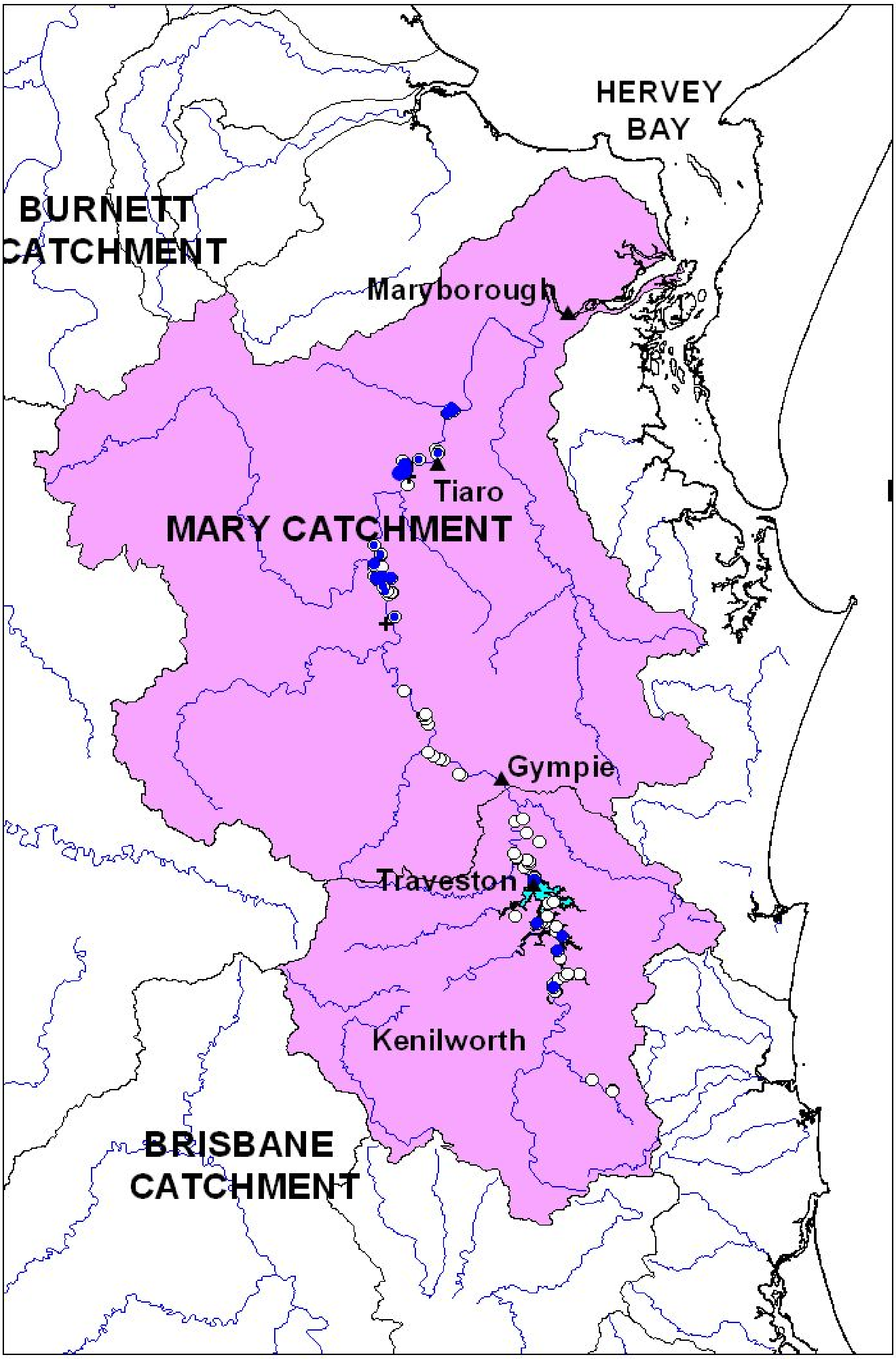
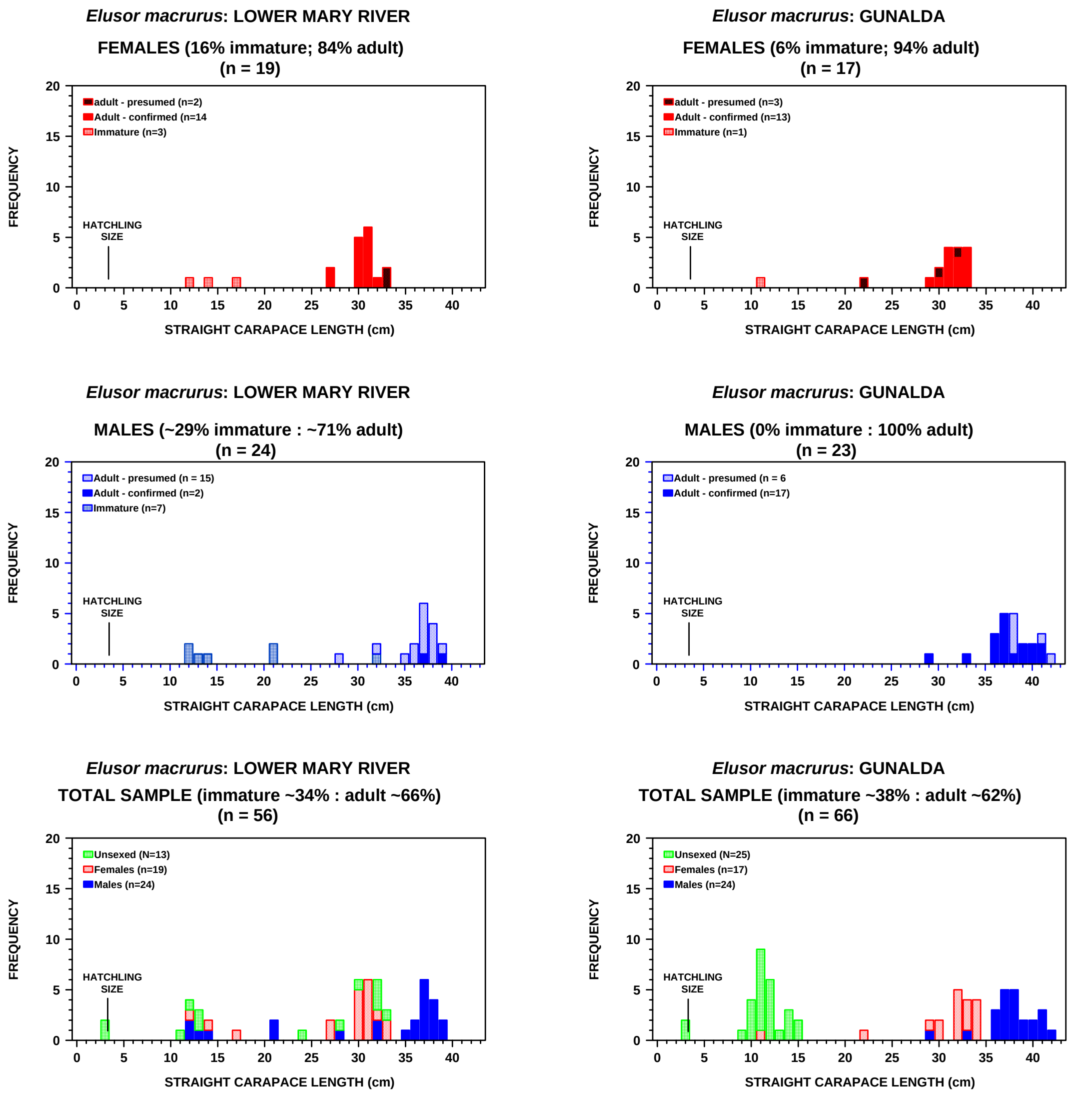


Figure 3.3b. Mary River turtle, *Elusor macrurus*: Distribution of nesting sites in the Mary River Catchment. Blue dots denote sites with observation nesting. White dots denote recorded sand banks at which nesting was not recorded. These records were extracted from the freshwater turtle research database of the former EPA Queensland.



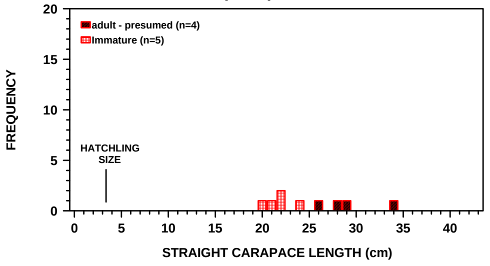
3.4a.The majority of the lower Mary River (Tiaro to Munna Creek Bridge site) sample was caught by snorkelling and by collecting nesting females off the banks.

3.4b. Gunalda sample was caught mostly by snorkelling.

Figure 3.4. Size class distribution by sex and maturity for *Elusor macrurus* within the Mary River. Data derived from the freshwater turtle research database of the former EPA Queensland. Confirmed sex and maturity were determined by gonad examination using laparoscopy or by palping to identify oviducal eggs. For other turtles, the sex and maturity was determined on morphometrics.

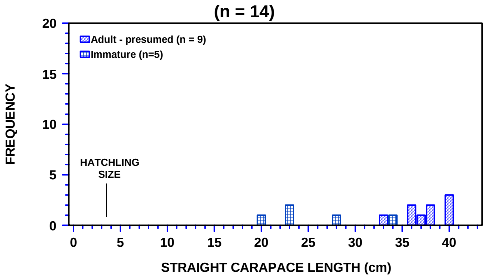
***Elusor macrurus*: TRAVESTON**

FEMALES
(n = 9)



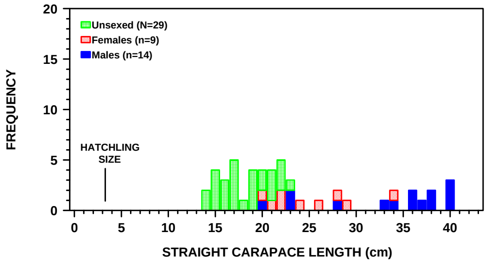
***Elusor macrurus*: TRAVESTON**

MALES
(n = 14)



***Elusor macrurus*: TRAVESTON**

TOTAL SAMPLE (immature ~75% : adult ~25%)
(n = 52)



3.4a.The majority of the upper Mary River (Traveston area) sample was caught by snorkelling.

Figure 3.4. Continued.

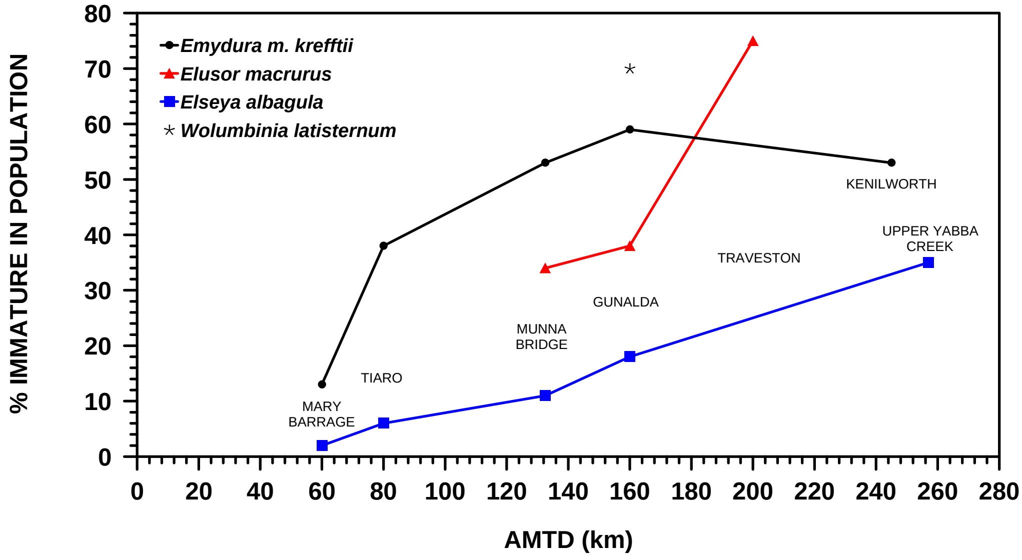


Figure 3.5. Variation in the proportion of immature turtles in the population for four species of freshwater turtles along the length of the Mary River Catchment from the downstream reaches in the Barrage up to the upstream reaches near Kenilworth and Imbil.

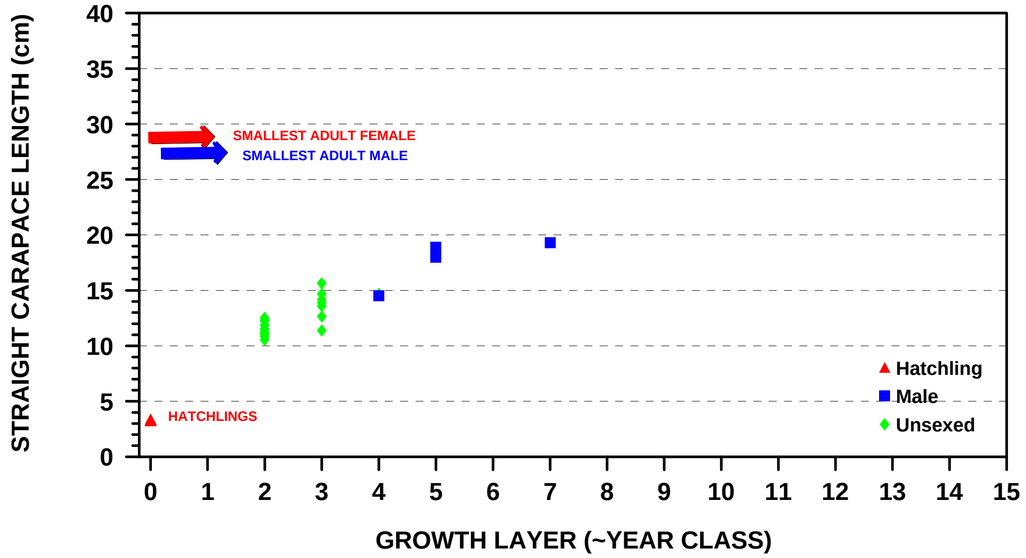


Figure 3.6. Growth of immature *Elusor macrurus*, based on numbers of growth layers present on individual scales (not counting the hatchling scale layer).

Table 3.1. Summary of straight carapace length (SCL) measurements for *Elusor macrurus* from three study sites within the Mary Catchment.

Sex	Age class	Measurement			
		mean	**SD**	**Range**	**N**
Lower Mary River	**Tiaro to Munna Bridge**				
Male	Adult based on tail	36.62	2.7610	28.70 – 39.08	15
	Adult Confirmed	38.20	1.73294	37.26 – 39.14	2
	Pubescent immature	24.74	6.3398	21.00 – 32.06	3
	Prepubescent immature	13.35	1.0203	12.22 – 14.51	4
Female	Adult based on tail	33.63	0.4596	33.30 – 33.95	2
	Adult Confirmed	30.59	1.5174	27.22 – 32.50	14
	Prepubescent immature	14.80	2.5680	12.16 – 17.29	3
Mid Mary River	**Gunalda**				
Male	Adult based on tail	39.37	1.7001	38.00 – 42.02	6
	Adult Confirmed	37.78	2.9911	29.04 – 41.70	17
Female	Adult based on tail	28.55	5.3356	22.44 – 32.29	3
	Adult Confirmed	32.98	1.5988	29.16 – 34.78	13
	Prepubescent immature	11.29			1
Upper Mary River	**Traveston**				
Male	Adult based on tail	38.17	2.3346	33.6 – 40.79	9
	Adult Confirmed				0
	Immature	25.97	5.4515	20.82 – 34.49	5
Female	Adult based on tail	29.74	3.6249	26.23 – 34.81	4
	Adult Confirmed				0
	Immature	22.15	1.3315	20.52 – 24.10	5
Pooled for catchment					
Male	Adult based on tail	37.47	2.5515	28.70 – 42.02	25
	Adult Confirmed	37.76	2.7785	29.04 – 41.7	20
	Pubescent immature	24.74	6.3398	21.00 – 32.06	3
	Prepubescent immature	15.65	2.9875	12.22 – 19.29	7
Female	Adult based on tail	29.97	4.3384	22.44 – 33.95	7
	Adult Confirmed	31.72	1.9170	27.22 – 34.78	28
	Pubescent immature				0
	Prepubescent immature	13.92	2.7332	11.29 – 17.29	4

4. WHITE-THROATED SNAPPING TURTLE, *Elseya albagula*

E. albagula (Figure 4.1) is one of the more recent turtle taxa described for Australia (Thomson et al. 2006). It also represents the extreme in normal chelid sexual dimorphism with the adult female being much larger than the adult male. Adult females of this species in the Burnett River are the largest freshwater turtles in Queensland.

