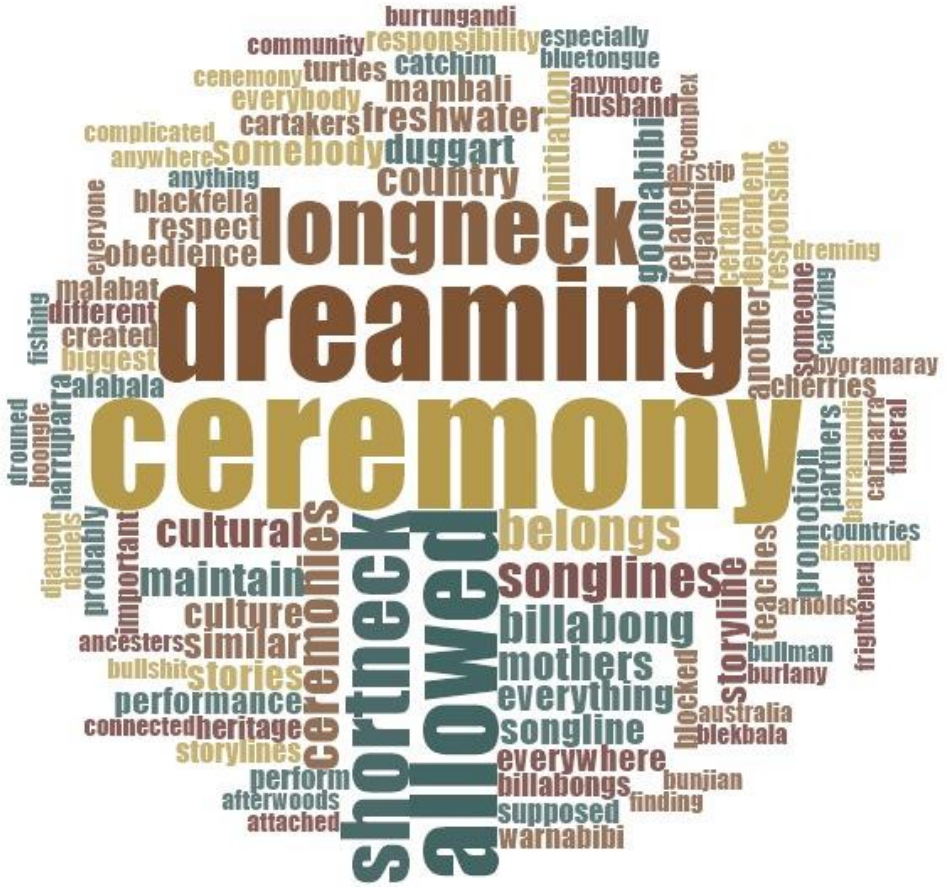
Indigenous Eco-Cultural Knowledge of Freshwater Turtles in South-East Arnhem Land, Australia



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Thesis presented in accordance with the requirement of the Master of Research

Department of Environmental Sciences

Submission Date: 12 October 2018

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Declaration

I hereby declare that this thesis has not been previously submitted to any other institution or university for a higher degree. This thesis is comprised entirely of my work, except otherwise acknowledged. Ethical aspects of this thesis have been approved by the Macquarie University Human Research Ethics Committee (Reference No. 5201800178).

Rukshana Sultana
Date: 12 October 2018

Acknowledgements

All praise goes to almighty Allah (SUB).

I would like to thank my supervisor Dr. Emilie Ens. Her passion drew me into this project. Her wisdom, continuous support, encouragement and invaluable suggestions have resourced me throughout this journey. Working alongside with the aboriginal communities in Australia was a dream that I've always treasured and through her it became true. So, my heartfelt gratitude goes to her. She believed in me and helped me throughout the journey to transform me into a researcher. Thank you.

I would like to thank the discipline panel Rachael Gallagher and Joseph Maina Mbui. I'm grateful to Rachael for her words of wisdom and humble approach in guidance throughout this journey. I really appreciate Maina's walk in approach and assist me with issues related to GIS and his invaluable suggestions to make the most of the field data. My heartfelt thanks go to both of you.

I'm grateful to predecessor, Shaina Russell, for her great work in Ngukurr and sharing her journey with me. Thank you, Shaina, for mentoring me thoroughly.

It was entirely my pleasure to work with you, Justine Rogers, Kiefer Hall, Cynthia Turner, Sandra Blitner and Karis Robertson in my research team. You people have amazed me with your assistance, guidance and enthusiasm during the field work. I enjoyed my time in Ngukurr and Numbulwar because of you guys. Love you all. I also want to expand my thanks to Jangu Nundhirribala. She enriched me with her philosophy towards life. Thanks, Jangu.

My special thanks go to my partner Greg Williamson for his unequivocal support throughout this journey and pampering my late night picking up requests, cooking special dinners and the list goes on. Without your support, I won't be able to pull this off. Thank you, my hero.

I also want to thank my parents, my siblings for their prayers and support. My mates Aashi, Khadija, Armin, Bec, Mike, Sam and Daniel for