Having been described as a new species in 2006, *E. albagula* has not been assessed for threatened species status under Federal or State legislation. However, it was assessed as high priority during the government's Back on Track prioritisation framework for conservation management of Queensland's wildlife in 2006.

Distribution

This species is a south Queensland endemic species, being restricted to the Mary, Burnett and Fitzroy Catchments. It occurs widely within the mainstream Mary River and a number of its larger tributaries (Figure 4.2). Within the Mary Catchment, it occurs from the freshwater limits of the lower Catchment within the Mary River Barrage near Tiaro up to Kenilworth in the upper Catchment. It also occurs in the main tributaries with permanent water including Tinana Creek, Wide Bay Creek and into the upstream mountain streams of Obi Obi Creek and Yabba Creek. Within Yabba Creek it occurs up-stream into the Borumba Dam impoundment. It has not been recorded from any temporary wetlands or from farm dams and other man-made water bodies within otherwise ephemeral stream areas. This is a turtle that occurs in the permanent stream and large pool habitats of the Mary Catchment.

While the entire Mary Catchment has not been systematically surveyed for turtle distribution and abundance, it has been sufficiently surveyed (Appendix 1) to enable a number of generalities to be made with confidence concerning the distribution of *E. albagula*:

- It occurs within the area of the Mary River that will be flooded if Traveston Crossing Dam is constructed.
- It has been recorded living within several long established impoundments:
    - Mary River Barrage Impoundment in the lower Mary River. Nesting has been recorded from within this impoundment.
    - Imbil Weir in lower Yabba Creek. Nesting has been recorded from this impoundment.
    - Borumba Dam impoundment on upper Yabba Creek.
    - Tallegalla Weir on Tinnana Creek.
- It is breeding successfully in the upstream reaches in Obi Obi Creek where farmers are actively culling foxes.

Population structure and dynamics

Figure 4.3 and Appendix 1 summarise the size class distribution by species, sex and maturity for *E. albagula* within the Mary River. Within all sites examined, *E. albagula* has populations that are seriously compromised by exceedingly poor representation of juvenile turtles in the river. For this species, the populations are composed mainly of aging adults.

There was no significant difference among the sizes of adults of each sex compared across six sampling sites throughout the catchment (Table 4.1): One way ANOVA,

males: $F_{5,43} = 0.586$, $p > 0.5$, not significant.

females: $F_{5,153} = 2.281$, $0.05 < p < 0.1$, not significant.
For the pooled data for *E. albagula* within the entire catchment (Table 4.1), the mean SCL for each sex was:

Adult males = 23.50 cm.
Adult female = 32.39 cm.

Adult *E. albagula* in the Mary River are smaller on average than their respective counterparts in both the Burnett River (Hamann et al. 2004) and the Fitzroy River (Limpus et al. 2011).

The limited data available for *E. albagula* with readable growth layers indicate that the species is slow growing with delayed maturity (Figure 4.4). It is expected that the species takes 15 years or more on average before either sex will commence breeding.

There is a increase in the proportion of immature turtles in the populations as one progresses up stream: Mary Barrage = 2% immature; Tiaro = 6%; Munna Bridge = 11%, Gunalda = 18% and Downstream of Borumba Dam = 35% (Figure 3.5).

Egg production and incubation

There have been no detailed studies of the breeding by this species in the Mary Catchment. It has however, been studied extensively in the Burnett and Fitzroy Catchments. The limited nesting data from the Mary Catchment is giving similar results to those recorded in the Burnett and Fitzroy Catchments. For *E. albagula* (Hamann et al. 2004; Limpus et al. 2011; unpublished data from the former EPA):

- Almost all adult females produce eggs each year and these eggs are viable.
- They rarely lay more than one clutch in a season, with an average clutch size of 13.8 eggs.
- They lay the largest eggs recorded for a freshwater turtle in Queensland (Legler, 1985. Figure 2.9). Eggs were 5.29 cm long and 3.20 cm wide and weighed 31.8 g.
- Nesting occurs during Autumn-Winter with most clutches deposited during May-June, even though some individuals may be carrying oviducal eggs at anytime during March to September.

The species aggregates its nesting on traditional nesting banks, with the same banks being revisited for nesting across the years (Hamann et al. 2004; Limpus et al. 2011). While many other sites are expected to exist, aggregations of gravid females have been recorded during April-May at widely scattered nesting banks in the Mary River (Figure 4.2b), including near Tiaro, near the junction with Munna Creek, Gunalda (Figure 4.5), upstream from Traveston and along Obi Obi Creek (Figure 2.7c). Almost all nesting occurs on alluvial sand – loam banks deposited by floodwaters. Many of these alluvial banks are reworked with each significant flooding event. However, this species does not restrict its nesting to sand banks. Nesting can occur on well grassed loam slopes adjacent to the river.

Measurements of nests with respect to distance from the water and depth are summarised from Limpus et al. (2011):

- Nests are constructed on average at 16.6 m from the waters edge, with no significant difference between years. While some nests may be within a metre or so of the water, others in the extreme have been recorded up to 86 m from the water. Figure 4.5 illustrates an *E. albagula* nest site approximately 60 m from the river at Gunalda.
- These are shallow nests with a mean depth to the bottom of a nest = 23.0 cm.

- Most nesting occurs on sloped banks, with an average bank slope = 26.5^{o} elevation.

It has a long post-oviposition embryonic diapause that delays embryonic development and hence delays hatchling emergence from nests until summer (Legler, 1985, Hamann et al. 2004). Legler and Georges (1993) recorded incubation periods of 77 days at 30^{o}C and 85 days at 28^{o}C.

Hatchling *E. albagula* incubated under laboratory conditions have a mean SCL = 4.9 cm and a weight = 15.9 g (Hamann et al. 2004).

The limited data on incubation success of eggs in natural nests on nesting banks within the lower Mary Catchment indicates that an excessively high proportion of eggs are destroyed by predators (Feral: fox, dog, pig. Native: goanna [Figure 2.7c], water rat) or trampling by cattle (unpublished data from the former EPA).

Diet

There has been no substantive study of *E. albagula* diet within the Mary River. Based on studies at Marlborough Creek in the Fitzroy Catchment, Rogers (2000) described *E. albagula* as a herbivorous turtle that feeds primarily on aquatic macrophytes (61.4% of food by weight was *Vallesnaria* leaves, *Scoenoplectus* and *Nitella* and 15.4% filamentous algae including *Mougeotia* and *Spyrogyra*). Fruit (*Livinstonia* and F*icus*) and leaves (*Ficus*) from riparian vegetation overhanging the stream were seasonally consumed (16.6%). A range of other food items occurred at low frequency by weight: periphyton (1.0%), *Bufo marinus* (1.8%), bivalves (1.6%), terrestrial insects (0.6%), aquatic insects and other animal material (0.5%), wood (0.5%). There was a strong correlation between turtle size (carapace length) and the proportion of plant material in their diet. Juveniles primarily consumed animal food and commenced eating plant material at SCL ~6 cm. It was hypothesised that *E. albagula* utilised microbial fermentation for digestion of the ingested plant material to the greatest degree for the herbivorous turtles in that catchment.

Injuries and mortality

As commented on with *E. macrurus*, turtles in other catchments are injured and killed as they attempt to progress upstream past impoundment structures and pass down over impoundment structures at flood time (Hamann et al. 2004). Many are also killed on the trash filter screens fitted to water outlets of dam and weir walls (Limpus et al. 2011). This aspect of the impact of impoundment infrastructure on *E. albagula* was examined at Borumba Dam in September 2003. At that time, 24% of the *E. albagula* captured had fractured carapaces or plastrons consistent with injuries resulting from impact with a hard substrate. In contrast, only 7% of *E. albagula* examined in the Mary River in the vicinity of Tiaro, 18% in the vicinity of Munna Bridge and 5% in the vicinity of Gunalda had fractures to the carapace and/or plastron. These latter three sites are not adjacent to any substantial impoundment infrastructure. The more severe fractures observed within the population at Munna Bridge were compressed fractures consistent with the turtle having been trampled by cattle rather than injuries from impact against a hard substrate.

E. albagula is commonly caught on lines by recreational fishers. In popular recreational fishing areas such as Borumba Dam, *E. albagula* have been captured with fishhooks in their mouths and throats (Figure 4.6). *E. albagula* have been found drowned following being hooked and tangling the fishing line in underwater snags at the Munna Bridge site. Adult *E. albagula* are the most commonly hooked turtle during the annual Tiaro Fishing competition (Appendix 1; Figure 4.3a). When lines are cut or broken and the hooks left imbedded in the turtles, there is a high probability that the turtles will be debilitated or die (Hyland, 2002). In addition, turtles are injured when fishers remove barbed hooks from the mouth or throat. The total mortality from this source for the Mary River has not been quantified.

Discussion

Adult *E. albagula* are plentiful and occur widely within the Mary Catchment but the current study has identified a chronic shortage of immature turtles in the population. Based on limited observation at nesting areas in the lower catchment, it is concluded that the critical threat to survival of *Elseya albagula* within the Mary Catchment is the long term, pervasive and intense egg loss from predation and cattle trampling of nests. For egg loss to have impacted the full range of immature age classes (Figure 4.3), the resulting failure in recruitment of young turtles to the river has to have been in progress for at least one generation (15-20 years. Figure 4.4). Within the Mary catchment, *E. albagula* warrants consideration as endangered.

The progressive increase in the proportion of immature turtles in the populations as one progresses up stream could be the result of decreasing mortality of eggs in the upper reaches of the Mary Catchment. This is an area with dairy and other small farms where farm management is probably directed to reducing dog, fox and pig impact on the farming activities. This type of farm management would be beneficial in reducing populations of turtle egg predators along the river. One of the few other areas of south east Queensland where the government's Turtle Conservation Project has recorded multiple turtle species with an abundance of immature turtles in the population has been in the dairy farming district along the Albert River upstream of Beaudesert during the 1990s. This association of higher immature representation in the turtle population and more intensive/small farming activities warrants further investigation.

E. albagula appears to have the poorest representation of immature turtles within its populations in the Mary River when compared with *E. macrurus, E. m. krefftii* and *W. latisternum* (Figure 3.5). This could be the result of several aspects of their reproductive biology, including the long embryonic diapause, low fecundity (1 clutch per year) and aggregated nesting, combing to increase egg mortality and reduce hatchling production. Based on the limited data presented in Figure 3.5, it is hypothesised that *E. albagula* has the poorest juvenile recruitment into the adult turtle populations within the Mary River Catchment. This is a problem that is unrelated to the proposal to construct the Traveston Crossing Dam.

E. albagula is a specialised cloacal ventilating turtle (see Chapter 6). In the absence of additional diving studies, Limpus et al (2011) presumed that *E. albagula* approaches *R. leukops* in its ability to forage in flowing water habitats where elevated dissolved oxygen levels enable the species to undertake prolonged dives, hence minimising energy expenditure and displacement while maintaining their foraging/resting location against the force of the current. Based on the distribution records in the Fitzroy Catchment (Limpus et al. 2011), *E. albagula* appears to be suited for inhabiting the aerobic margins of large slow flowing reaches and large non-flowing pools. They would be particularly well adapted for maintaining their position at specific foraging sites in very structured habitat such as log tangles and rock outcrops, with or without currents. However, as a benthic foraging species, it is unlikely that the species would function well in the deeper habitats of the larger pools if they are associated with very low dissolved oxygen levels, especially under dry season conditions with standing water bodies. The observations of *E. albagula* within impoundments of the Mary Catchment are consistent with the conclusions drawn from the studies in the Fitzroy Catchment. With other aspects of their population dynamics being functional, *E. albagula* can be expected to maintain sustainable populations within the shallow water upper reaches of impoundments within the Mary River Catchment.

The Queensland Government has been working with the local community to provide protection to natural nests and increase hatchling production from the nesting banks in the Tiaro area (Tiaro and District Landcare Group Inc., 2005). This successful project is expanding to engage community members in nest protection throughout a greater part of the Mary Catchment.

4.1a. Adult female (left) and male (right).

4.1b. Plastron view of an adult female.

4.1c. Head of adult female.

4.1d. Hatchling

Figure 4.1. White throated snapping turtle, *Elseya albagula*.

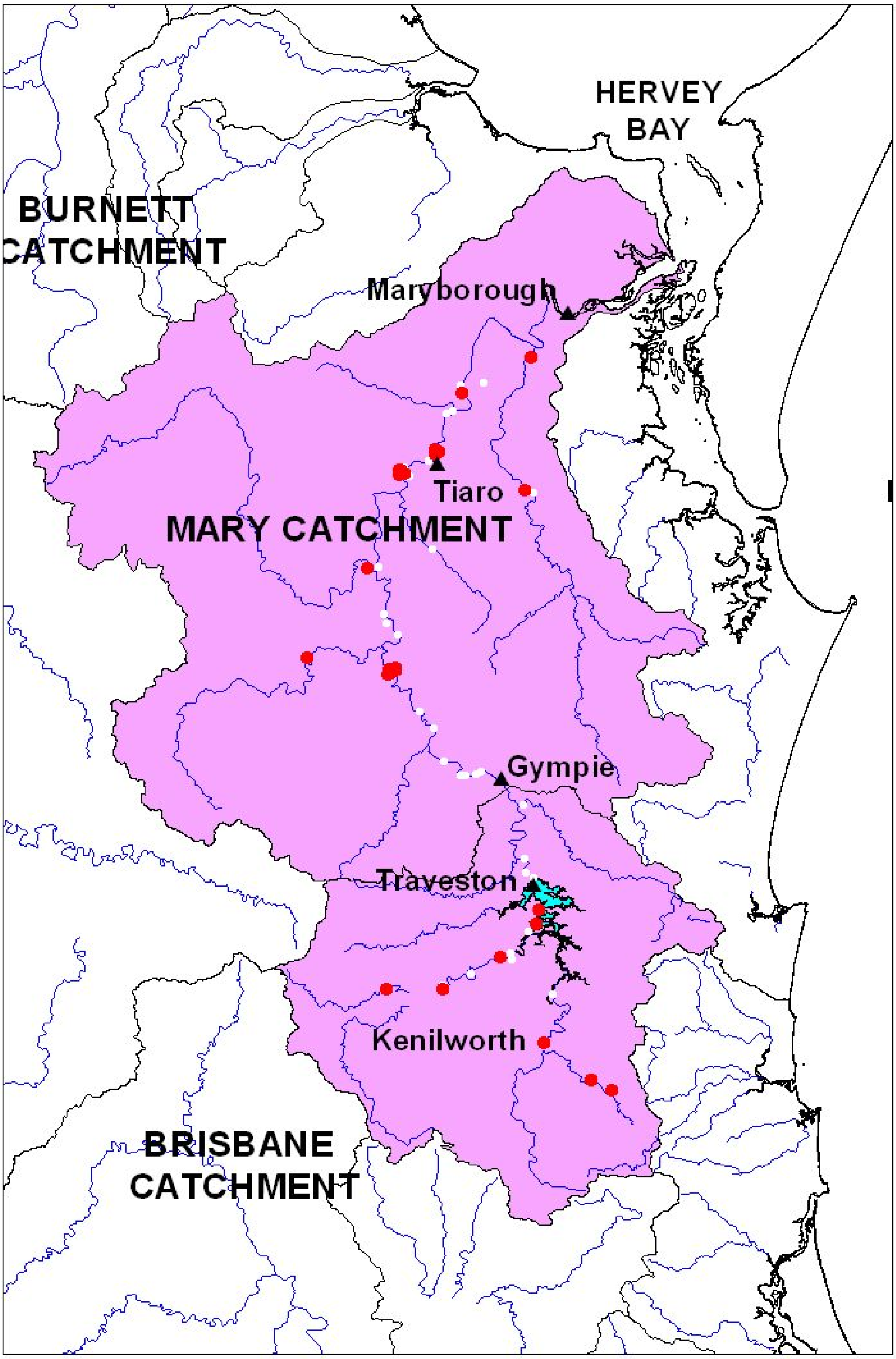


Figure 4.2a. White throated snapping turtle, *Elseya albagula*: distribution of recorded sites within the Mary River Catchment. Red dots denote capture and/or observation records. White dots denote sites examined where the species was not recorded.

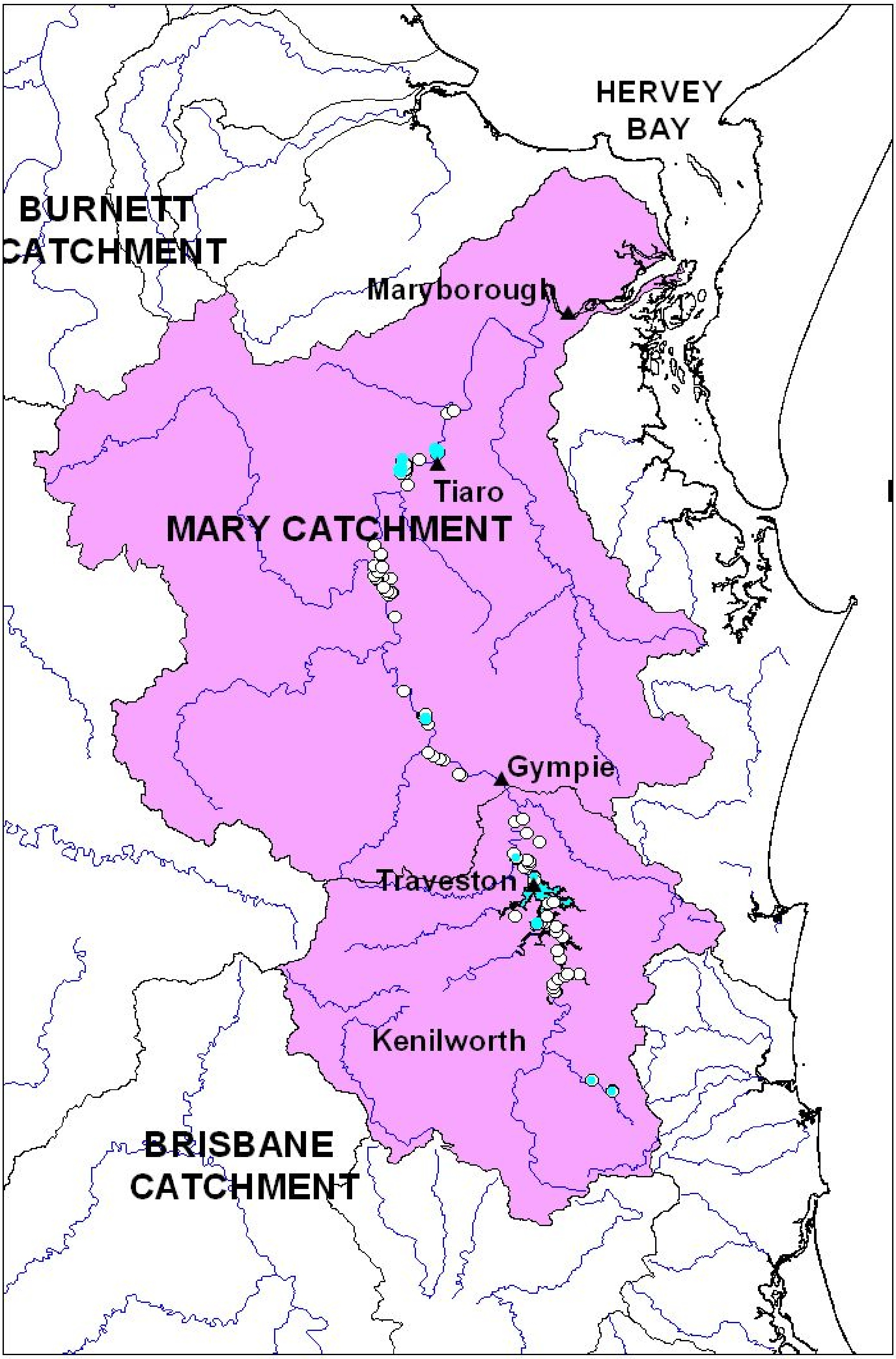
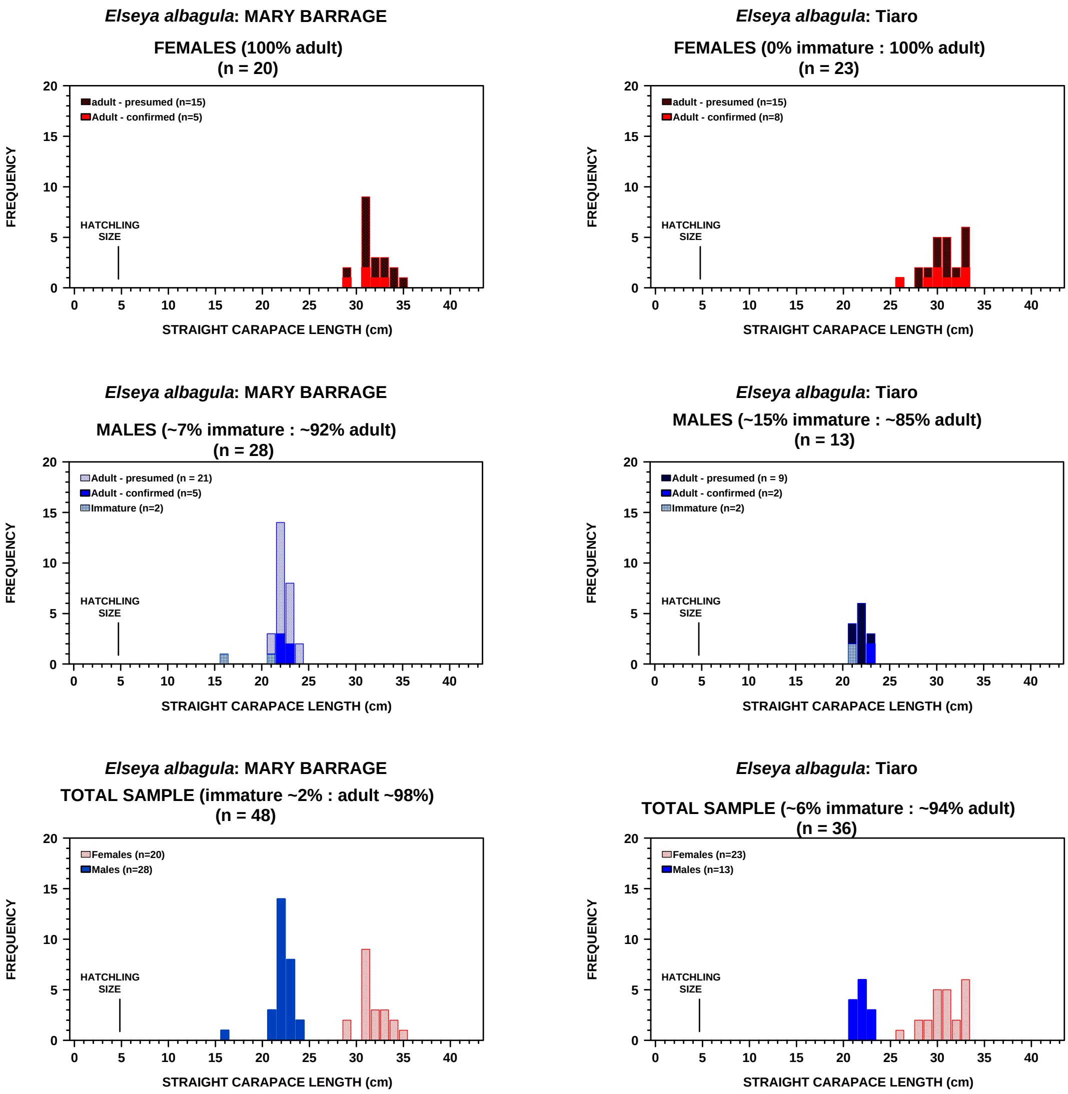


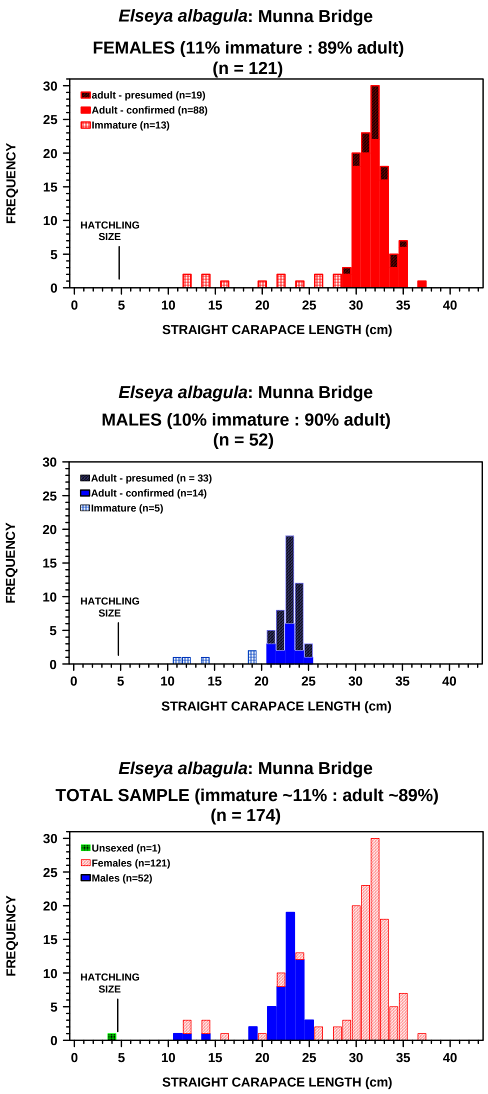
Figure 4.2b. White throated snapping turtle, *Elseya albagula*: distribution of nesting sites within the Mary River Catchment. Blue dots denote recorded nesting banks. White dots denote sand banks that were examined and for which nesting was not recorded.



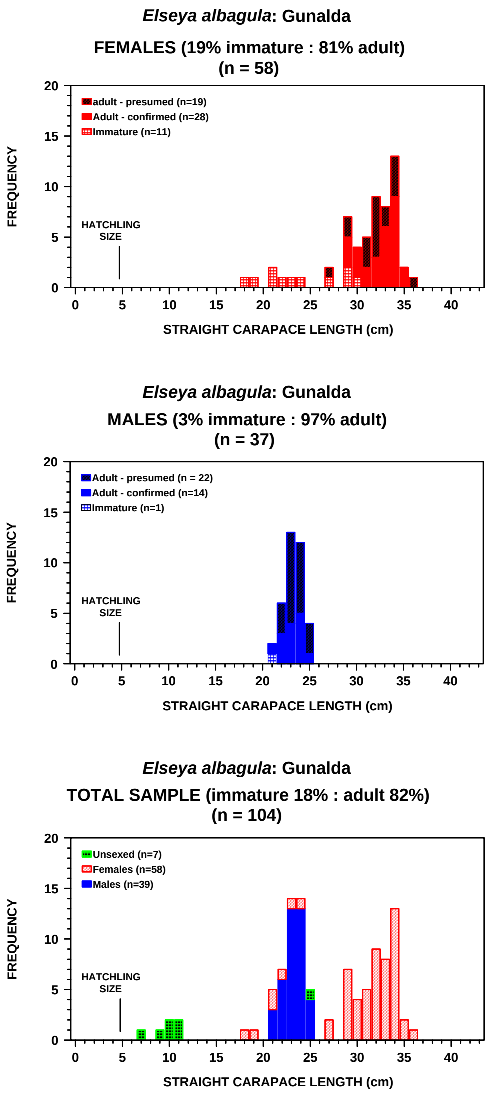
4.3a.88% of Mary Barrage sample was caught on lines during fishing competitions.

4.3b. Tiaro sample was caught by snorkelling, trapping and by hand on the nesting banks.

Figure 4.3. Size class distribution by sex and maturity for *Elseya albagula* within the Mary River. Data derived from the freshwater turtle research database of the former EPA Queensland. Sex and maturity were determined by gonad examination using laparoscopy or by palping to identify oviducal eggs. For the remainder, sex and maturity was determined using morphometric measurements.

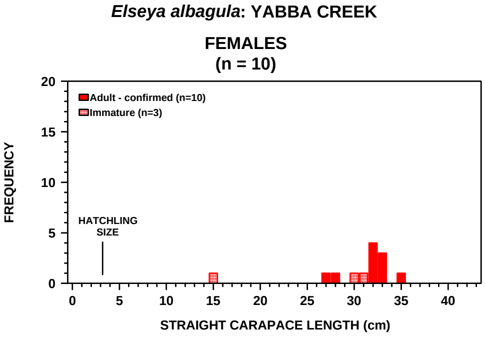


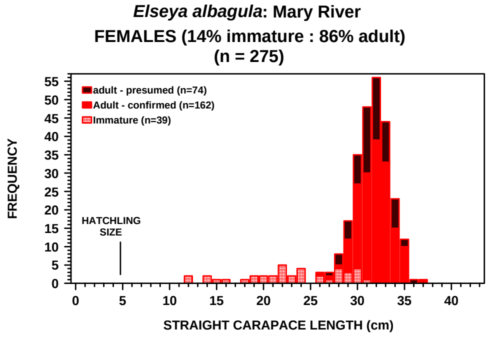
4.3c. Munna Bridge sample was caught primarily by snorkelling.

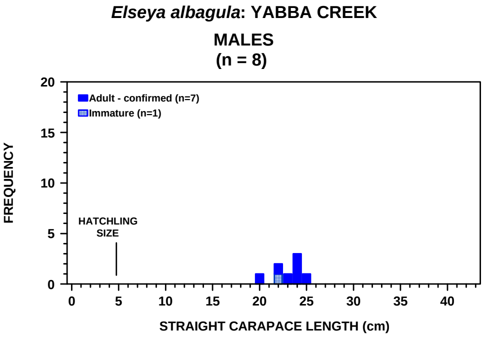


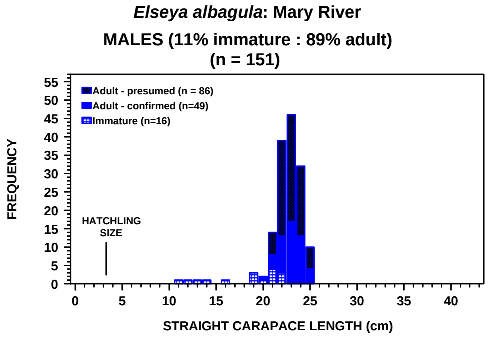
4.3d.Gunalda sample was caught primarily by snorkelling.

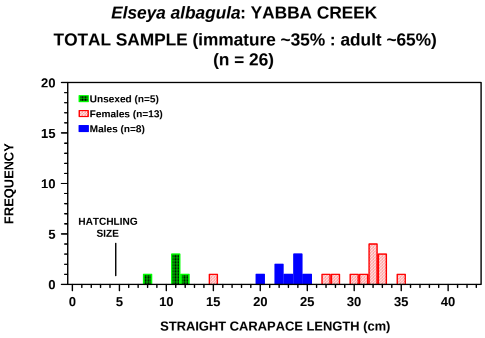
Figure 4.3. Continued.

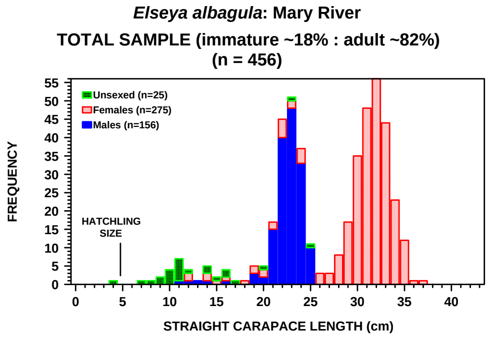












4.3e.Yabba Creek sample was captured mostly by netting and muddling after pumping out the plunge pool below Borumba dam.

4.3f. This is the pooled captured sample from the entire catchment.

Figure 4.3. Continued.

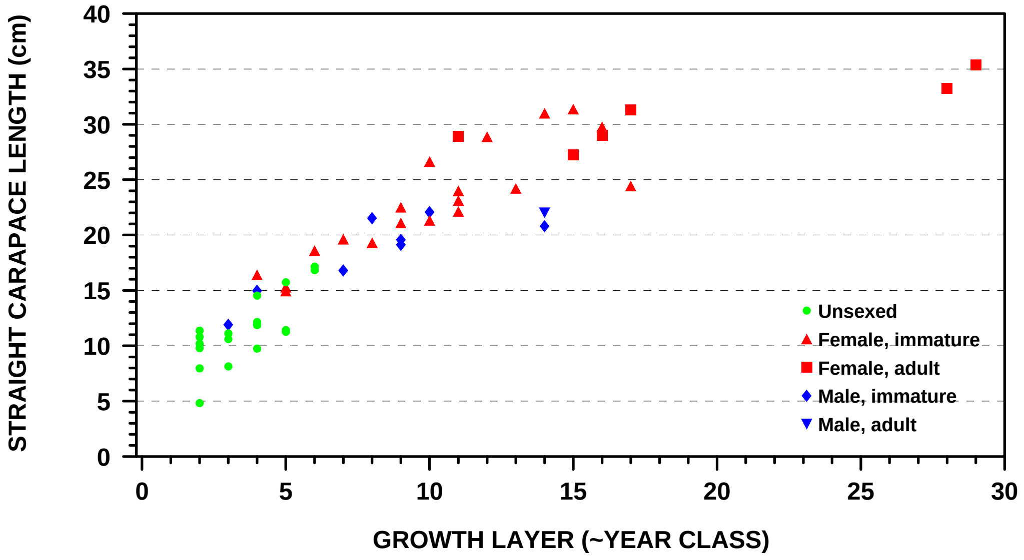


Figure 4.4. Growth of *Elseya albagula*, based on numbers of growth layers present on single scales (not counting the hatchling scale layer).

Figure 4.5. Predated *Elseya albagula* nest on an elevated slope, Gunalda, Mary River.

Figure 4.6. Adult male *Elseya albagula* with a fishhook through the mouth from a past encounter with a recreational fisher, Borumba Dam plunge pool, September 2003.

Table 4.1. Summary of straight carapace length (SCL) measurements for *Elseya albagula* from six primary study sites within the Mary Catchment.

Sex	Age class	Measurement			
		mean	SD	Range	N
Mary River Barrage	**(including Petrie Park)**				
Male	Adult based on tail	22.90	0.8421	21.30 – 24.66	21
	Adult Confirmed	22.93	0.7052	22.16 – 23.90	5
	Pubescent immature	21.33			1
	Prepubescent immature	16.79			1
Female	Adult based on tail	32.45	1.6428	29.26 – 35.32	15
	Adult Confirmed	31.87	1.4865	29.91 – 33.96	5
Tiaro					
Male	Adult based on tail	22.57	0.6713	21.58 – 23.72	9
	Adult Confirmed	23.23	0.1273	23.14 – 23.32	2
	Pubescent immature	21.34	0.1202	21.25 – 21.42	2
Female	Adult based on tail	31.42	1.8271	28.20 – 33.87	15
	Adult Confirmed	30.83	2.2175	26.46 – 33.30	8
Munna Bridge					
Male	Adult based on tail	23.62	0.9659	21.54 – 25.98	33
	Adult Confirmed	23.37	1.1050	21.69 – 25.11	14
	Prepubescent immature	15.59	3.7214	11.89 – 19.56	5
Female	Adult based on tail	32.49	1.4225	29.37 – 35.02	19
	Adult Confirmed	32.27	1.5368	29.34 – 37.60	88
	Pubescent immature	28.61	0.3606	28.35 – 28.68	2
	Prepubescent immature	19.33	5.2910	12.32 – 26.63	11
Gunalda					
Male	Adult based on tail	23.98	0.9232	22.20 – 25.80	22
	Adult Confirmed	23.49	1.0900	21.70 – 25.65	14
	Pubescent immature	21.10			1
Female	Adult based on tail	32.57	2.0824	27.87 – 36.60	19
	Adult Confirmed	32.91	1.8753	29.06 – 35.55	28
	Pubescent immature	29.29	1.5234	27.34 – 30.99	4
	Prepubescent immature	21.51	2.1428	18.57 – 24.20	7
Wide Bay Creek					
Male	Adult Confirmed	24.00	1.1843	22.13 – 25.84	7
	Immature	18.95	5.1752	13.10 – 22.94	3
Female	Adult Confirmed	32.73	1.2506	29.82 – 35.94	20
	Immature	26.32	4.474	20.33 – 30.79	9
Yabba Creek	**Including Borumba Dam**				
Male	Adult Confirmed	23.77	1.6393	20.93 – 25.52	7
	Prepubescent immature	22.33			1
Female	Adult Confirmed	32.17	2.3655	27.25 – 35.33	10
	Immature	25.67	9.0174	15.27 – 31.36	3
Pooled for catchment					
Male	Adult based on tail	23.43	1.0101	21.30 – 25.98	85
	Adult Confirmed	23.50	1.1374	20.93 – 25.84	49
	Pubescent immature	21.18	0.2428	20.80 – 21.42	5
	Prepubescent immature	17.66	4.1194	11.89 – 22.94	11
Female	Adult based on tail	32.19	1.7991	27.87 – 37.60	71
	Adult Confirmed	32.39	1.7153	26.46 – 37.60	160
	Pubescent immature	29.40	1.1826	27.34 – 31.36	11
	Prepubescent immature	21.19	4.6997	12.32 – 30.79	27

5. KREFFT'S RIVER TURTLE, Emydura macquarii krefftii

E. m. krefftii (Figure 5.1) is part of the wide spread *E. macquarii* species complex that spans the Murray-Darling Catchment of South Australia, Victoria, New South Wales, and Queensland, the Coopers Creek Catchment of Western Queensland and South Australia and east coast rivers from northern New South Wales to Princess Charlotte Bay in eastern Cape York Peninsula. This is the most widely distributed freshwater turtle species in Queensland. The species is undergoing active speciation with five currently recognised sub-species (Cann, 1998; Georges and Adams, 1996; McCord et al. 2003).

None of the subspecies within this taxon are currently listed as threatened species under State or Federal legislation: *Nature Conservation Act 1992* or the *Environmental Protection and Biodiversity Conservation Act 1992*.

E. m. krefftii, because of its abundance and near ubiquitous distribution within the Mary River Catchment, was chosen for assessment during this study to shed increased understanding of the functioning of freshwater turtle populations within the catchment. This account does not address the biology of the *E. m. nigra*, the endemic subspecies occurring on Fraser Island.

Distribution

The subspecies, *E. m. krefftii*, is a widely distributed taxon, occurring in the coastal rivers of eastern Queensland from at least the Mary River in the south to the rivers flowing into Princess Charlotte Bay in Cape York Peninsula. It is an extremely abundant and wide spread turtle within the Mary Catchment, occurring widely within the mainstream Mary River and its tributaries (Figure 5.2. Appendix 1). Within the Mary Catchment, it occurs from downstream within the Mary Barrage near Tiaro up to at least Kenilworth in the Mary River. It also occurs in the main tributaries with permanent water including Tinana Creek, Wide Bay Creek and in Yabba Creek up-stream into Borumba Dam impoundment and the Mountain stream habitats of Obi Obi Creek. It is common in permanent and semi-permanent farm dams and other man-made water bodies within otherwise ephemeral stream areas. This is a turtle that occurs in the natural and man-made permanent and semi-permanent stream and pool habitats of the Mary Catchment.

E. m. krefftii have been recorded washed downstream over the Mary River Barrage into the estuarine waters. It appears unlikely that they can return back upstream past the barrage wall. The fate of these turtles has not been determined.

Population dynamics

Figure 5.3 and Appendix 1 summarise the size class distribution by species, sex and maturity for *E. m. krefftii* within the Mary River. There were highly variable proportions of immature turtles within the populations sampled. As with *E. macrurus* and *E. albagula*, there was a trend for increasing proportions of immature turtles in the population for *E. m. krefftii* as one progressed upstream from the lower to upper reaches of the Mary River (Figure 3.5). The highest immature percentage was recorded in the mid to upper catchment within the Mary River, where approximately 50% of the populations are immature turtles (Figure 3.5). In contrast, within the impounded waters of Borumba Dam, the *E. m. krefftii* population appears to have been severely compromised with only 7% immature turtles. Overall there was a higher proportion of immature *E. m. krefftii* at the various study sites than there was immature turtles in the *E. macrurus* and *E. albagula* samples at the same sites (Figure 3.5). *E. m. krefftii* appears not to be under threat from poor recruitment of juveniles to the catchment.

The mean size of adults pooled for the entire catchment was:

- Adult males: mean SCL = 21.04 cm (SD = 1.290, range = 18.2 – 23.82, n = 86).
- Adult female: mean SCL = 23.77 cm (SD = 1.8321, range = 17.18 – 28.00, n = 174).

Adult females are on average larger than the adult males.

There was an indication of decreasing size of adult females as samples were taken from higher in the catchment:

- Tiaro: Mean SCL = 23.91 (SD = 1.9326, range = 20.68 – 26.80, n = 14)
- Gunalda: Mean SCL = 22.16 (SD = 1.7307, range = 19.65 – 24.57, n = 13)
- Borumba Dam: Mean SCL = 21.41, (SD = 1.5806, range =18.20 – 28.20, n = 53)

This warrants reinvestigation using larger sample sizes and additional sampling sites.

Reproduction

There has been no detailed study of the reproduction of *E. m. krefftii* within the Mary Catchment.

Based on studies in the Burnett River (Limpus et al. 2002) and the Fitzroy River (Limpus et al. 2011), most adult females can be expected to breed each year, most females can be expected to lay multiple clutches within their summer breeding season which extends from October to January. *E. m. krefftii* lays about 14 eggs per clutch. Their eggs are among the smallest laid by turtles in the Mary Catchment (Figure 2.9): mean egg length = 3.46 cm, mean egg diameter = 2.01 cm, mean egg weight = 8.7 g.

Nesting habitat and incubation success of *E. m. macquarii* natural nests within the Mary Catchment has not been studied.

Diet

There has been no detailed study of the diet of *E. m. krefftii* from within the Mary Catchment. The species has been described as ‘omnivorous, opportunistically eating whatever food is available’ (Cann, 1998). Within Marlborough Creek in the Fitzroy Catchment, Rogers (2000) also described *E. m. krefftii* as omnivorous with 53.3% of its food by weight being gastropods, 26.1% aquatic macrophytes, 8.5% filamentous algae, and the remainder including a wide variety of other food types including bivalves, terrestrial insects, aquatic insects, sponge on *Vallisneria*, periphyton (algae & sponge on wood). With such a varied diet, this species is well adapted for foraging within a great range of habitats and water conditions. Diet is unlikely to be a primary limiting factor for determining the distribution of this species within the catchment.

Injuries and mortality

As commented on with *E. macrurus* and *E. albagula*, turtles in other catchments are injured and killed as they attempt to pass upstream past impoundment structures and pass down over impoundment structures at flood time (Hamann et al. 2007). Many are also killed on the trash filter screens fitted to water outlets of dam and weir walls

(Limpus et al. 2011). This aspect of the impact of impoundment infrastructure on *E. m. krefftii* was examined at Borumba Dam in September 2003. At that time, 43% of the *E. m. krefftii* captured had fractured carapaces or plastrons consistent with injuries resulting from impact with a hard substrate. In contrast, only 7% of *E. m. krefftii* examined in the Mary River in the vicinity of Tiaro, 7% in the vicinity of Munna Bridge and 5% in the vicinity of Gunalda had fractures to the carapace and/or plastron. These latter three sites are not adjacent to any substantial impoundment infrastructure.

E. m. krefftii is commonly hooked on lines by recreational fishers. In popular recreational fishing areas such as Borumba Dam, *E. m. krefftii* have been captured with fishhooks in their mouths and throats. Adult *E. m. krefftii* are commonly hooked turtles during the annual Tiaro Fishing competition. When lines are cut or broken and the hooks left imbedded in the turtles, there is a high probability that the turtles will be debilitated or die (Hyland, 2002). In addition, turtles are injured when fishers remove barbed hooks from the mouth or throat region. The total *E. m. krefftii* mortality from this source for the Mary River has not been quantified.

Mass turtle mortality events

Few of the multiple mortality events for freshwater turtles within the Mary Catchment in recent years have been investigated:

- During 12 April – 21 May 2002, a freshwater turtle multiple mortality event was reported from the margin of a farm dam adjacent to Goochie Creek with 54 carcasses reported by the local farmer. Mortality occurred progressively across this period and coincided with low, dropping water levels in the dam. The main area of the dam was dry with the limited remaining water only in the “bottom deeper holes”. The carcasses were found only along the northern edge of the dam closest to the forest margin of the creek which was several hundred metres away. The local farmer reported that there was no parallel kill of fish. The water was described as “clear” and no fertiliser or pesticides usage had occurred on the property in recent years. No turtles were found dead in the water. All dead turtles were on the adjacent bank and all were “empty shells”. On 27 May 2002, the water remaining in the next dam up the hill from the dam with the dead turtles was pumped out for deepening the dam. A few tens of live turtles were rescued from this second dam and relocated to the creek. These were mostly short-neck turtles (1 adult sized *E. m. krefftii* was identified from a photograph) and one long-neck turtle. When the dead turtles were inspected on site by CJL on 29 May 2002, 52 *E. m. krefftii* and 5 *C. expansa* eviscerated carcasses were examined (Figure 5.4a) and all were immature turtles (Figure 5.4b). There were tracks of adult sized turtles that lead from this drying dam towards the creek and one of the other two dams further up hill on this farm. Almost all carcasses had scrapes on the plastron consistent with raptor beak marks (Figure 5.4c). It is hypothesised that as the dam shallowed, large raptors lifted larger sized immature turtles to the dam bank where they were killed and picked clean. The smaller immature turtles were probably carried further from the dam to feeding stations in the trees and hence not detected during the site inspection. Adult sized turtles were probably too large for the local raptors to lift from the dam shallows. This event illustrates the elevated risk of predation facing small turtles in shallow waters, especially with drying pools under drought conditions.
- Twenty-three dead *E. m. krefftii* were reported as badly decomposed carcasses on the bank of the Mary River near Miva on 8 December 2003. No other aquatic species were reported dead in association with this mass mortality of turtles. The majority of these turtles were in the immature size range for the species (Figure 5.5). No cause of death was identified for this event.

- EPA staff reported 19 freshly dead freshwater turtles (Mostly immature and adult sized *E. m. krefftii* and at least 1 immature *W. latisternum*. Figure 5.6), 1 dead eel and 1 dead fish at Lake Alford, a small artificial lake on the southern side of Gympie, 16 January 2004 (L. Gilshenan email 20 January 2004). Ducks and swans on the lake appeared to be healthy. Small fish were also noted in the lake, and appeared to be in good health and not gasping for air or displaying any unusual behaviour. Many other turtles were still swimming in the lake and appeared to be behaving normally. With algal mats containing potentially toxic algae including *Lyngbya* and *Phormidium* being present in the lake, blue green algal poisoning of these turtles was suspected but not confirmed (L. Fabro, email 23 February 2004). The cause of this mortality event was not determined.

The high proportion of immature turtles with each of these mass turtle mortality events raises questions regarding the susceptibility of immature turtles to changed habitats and in-stream environments.

Discussion

E. m. krefftii is a species that has been largely ignored for scientific study in the Mary River, the southern limit of its naturally occurring range. It is a particularly abundant species within the catchment.

While populations in all parts of the range within the catchment are not functioning equally well, the species is not associated with warning signals of a species in distress. For example, while the immature population proportions could be higher, there does not appear to be a chronic shortage of immature turtle recruitment for the population (Figure 3.5).

Scientific studies of this more abundant species within the catchment should be encouraged as an alternate index species for which large robust sample sizes can be obtained (Limpus et al. 2002; Limpus et al. 2011). In addition, studies of its diet, reproduction including seasonal fecundity, nesting habitat, incubation success, growth and age structure are recommended.

Because of its abundance, this species is ideally suited for assessing the response of turtle population dynamics, especially for recruitment and survivorship. With the increasing impact of climate change, *E. m. krefftii* should be considered as a surrogate model species for gaining insights into population responses for the more difficult to study and less abundant species such as *E. albagula* and *E. macrurus*.

E. macrurus and *E. albagula* have not been identified among turtles species impacted by mass turtle kills within the Mary River Catchment. The three recently investigated mass kills of turtles all had a strong bias to immature turtles among the dead. Attention should be paid to multiple mortality events, even when they occur with the less threatened species. These events need better veterinary pathology and toxicology assessment of the turtle to resolve the causes of death and better identify threats to immature turtles.

5.1a. Dorsal view of adult male (tag: 4546), Borumba Dam plunge pool.

5.1b. Ventral view of adult male with partly everted penis (tag: 4546), Borumba Dam plunge pool.

5.1c. Face, adult male, Ned Churchward Weir, Burnett River..

5.1d. Head of adult female. Burnett River.

5.1e. Facial markings of immature *E. m. signata* (top) and *E. m. krefftii* (bottom), Sandgate Lagoons, Pine river.

Figure 5.1. *Emydura macquarii krefftii*

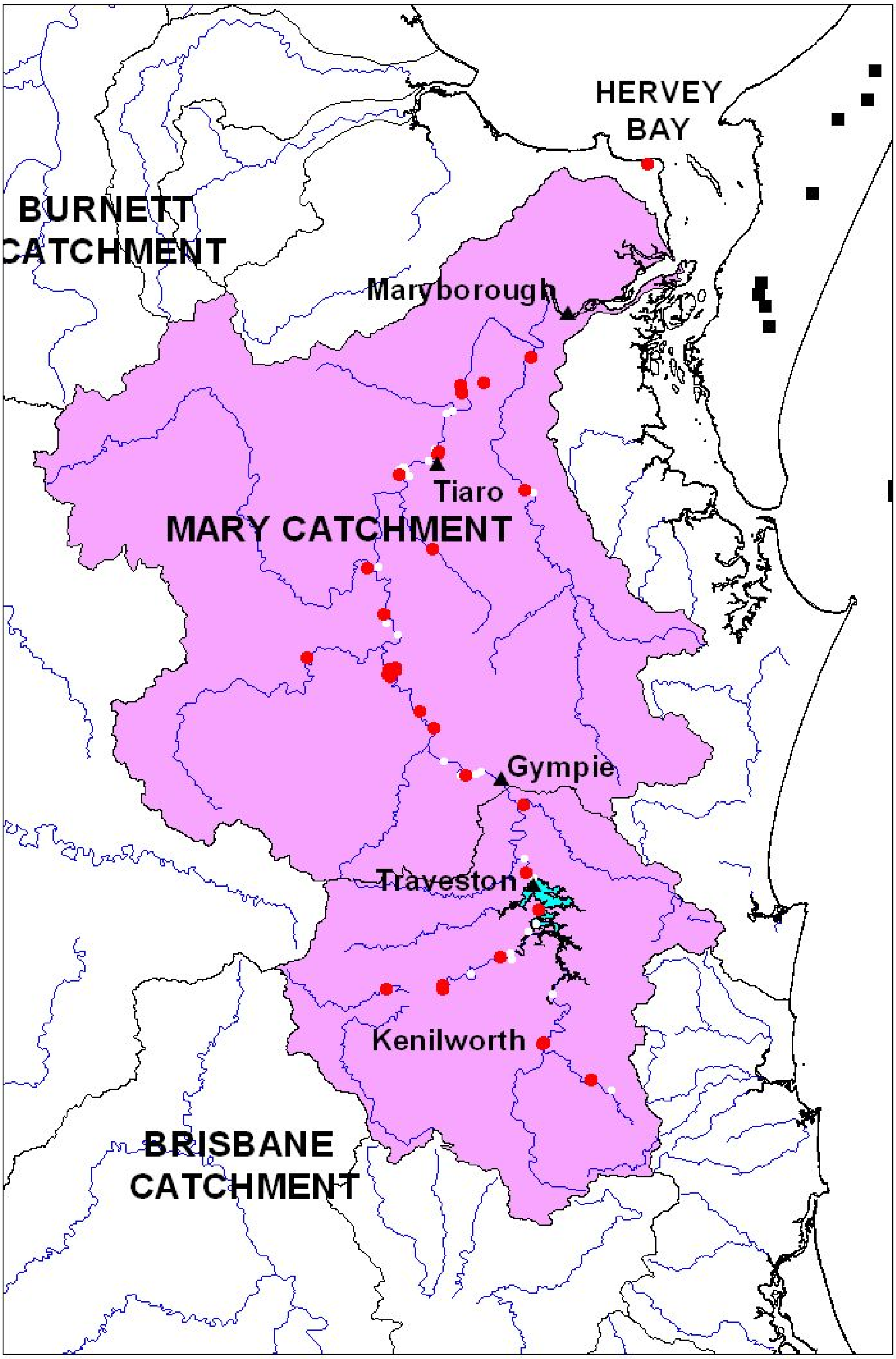
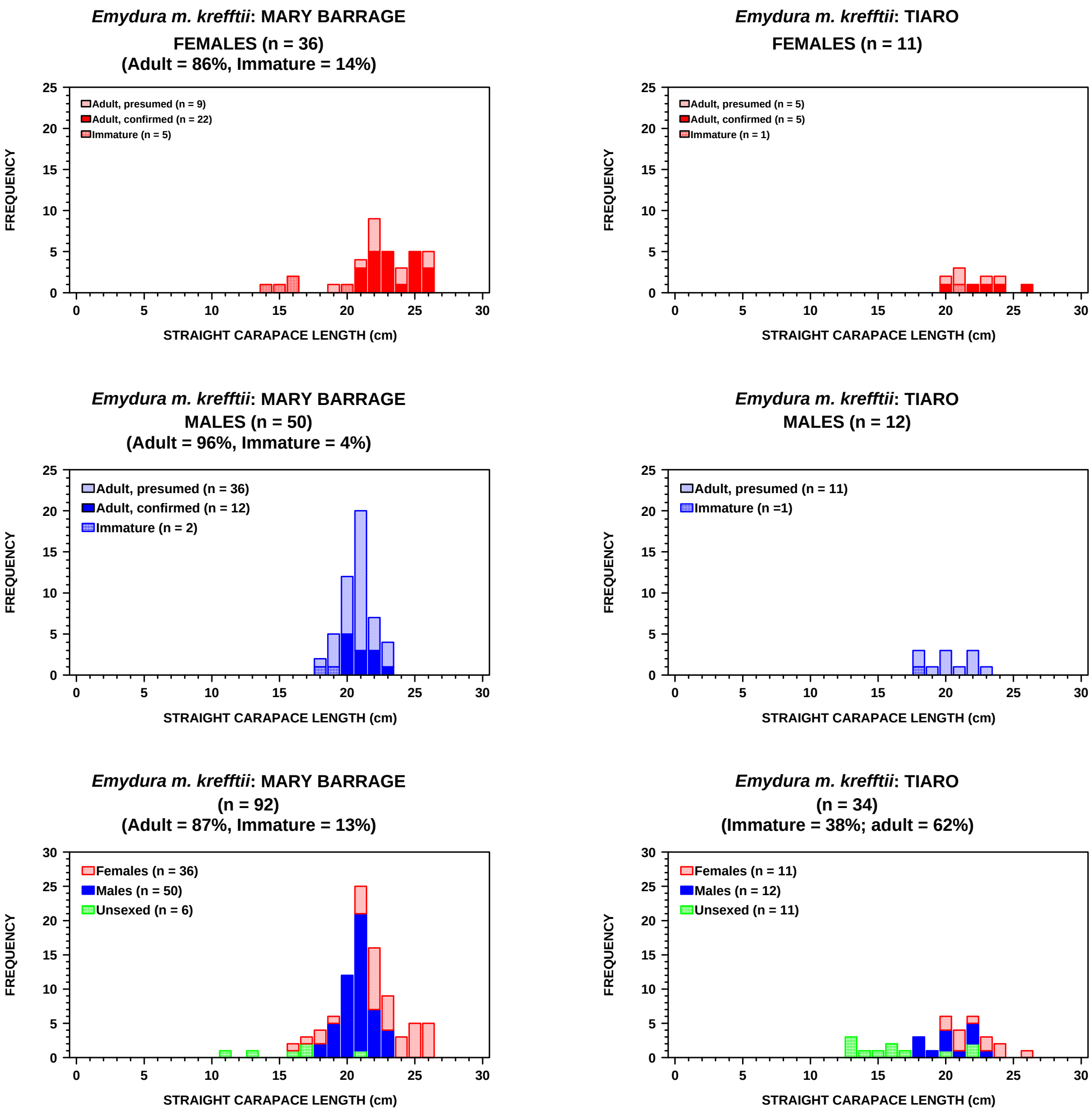


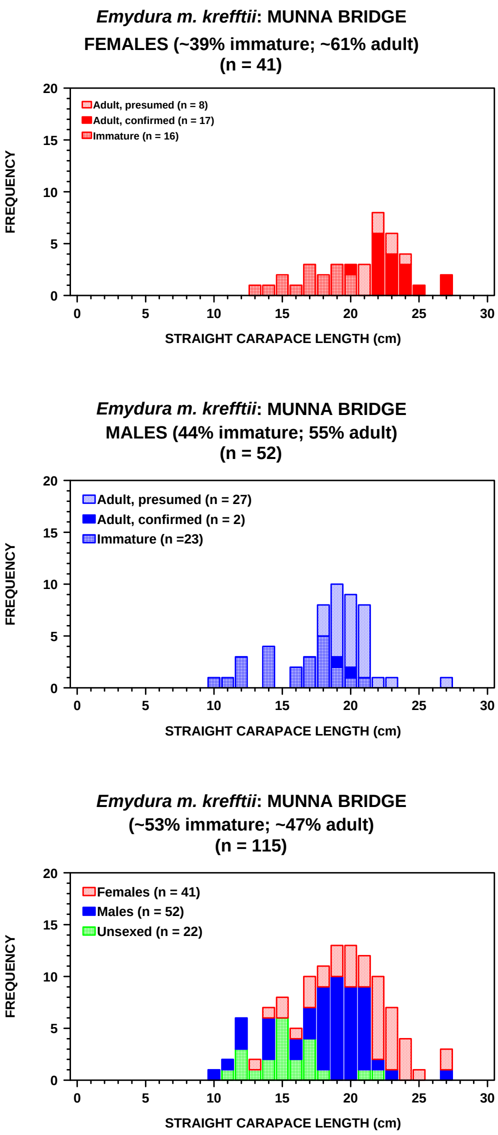
Figure 5.2. Krefft's river turtle, *Emydura macquarii krefftii*: distribution of recorded sites within the Mary River Catchment. Red dots denote capture and/or observation records. White dots denote sites examined where the species were not recorded.



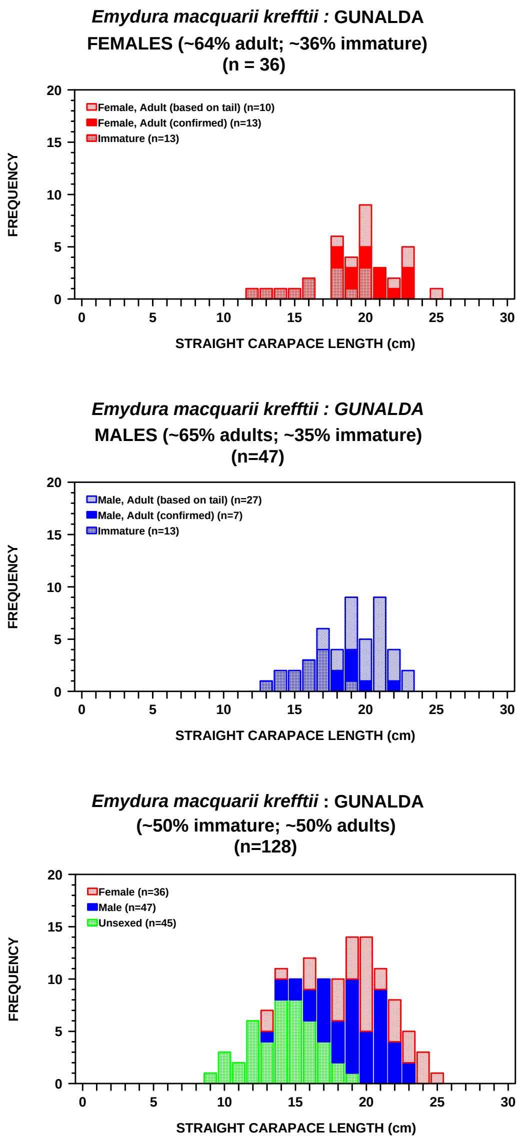
5.3a. Mary River Barrage impoundment sample was caught using seine netting and trapping.

5.3b. Tiaro sample was caught using seine netting and trapping.

Figure 5.3. Size class distribution by sex and maturity for *Emydura macquarii krefftii* within the Mary River. Data derived from the freshwater turtle research database of the former EPA Queensland. Sex and maturity were determined by gonad examination using laparoscopy or by palping to identify oviducal eggs.

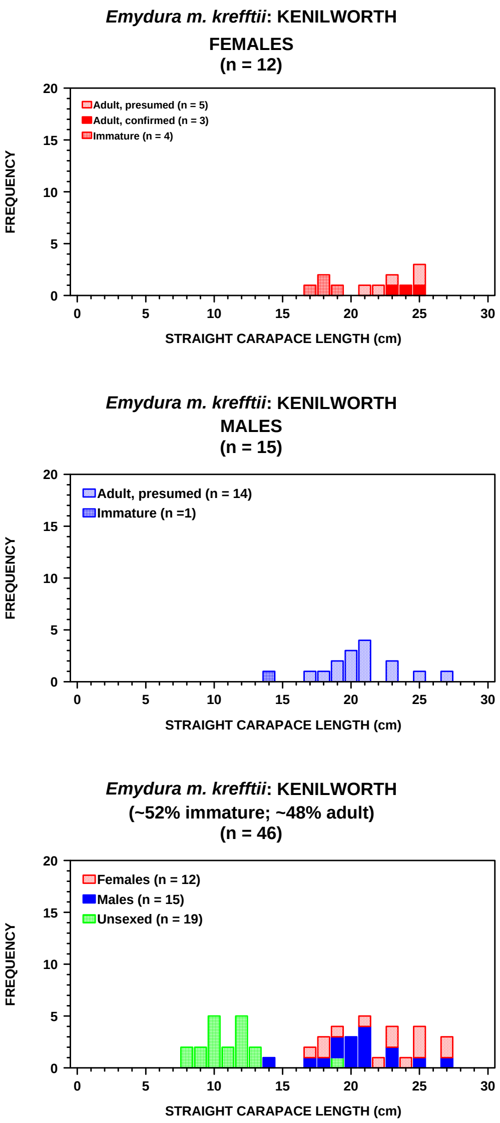


5.3c. Tiaro sample was caught using seine netting and trapping.



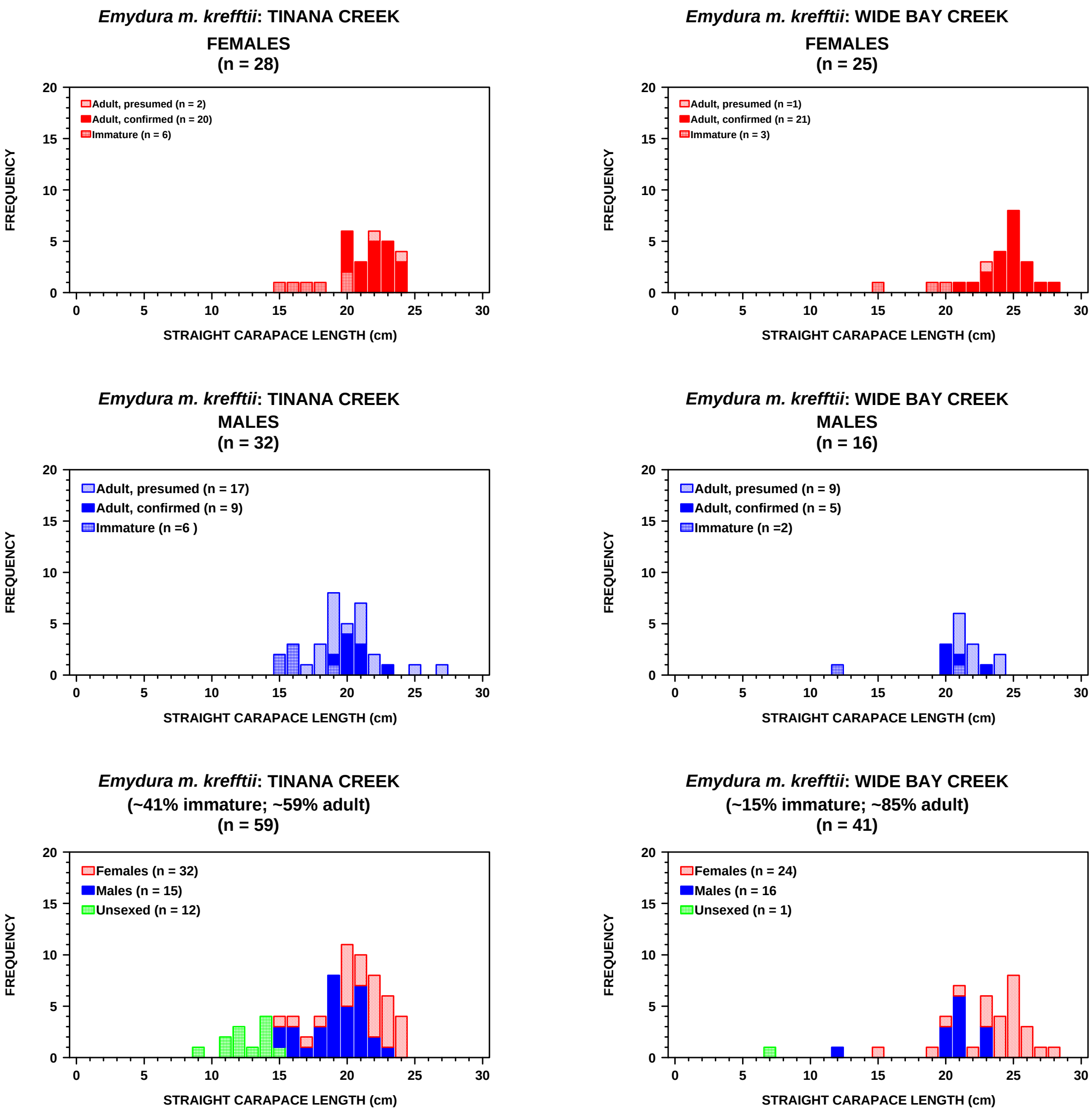
5.3d. Gunalda, Mary River, sample.

Figure 5.3. Continued



5.3e. Kenilworth area sample was caught using snorkelling and trapping.

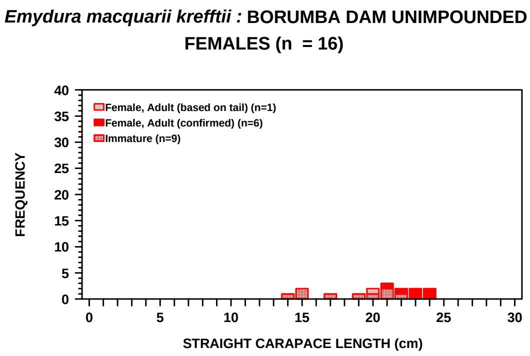
Figure 5.3. Continued

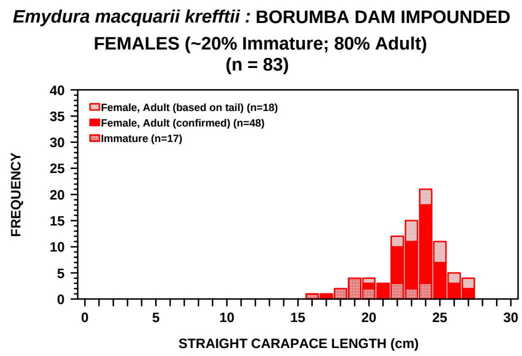


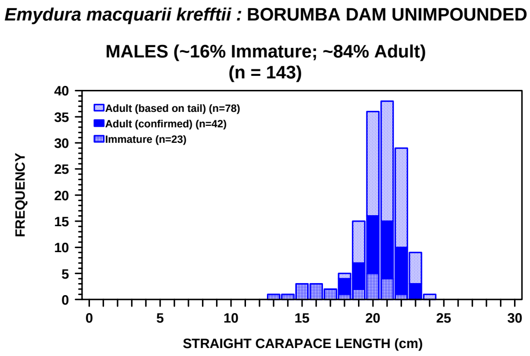
5.3e. Tinana Creek sample was caught by trapping.

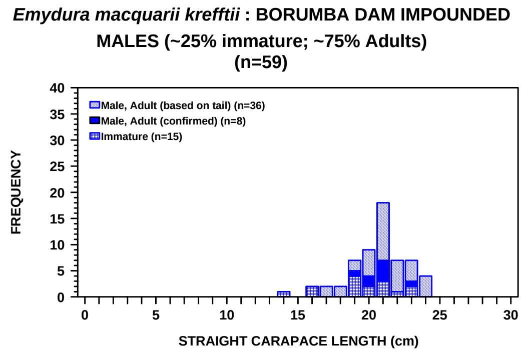
5.3e. Wide Bay Creek sample was caught by seine netting a drying pool.

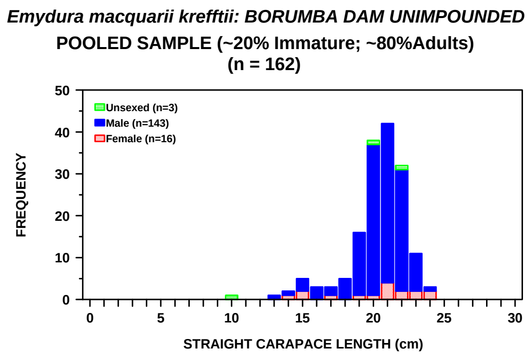
Figure 5.3. Continued

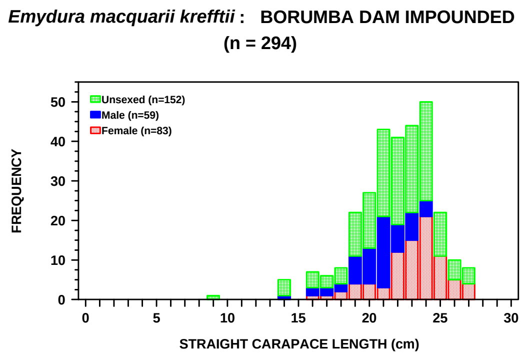












5.3a. Borumba Dam unimpounded sample was caught after the pump out of the plunge pool using netting and muddling.

5.3b. Borumba Dam impounded sample was caught using netting and trapping.

Figure 5.3. Continued.

5.4a. Portion of the sampled turtle carcasses gathered for identification and measurement.

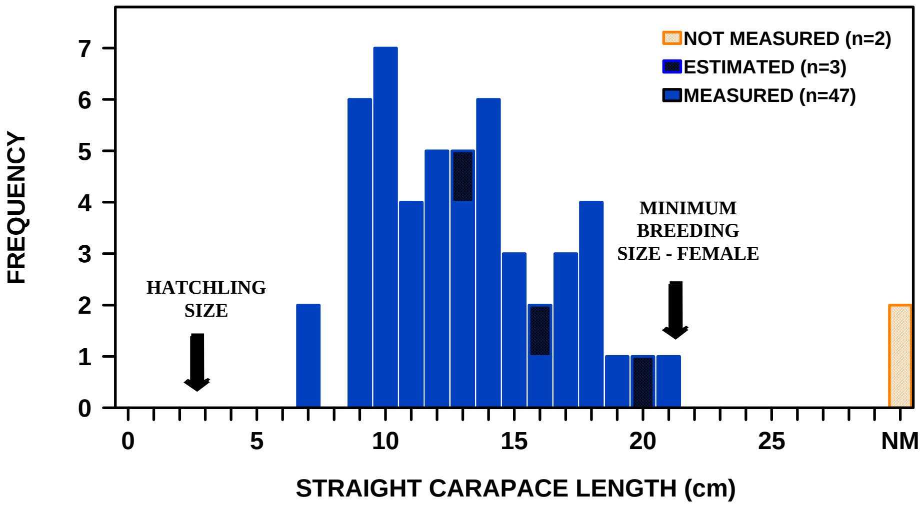


Figure 5.4b. Size class frequency distribution for *Emydura macquarii krefftii* carcasses.

5.4 *Emydura macquarii krefftii* multiple mortality at a farm dam on Gootchie Creek, 29 May 2002.

5.4c. *E. m. krefftii* carcass with scrape marks on the plastron that are consistent with having been preyed on by a raptor.

Figure 5.4. Continued.

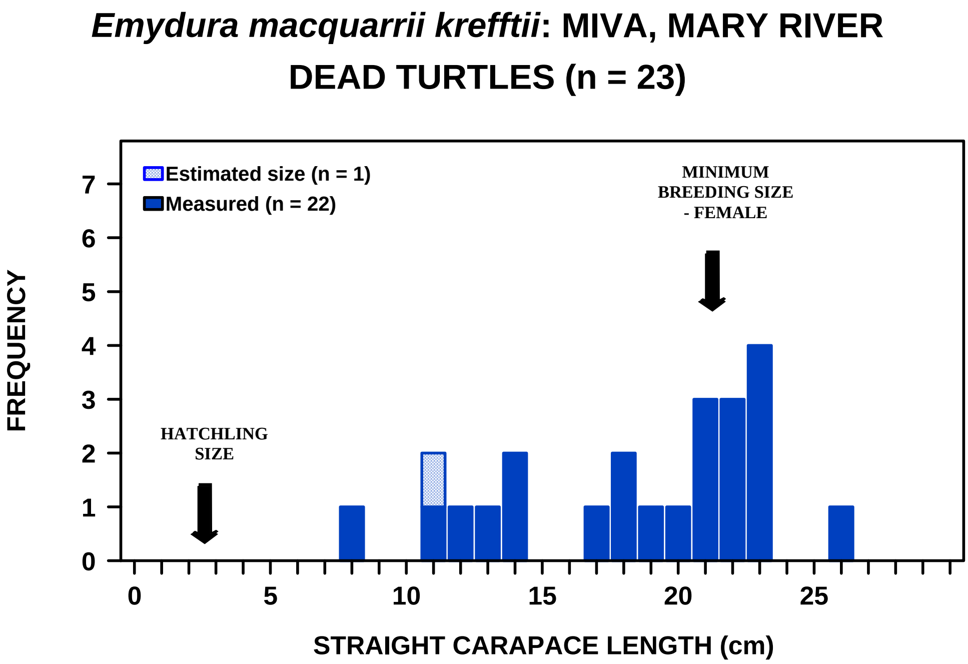


Figure 5.5. Frequency distribution by size of *Emydura maxquarrii krefftii* that were found dead on the bank of the Mary River at Miva on 8 December 2003.

Figure 5.6. Some of the freshly dead *Emydura macquarii krefftii* and *Wullombinia latisternum* at Lake Alford, south Gympie, 16 January 2004.

Table 5.1. Summary of straight carapace length (SCL) measurements for *Emydura macquarii krefftii* from multiple study sites within the Mary Catchment.

Sex	Age class	Measurement			
		Mean	SD	Range	N
Mary River Barrage	**(including Petrie Park)**				
Male	Adult based on tail	21.34	1.1611	18.66 – 23.82	36
	Adult Confirmed	21.54	0.7761	20.79 – 23.15	12
	Prepubescent immature	18.60	0.8485	18.00 – 19.20	2
Female	Adult based on tail	23.30	2.1794	19.78 – 26.81	10
	Adult Confirmed	24.00	1.6632	21.61 – 26.80	22
	Prepubescent immature	18.35	1.8941	16.27 – 21.21	5
Tiaro					
Male	Adult based on tail	20.97	1.7612	18.23 - 2358	11
	Adult Confirmed				0
	Pubescent immature	18.00			1
Female	Adult based on tail	22.26	1.4517	20.81 – 24.12	5
	Adult Confirmed	23.61	2.1725	20.68 – 26.58	5
	Pubescent immature	21.00			1
Munna Bridge					
Male	Adult based on tail	20.79	1.8571	18.60 – 27.80	27
	Adult Confirmed	20.05	1.1031	19.27 – 20.83	2
	Immature	15.79	3.2201	10.84 – 21.70	18
Female	Adult based on tail	22.54	1.1620	21.27 – 24.11	8
	Adult Confirmed	23.74	1.9109	20.76 – 27.88	17
	Immature	17.77	2.1836	13.59 – 20.92	16
Gunalda					
Male	Adult based on tail	20.69	1.5829	17.66 – 23.41	27
	Adult Confirmed	19.79	1.4137	18.37 – 22.49	7
	Immature	17.44	2.3347	13.87 – 20.12	13
Female	Adult based on tail	21.46	2.1654	18.68 – 25.68	10
	Adult Confirmed	22.16	1.7307	19.65 – 24.57	13
	Prepubescent immature	16.36	1.5963	13.62 – 19.73	13
Kenilworth area					
Male	Adult based on tail	20.99	2.0853	17.71 – 25.36	14
	Adult Confirmed				0
	Prepubescent immature	14.00			1
Female	Adult based on tail	23.53	1.7313	21.38 – 25.51	5
	Adult confirmed	24.45	1.2245	23.09 – 25.47	3
	Prepubescent immature	18.71	0.8707	17.77 – 19.82	4

Table 5.1 Continued.

Tinana Creek					
Male	Adult based on tail	20.06	1.5754	17.83 – 22.61	17
	Adult confirmed	21.02	1.1783	19.72 – 23.73	9
	Immature	16.69	1.5452	15.25 – 19.55	6
Female	Adult based on tail	32.19	1.1314	22.67 – 24.27	2
	Adult confirmed	22.42	1.3455	20.01 – 24.57	20
	Immature	18.10	1.9502	15.77 – 20.76	6
Wide Bay Creek					
Male	Adult based on tail	22.47	1.2887	21.00 – 24.45	9
	Adult confirmed	21.58	1.3449	20.49 – 23.82	5
	Immature	16.65	6.4983	12.05 – 21.24	2
Female	Adult based on tail	23.00			1
	Adult confirmed	25.09	1.5109	21.51 – 28.00	21
	Immature	18.65	2.8516	15.38 – 20.62	3
Yabba Creek	**Below Borumba Dam**				
Male	Adult based on tail	21.40	1.1738	18.65 – 24.18	78
	Adult confirmed	21.09	1.3249	18.20 – 23.41	42
	Immature	18.46	2.7241	13.57 – 22.74	23
Female	Adult based on tail	21.00			1
	Adult Confirmed	23.11	0.9446	21.78 – 24.08	6
	Immature	18.70	3.0808	14.51 – 22.67	9
Yabba Creek	**Inside Borumba Dam**				
Male	Adult based on tail	21.58	1.8074	17.80 – 24.65	36
	Adult confirmed	21.26	1.2100	19.13 – 23.22	8
	Immature	19.94	2.5743	14.44 – 23.25	15
Female	Adult based on tail	24.45	1.7576	20.86 – 27.42	18
	Adult Confirmed	24.01	1.8750	17.18 – 27.62	48
	Immature	21.17	2.5355	16.77 – 24.91	17
Pooled for catchment					
Male	Adult based on tail	21.19	1.5653	17.66 – 27.80	271
	Adult confirmed	21.04	1.2902	18.02 – 23.82	86
	Pubescent immature	19.57	2.1365	14.99 – 22.74	21
	Prepubescent immature	16.76	3.1192	10-55 – 25.07	71
Female	Adult based on tail	23.20	1.9847	18.68 – 27.42	67
	Adult Confirmed	23.77	1.8321	17.18 – 28.00	174
	Pubescent immature	19.52	2.0720	13.90 – 22.90	22
	Prepubescent immature	18.34	2.8262	13.59 – 24.91	62

6. CLOACAL VENTILATION

There have been limited studies regarding the diving physiology and behaviour of cloacal ventilating turtle species in the Mary Catchment. However, there have been numerous studies of cloacal ventilation and diving physiology of turtles in other Queensland rivers in recent years. These studies are summarised to provide a collective insight into this phenomenon for the species of the Mary Catchment.

All Australian chelid turtles are capable of bimodal ventilation – using breathing at the surface to give gas exchange via the lungs and acquiring dissolved oxygen from water flushed over the lining of the cloacal bursae (Legler and Georges, 1993). The long-necked turtles, *Chelodina*, have the simplest bursae (Legler and Georges, 1993) and are expected to have the least reliance on cloacal ventilation among the six turtle species that occur within the Mary Catchment. There is a decreasing order of complexity in development of the vascularized gills filaments lining the cloacal bursae that provide increased surface area for oxygen exchange as water is flushed in and out of the cloacal bursae with *Rheodytes leukops* (Figure 6.1b,c), *Elseya albagula* (Figure 6.1a,d), *Wollumbinia latisternum* (Figure 6.1e) and *Emydura macquarii krefftii*. Although recognised as a cloacal ventilating species, the degree of development of the cloacal gills of *Elusor macrurus* has not been described.

Rheodyte leukops

The Fitzroy River turtle, *Rheodytes leukops*, is at the pinnacle of development of cloacal ventilation among Australian chelid turtles. *R. leukops* are negatively buoyant in water (Legler and Georges, 1993). *R. leukops* can obtain up to 70% of its total oxygen requirements by flushing water over the well developed gill system lining the cloacal bursae (Priest, 1997). This species has the most highly developed cloacal gill system among chelid turtles (Legler and Georges, 1993) (Figure 6.1c).

Limpus et al. (2011) reported on observations of hatchlings in an aerated aquarium where *R. leukops* were continually flushing water in and out of the cloaca. They rarely surfaced for a breath while other species in the same aquarium were surfacing on a regular basis. When *R. leukops* did come to the surface for a breath, they were more likely to walk up a submerged object than swim. In the extreme, post hatchlings burrowed under the root mass of aquatic vegetation by day, leaving their posterior end unobstructed to water exchange via the cloaca.

In a study of free-ranging wild *R. leukops,* a species with a high reliance on aquatic respiration, and *E. m. krefftii,* a species with low reliance on aquatic respiration, at Marlborough Creek in the Fitzroy Catchment, Gordos and Franklin (2002) recorded significant differences in diving performance between these species:

- Dives per day: *R. leukops* – 39.3 ± 5.38 dives/day; *E. m. krefftii* – 112.2 ± 11.73 dives/day.
- Mean dive length: R. leukops – 33.1 ± 7.33 min; E. m. krefftii – 9.6 ± 2.26 min.
- Maximum dive length: R. leukops – 623 ± 104.74 min; E. m. krefftii – 67.1 ± 8.14 min.

Both species had heightened activity levels during twilight.

In a second study of free-ranging wild *R. leukops* at Marlborough Creek, Gordos et al. (2003) found that individuals generally remained at depths >1 m throughout the day where the effects of diel fluctuations in water temperature and aquatic PO_2 level was considered to be negligible. During summer and autumn, surfacing frequency increased significantly during daylight hours with peak levels normally occurring around dawn and dusk. No consistent deil surfacing trend was recorded during winter and spring.

Under laboratory conditions, *R. leukops* decreased its surfacing frequency 20 fold in response to increasing water velocity and, at higher water velocities selected low-velocity microhabitats (Gordos et al. 2004a). The same study detected no change in surfacing frequency in response to water depths up to 1.50 m. The results indicated a heightened reliance on aquatic gas exchange with increased water velocity and a high reliance upon aquatic O_2 uptake regardless of water depth.

In another laboratory study, Gordos et al. (2004b) investigated blood-gas, acid-base and plasma-ion status of *R. leukops* during prolonged dives of up to 2 hr and concluded *R. leukops* utilises aquatic respiration to remain aerobic during prolonged dives, effectively avoiding the development of metabolic and respiratory acidosis.

Under normal ambient dissolved oxygen conditions in an aerated pond (PO_2 ~`7.85 kPa), *R. leukops* diving heart rate and cloacal ventilation rate remained constant with increased submergence length, indicating that bradycardia failed to develop during extended dives of up to 3 days (Gordos et al. 2006). With increasing dive duration under hypoxic (PO_2 ~3.79 kPa) conditions, the same study recorded bradycardia attributed to a hypoxic-induced metabolic depression.

Limpus *et al*. (2011) concluded that these studies leave little doubt that *R. leukops* is well adapted for foraging in flowing riffle zones where elevated dissolved oxygen levels enable the species to undertake prolonged dives, hence minimising energy expenditure and displacement while maintaining their foraging/resting location against the force of the current. However, none of these studies have demonstrated that *R. leukops* is not equally well adapted for foraging and resting in the shallow, and aerobic margins of large slow flowing reaches and large non-flowing pools within the Fitzroy Catchment. They would be particularly well adapted for maintaining their position at specific foraging sites in very structured habitats such as log tangles and rock outcrops, with or without currents. As a benthic foraging species, it is unlikely that the species would function well in the deeper habitats of the larger pools if these are associated with very low dissolved oxygen levels, especially under dry season conditions with non-flowing water conditions.

The best breeding population identified within the Fitzroy Catchment is found within the shallow upper reaches of the Fitzroy Barrage impoundment (Limpus et al. 2011)

E. albagula

E. albagula is another species with highly developed gills lining the cloacal bursae (Legler and Georges, 1993. Figure 6.1d). During normal swimming and resting periods the species is continually flushing water in and out of the cloacal bursae via the vent (Figure 6.1a).

In laboratory studies with *E. albagula* from the Mary River, the species was found to obtain on average, 74% of its oxygen requirements from the water (FitzGibbon, 1998). The same author also recorded extended submergence periods exceeding 2 hr with free ranging wild *E. albagula* in the Mary River.

In a laboratory study, Mathie and Franklin (2006) investigated the relationships between body size, aquatic respiration, and dive duration in the bimodally respiring turtle, *E. albagula*. Turtles used in this study came from all three rivers: Mary, Burnett and Fitzroy Rivers. They found that:

- dive duration was found to be independent of body mass under normoxic conditions.
- dive durations of smaller turtles were equivalent to that of larger individuals despite their relatively smaller oxygen stores and higher mass specific metabolic rates.
- smaller turtles were able to increase their dive duration through the use of aquatic respiration.
- smaller turtles had a relatively higher cloacal bursae surface area than larger turtles, which allowed them to extract a relatively larger amount of oxygen from the water.
- by removing the ability to respire aquatically (hypoxic conditions), the dive duration of the smaller turtles significantly decreased, restoring the normal positive relationship between body size and dive duration that is seen in other air-breathing vertebrates.

In a study of free-ranging, wild *E. albagula* in the Burnett River, Gordos et al. (2007) recorded maximum submergence times for the species (exceeding 3 hr) that are among the longest recorded for voluntarily diving vertebrates. This was attributed to the species ability to respire aquatically. Turtles undertook deep resting dives (>1.5 m) during the day before moving into shallower habitats (<1.0 m) for the night. The crepuscular hours were associated with increased surfacing frequencies.

In the absence of additional diving physiology studies, it is presumed that *E. albagula* approaches *R. leukops* in its ability to forage in flowing water habitats where elevated dissolved oxygen levels enable the species to undertake prolonged dives, hence minimising energy expenditure and displacement while maintaining their foraging/resting location against the force of the current. Based on the distribution records (Limpus et al. 2011), *E. albagula* is also suited for inhabiting the aerobic margins of large slow flowing reaches and large non-flowing pools within the Fitzroy Catchment, including the shallow upper reaches of the Fitzroy Barrage impoundment. They would be particularly well adapted for maintaining their position at specific foraging sites in very structured habitats such as log tangles and rock outcrops, with or without currents. As a benthic foraging species, it is unlikely that the species would function well in the deeper habitats of the larger pools if they are associated with very low dissolved oxygen levels, especially under dry season conditions within standing water bodies.

Elusor macrurus

Based on laboratory studies, Mathie (2007) concluded:

- *E. macrurus* can extract up to 50% of its oxygen requirements from the water. The time that the turtle spends underwater is a function of temperature. The amount of time underwater reduces at higher temperature.
- *E. macrurus* is unable to acclimatise to warm temperatures but does have the ability to increase dive duration in cold conditions.
- In cool water without high oxygen levels in the water, as can be the situation in deeper layers of standing water bodies, turtles will be unable to maintain an increased dive duration via cloacal ventilation. With resulting increased surfacing rates, small immature turtles may face increased predation rates because at cold temperatures they swim slower and their escape from predators may be compromised.

Emydura macquarii krefftii

Species in the genus *Emydura* have a simplified cloacal gill system with a rugous lining to the bursae and elongate papillae only near the entrance to the bursae from the cloaca (Legler and Georges, 1993).

In a study of free-ranging wild *R. leukops,* a species with a high reliance on aquatic respiration, and *E. m. krefftii,* a species with low reliance on aquatic respiration, at Marlborough Creek, Gordos and Franklin (2002) recorded significantly different diving performance between these species with *E. m. krefftii* making more and shorter dives per day (See *R. leukops* above for details).

While *E. m. macquarii* has some capacity to utilise dissolved oxygen directly from the water, it has a lower capacity for aquatic respiration via the cloaca than the specialised species such a *R. leukops* and *E. albagula*.

Wollumbinia latisternum

W. latisternum has less fully developed gill papillae in the cloacal bursae than *R. leukops* or *E. albagula* (Legler and Georges, 1993) (Figure 6.1e).

King and Heatwole (1994a,b) described cloacal ventilation for the closely related *W. georgesi* from New South Wales. At the time of that study the taxon was included in *Elseya latisternum*.

W. latisternum is presumed to function at an intermediate level of reliance on aquatic respiration when compared with the other species of turtles in the Catchment. Any negative impacts on *E. albagula* and *E. macrurus* resulting from changes in oxygen levels in impoundment water bodies in the catchment should apply to *W. latisternum* but at a less intense level.

Discussion

Cloacal ventilating turtle species are among those most susceptible to the impacts of habitat change. There are three species of turtles in the Mary Catchment that have well developed gill systems lining their cloacal bursae: *E. albagula*, *E. macrurus* and *W. latisternum*. These species will have the greatest reliance on extracting dissolved oxygen from the water during their normal daily activities.

Tucker (2000) in a two-year study of turtle populations associated with dams and weirs in the Fitzroy, Burnett and Mary River Catchments concluded that the larger the impoundment and the longer it is in place, the greater the reduction in freshwater turtle species diversity living within the impoundment. The species identified as most likely to be negatively impacted by impoundments are the cloacal ventilating, delayed maturity species, *E. macrurus*, *R. leukops* and *E. albagula*. There was insufficient data to identify with certainty why these species do not function well in impoundments. However, proposed possible factors included:

- Reduced or stratified dissolved oxygen levels within benthic habitats in large impoundments may compromise oxygen uptake via cloacal ventilation.
- Impoundment may result in significant reduction in the availability of specific dietary requirements. For example, loss of original riparian vegetation may preclude specific fruit types included in their diet from falling into *E.albagula* and *E. macrurus* habitats, or the benthic species required for food may not grow in low oxygen content water with poor light penetration.

- The loss and/or periodic flooding of nesting habitat that can result from fluctuating water levels associated within impoundments may compromise nesting and hatching success.
- Alterations to the quality or availability of in-stream microhabitats such as woody debris (logs and snags), rock crevices and overhangs may compromise species survival.

Limpus et al. (2011) have identified that in the Fitzroy Catchment, the best functioning *R. leukops* and *E. albagula* populations were found in the upper reaches of the Fitzroy Barrage impoundment. Within the current study, *E. albagula* has been identified as a common turtle in the upper reaches of the Mary River Barrage impoundment. *E. macrurus* also occurs in this impoundment but at lower numbers and both species breed on the adjacent banks. Recent studies in the Burnett River have identified the best concentration of nesting and an associated aggregation of adult *E. albagula* in the upper reaches of the Ben Anderson Barrage impoundment (D. Limpus, pers. comm. June 2007). These species appear to be functioning well in shallow, slowly flowing impoundment habitats. These field observations are at variance with the conclusions drawn from laboratory studies (Mathie, 2007) and with the conclusions drawn by Tucker (2000) from extensive field studies. However, the Tucker (2000) study did not include the sampling of the upstream shallow water reaches of the impoundments. That study sampled the deeper habitats immediately upstream of the impoundment infrastructures to provide representation of the impoundment turtle populations.

The recent field studies are clearly demonstrating that these cloacal ventilating species are continuing to function within the shallow upstream, slow flowing habitats of impoundments for decades after the dam and weir infrastructures have been put in place. This phenomenon of cloacal ventilating species living in and breeding from habitats in the upper reaches of impoundments warrants further investigation.

There are other potential human related problems facing cloacal ventilating turtle species. Legler (1993) concluded that turtles that use cloacal gills for respiration are vulnerable to fish poisons such as derris and rotenone. In the absence of experimental data, it is presumed that cloacal ventilating turtles like *E. albagula*, *E. macrurus* and *W. latisternum* will be at higher risk to the uptake of water born pollutants such as organic herbicides derived from agriculture and pastoral industries within the catchment than the turtles with limited development of cloacal gill systems.

In contrast to the problems encountered by the above cloacal ventilating, delayed maturity turtle species, other turtle species which do not rely on cloacal ventilation and do not have delayed maturity such as *Emydura m. krefftii* and *Chelodina longicollis* may be favoured by shallow standing water bodies and may have enhanced population levels in some impoundments.

In a Commonwealth Government independent review of the Walla/Ned Churchward Weir proposal in the Burnett Catchment, Boardman (1996) identified that individual impoundments were unlikely to threaten species survival for the lungfish and turtle, *Elseya albagula,* in the Burnett River but that cumulative impacts of multiple dams and weirs in a river system could be significant. He identified the cumulative impact of multiple impoundments in a catchment as a priority issue for investigation.

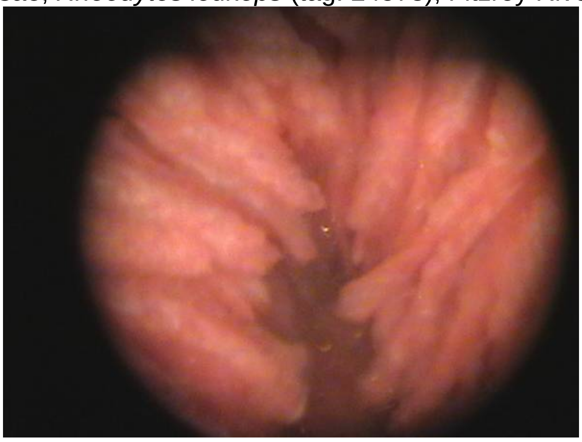
Elseya and *Rheodytes* are genera that have undergone contractions in range and a reduction in species in response to long-term climate change and associated habitat change since the last ice age (Georges and Thomson, 2006). The accelerated rate of large-scale alteration to river flow regimes and habitat characteristics through human activities are likely, in their own right, to be a problem for specialised species like *E. albagula* and *E. macrurus.* However, these human impacts within the river occur in conjunction with the impacts of natural long-term climate change or possible global warming impacts that are acting on the species.

Therefore taking the above into account, within the Mary Catchment, *E. macrurus*, *E. albagula* and *W. latisternum* are identified as the turtles at greatest risk from the existing and planned changes to the in-stream habitat and flow regimes.

6.1a. Vent to cloaca, *Elseya albagula* (Type specimen, tag: 27139) from the Burnett River.

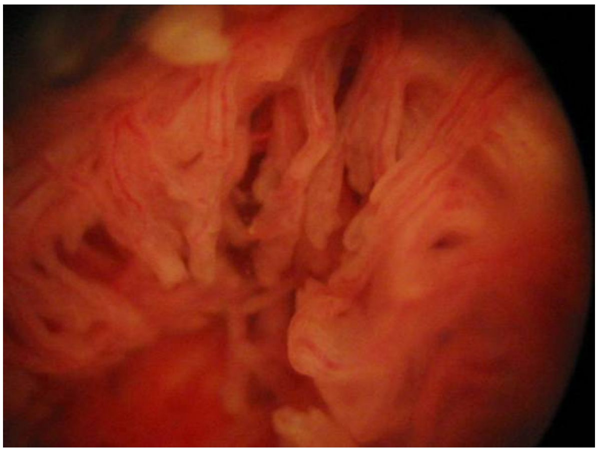
6.1b. Widely gaping vent to the cloaca with vascularized gill filaments visible at the entrances to the cloacal bursae, *Rheodytes leukops* (tag: 24578), Fitzroy River.

6.1c. Laparoscopic view of a highly branched gill filament on the lining of a cloacal bursa, *Rheodytes leukops* (tag: 4802) Fitzroy Catchment.



6.1d. Laparoscopic view of relatively unbranched gill filaments lining the entrance to a cloacal bursa, *Elseya albagula* (Type specimen, tag: 27139) from the Burnett River.

6.1e. Photograph of a video monitor displaying a laparoscopic view of simple gill filaments in the cloacal bursa of *Wollumbinia latisternum*, Fitzroy Catchment.



6.1f. Laparoscopic view of relatively unbranched gill filaments lining the entrance to a cloacal bursa, *Elseya lavarackorum* from the Nicholson River.

Figure 6.1. Cloacal gills in the cloacal ventilating turtles.

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APPENDIX 1.

Summary of turtle data in the Queensland Freshwater Turtle database for turtles sampled within the Mary River Catchment by sampling site, date and capture method. Summary prepared 15 September 2008.

These data refer only to observations and capture of turtles.

The core sampling areas are defined on the text of the above report and in the accompanying Mary River Catchment map (Figure 2.1).

Core sampling area: **1. Mary Barrage,** down stream from Tiaro within the impounded waters of the Mary River Barrage.

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
20 Jan 1998 – 28 Oct 1999	7 x 1 day	Seine netting, trapping, snorkelling, observation from bank.	Tucker (2000); Flakus (2002)
10 Nov – 1 Dec 2003	Several days	Incidental observations from bank	
16 Oct 2004 – 22 Oct 2006	3 x 2 day	Sampling turtles caught in annual fishing competition, trapping, snorkelling	Unpublished EPA *Elseya* reproductive studies

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	***Elusor macrurus***	***Elseya albagula***	***Wollumbinia latisternum***	***Emydura m. krefftii***	***Chelodina expansa***	***Chelodina longicollis***
20 Jan 1998 – 28 Oct 1999	1	11	1	79	0	0
10 Nov – 1 Dec 2003	1	0	0	1	0	0
16 Oct 2004 – 22 Oct 2006	1	45	0	12	0	0
TOTAL	**3**	**56**	**1**	**92**	**0**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	**Population**	**Structure**						
	Sex	**Maturity**						**Dead**
		Adult	**Presumed adult**	**Pubescent**	**Pre-pubescent**	**maturity not determined**		
Elusor macrurus	Male		1		1			1
	Female		1					
	Not sexed							
Elseya albagula	Male	5	23	1	1	3		
	Female	5	16			2		
	Not sexed							
Wollumbinia latisternum	Male							
	Female		1					
	Not sexed							
Emydura m. krefftii	Male	12	36		2			
	Female	22	10	1	4			3
	Not sexed				5			
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **2. Tiaro,** above the Mary Barrage in the vicinity of the traditional high density nesting banks in the Mary River.

Number of sampling periods: 3

Sampling period	**No. of visits**	**Sampling methods**	**Study**
30 Aug 1997 – 18 Nov 1999	21 x 1 day	Snorkelling, observations from the bank, trapping, spotlight capture of nesting females	FitzGibbon, 1998; Tucker, 2000; Flakus, 2002
14 Jan 2000 – 5 Feb 2002	2 x 1 day	Trapping, observations from the bank	Flakus, 2002, Thomson *et al*. (2006)
20 Oct 2004 – 15 Oct 2005	2 x 1 day	Snorkelling, observations from the bank	Tiaro & District landcare Group, 2005; Connell and Wedlock, 2006; Unpublished EPA *Elseya* reproductive studies

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	***Elusor macrurus***	***Elseya albagula***	***Wollumbinia latisternum***	***Emydura m. krefftii***	***Chelodina expansa***	***Chelodina longicollis***
30 Aug 1997 – 18 Nov 1999	15	34	4	22	0	0
14 Jan 2000 – 5 Feb 2002	1	1	0	11	0	0
20 Oct 2004 – 15 Oct 2005	1	2	0	1	0	0
Total	**17**	**37**	**4**	**34**	**0**	**0**

Core sampling area: 2. Tiaro (continued)

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area. * The six unsexed immatures were found dead along the river bank and cause of death was not determined.

Species	Population Structure							
	Sex	**Maturity**						**Dead**
		Adult	**Presumed adult**	**Pubescent**	**Pre-pubescent**	**maturity not determined**		
Elusor macrurus	Male							
	Female	9	1					1
	Not sexed				6*	1		6*
Elseya albagula	Male	2	9	2				
	Female	9	15					1
	Not sexed							
Wollumbinia latisternum	Male	1						
	Female							
	Not sexed				3			
Emydura m. krefftii	Male		11		1			1
	Female	5	5		1			
	Not sexed				11			
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **3. Mary River at Munna Creek junction**, upstream and downstream from the bridge adjacent to Munna Creek junction.

Number of sampling periods: 3

Sampling period	No. of visits	Sampling methods	Study
5 Sep 1997 – 21 Jan 1999	14 x 1 day	Snorkelling, observations from the bank	Tucker (2000); Flakus (2002)
3-4 Nov 2002	2 x 1 day	Snorkelling, trapping	Thomson *et al*. (2006);
23 Apr 2006 – 02 May 2007	3 x 1 day	Snorkelling	Unpublished EPA *Elseya* reproductive studies

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
5 Sep 1997 – 21 Jan 1999	32	133	1	83	1	0
3-4 Nov 2002	9	18	1	28	0	0
23 Apr 2006 – 02 May 2007	1	27	0	4	0	0
Total	**42**	**178**	**2**	**115**	**1**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population Structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male	2	16	3	4			
	Female	6	2		3			
	Not sexed				5	1		1
Elseya albagula	Male	14	33		5			
	Female	91	20	2	12			1
	Not sexed				1			
Wollumbinia latisternum	Male	1		1				
	Female							
	Not sexed							
Emydura m. krefftii	Male	2	27	6	12	5		
	Female	17	8	4	12			1
	Not sexed				17	5		2
Chelodina expansa	Male							
	Female	1			1			
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **4. Gunalda**, Mary River.

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
30 Aug 1997 – 17 Nov 1999	30 x 1 day	Snorkelling, trapping, netting	Tucker, 2000; Flakus, 2000
22 Sept 2000 – 14 Dec 2000	3 x 1 day	Snorkelling, trapping	Incidental observations by EPA staff

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	***Elusor macrurus***	***Elseya albagula***	***Wollumbinia latisternum***	***Emydura m. krefftii***	***Chelodina expansa***	***Chelodina longicollis***
30 Aug 1997 – 17 Nov 1999	70	107	5	109	0	0
22 Sept 2000 – 14 Dec 2000	2	6	2	20	0	0
Total	**72**	**113**	**7**	**129**	**0**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	**Population Structure**							
	Sex	**Maturity**						**Dead**
		Adult	**Presumed adult**	**Pubescent**	**Pre-pubescent**	**maturity not determined**		
Elusor macrurus	Male	18	8					
	Female	16	3		1			
	Not sexed				26			
Elseya albagula	Male	15	25	1		2		
	Female	31	21	4	7			
	Not sexed				7			
Wollumbinia latisternum	Male	1	1		1			
	Female	1			1			2
	Not sexed				2			1
Emydura m. krefftii	Male	7	28	1	12			
	Female	13	10	6	7			
	Not sexed				43	2		
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: 5. Gympie and Widgee, Mary River.

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
22 Jul 1996 – 28 May 1998	4 x 1 day	Snorkelling, trapping, electro fishing	Tucker, 2000
1 Nov 2006	1 day	Observations from the bank	Incidental observations by EPA staff

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
22 Jul 1996 – 28 May 1998	1	O	3	12	1	o
1 Nov 2006	2	0	0	1	0	0
Total	**3**	**0**	**3**	**13**	**1**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population Structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male	1						
	Female							
	Not sexed					2		
Elseya albagula	Male							
	Female							
	Not sexed							
Wollumbinia latisternum	Male							
	Female				1			
	Not sexed				2			
Emydura m. krefftii	Male		4					
	Female		3					
	Not sexed				5	1		
Chelodina expansa	Male							
	Female		1					
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **6. Traveston**, upstream from Traveston Crossing on the Mary River to the junction with Yabba Creek.

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
12 Aug 1997	1 day	Snorkelling	Tucker, 2000
1 Apr 2007 – 11 May 2007	7 x 1 day	Snorkelling, muddling	Data from Qld Turtle Conservation volunteer (C. Latta).

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia Latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
12 Aug 1997	0	0	1	4	0	0
1 Apr 2007 – 11 May 2007	52	12	0	7	1	0
Total	**52**	**12**	**1**	**11**	**1**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population Structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male		9		5			
	Female		4		5			
	Not sexed				29			
Elseya albagula	Male		1		1			
	Female	1	3		1			
	Not sexed				5			
Wollumbinia latisternum	Male		1					
	Female							
	Not sexed							
Emydura m. krefftii	Male		1		1			
	Female		3		1			
	Not sexed			4	1			
Chelodina expansa	Male							
	Female							
	Not sexed				1			
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: 7. Kenilworth & Walker Road Bridge

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
15 June 1999 – 27 Oct 1999	2 x 1 day	Snorkelling, trapping	Tucker, 2000
27 Mar 2007	1 day	Snorkelling	Data from Qld Turtle Conservation volunteer (C. Latta).

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
15 June 1999 – 27 Oct 1999	3	7	8	46	0	0
27 Mar 2007	1	0	0	0	0	0
Total	**4**	**7**	**8**	**46**	**0**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male		3					
	Female		1					
	Not sexed							
Elseya albagula	Male				1			
	Female		2		1			
	Not sexed					3		
Wollumbinia latisternum	Male		1		2			
	Female	1			1			
	Not sexed				3			
Emydura m. krefftii	Male		14		1			
	Female	3	5		4			
	Not sexed				19			
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: Tinana Creek

Number of sampling periods: 1

Sampling period	No. of visits	Sampling methods	Study
21 Jan 1998 – 21 Apr 1999	3 x 1 day	Observations from the bank and canoe, trapping	Tucker, 2000; Flakus, 2002

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
21 Jan 1998 – 21 Apr 1999	1	6	3	72	0	0
Total	**1**	**6**	**3**	**72**	**0**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population Structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male		1					
	Female							
	Not sexed							
Elseya albagula	Male				1			
	Female	2	1		1			
	Not sexed				1			
Wollumbinia latisternum	Male		2					
	Female							
	Not sexed				1			
Emydura m. krefftii	Male	9	17	1	5			
	Female	20	2	2	4			
	Not sexed				12			
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **Wide Bay Creek**, rescue of turtles stranded in a drying waterhole under drought conditions.

Number of sampling periods: 1

Sampling period	No. of visits	Sampling methods	Study
21 Dec 1997	1 day	Netting	Tucker, 2000

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
21 Dec 1999	0	39	0	42	0	0
Total	**0**	**39**	**0**	**42**	**0**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species			Population	structure				
	Sex			Maturity				Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male							
	Female							
	Not sexed							
Elseya albagula	Male	7		1	2			
	Female	20		3	6			
	Not sexed							
Wollumbinia latisternum	Male							
	Female							
	Not sexed							
Emydura m. krefftii	Male	5	9	1	1			
	Female	21	1	2	1			
	Not sexed				1			
Chelodina expansa	Male							
	Female							
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **Imbil – Yabba Creek**

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
1 Dec 1997 – 26 Oct 1999	6 x 1 day	Observations from the bank, electro fishing & trapping	Tucker, 2000
25 Aug 2003 – 12 Sept 2003	6 x 1 day	Observations from the bank, electro fishing, netting, trapping	Thomson *et al*. (2006)

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
1 Dec 1997 – 26 Oct 1999	3	5	7	200	1	0
25 Aug 2003 – 12 Sept 2003	0	21	1	157	5	1
Total	**3**	**26**	**8**	**357**	**6**	**1**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male		1		1			
	Female							
	Not sexed				1			
Elseya albagula	Male	7			1			
	Female	10		2	1			1?
	Not sexed				5			
Wollumbinia latisternum	Male	1			1			
	Female	3			2			
	Not sexed				1			
Emydura m. krefftii	Male	50	123	12	26			
	Female	71	19	5	23			
	Not sexed				28			1
Chelodina expansa	Male	3						
	Female	3						
	Not sexed							
Chelodina longicollis	Male							
	Female							
	Not sexed				1			

Core sampling area: Obi Obi Creek

Number of sampling periods: 1

Sampling period	No. of visits	Sampling methods	Study
8 Mar 2008 – 4 Sep 2008	5 x 1 day	Caught on fishing line, observation from bank, trapping, snorkelling	EPA incidental turtle surveys and reports from local farmers

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. krefftii*	*Chelodina expansa*	*Chelodina longicollis*
8 Mar 2008 – 4 Sep 2008	3	4	2	10	1	0
Total	**3**	**4**	**2**	**10**	**1**	**0**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male	3						
	Female							
	Not sexed							
Elseya albagula	Male							
	Female	1						
	Not sexed				3			
Wollumbinia latisternum	Male			1				
	Female							
	Not sexed				1			
Emydura m. krefftii	Male		1		3			
	Female		2		1			
	Not sexed				3			
Chelodina expansa	Male							
	Female							
	Not sexed					1		
Chelodina longicollis	Male							
	Female							
	Not sexed							

Core sampling area: **Fraser Island**

Number of sampling periods: 2

Sampling period	No. of visits	Sampling methods	Study
19 Jan 1986 – 17 May 1999	6 x 1 day	Typing visit, Observations, & ?	Tucker (2000)
4 Mar 2006	1 day		Incidental reports from EPA staff.

Captures by species. These data area pooled for all capture methods for this area.

Sampling period	*Elusor macrurus*	*Elseya albagula*	*Wollumbinia latisternum*	*Emydura m. nigra*	*Chelodina expansa*	*Chelodina longicollis*
19 Jan 1986 – 17 May 1999	0	0	0	474	8	1
4 Mar 2006	0	0	0	2	1	0
Total	**0**	**0**	**0**	**476**	**9**	**1**

Population structure by species, sex and maturity. These data are pooled across all sampling periods and sampling methods for this area.

Species	Population structure							
	Sex	Maturity						Dead
		Adult	Presumed adult	Pubescent	Pre-pubescent	maturity not determined		
Elusor macrurus	Male							
	Female							
	Not sexed							
Elseya albagula	Male							
	Female							
	Not sexed							
Wollumbinia latisternum	Male							
	Female							
	Not sexed							
Emydura m. nigra	Male	27	114	2	8			
	Female	206	7		34			
	Not sexed				78			2
Chelodina expansa	Male		2					
	Female	4						
	Not sexed				2	1		1
Chelodina longicollis	Male							
	Female							
	Not sexed				1			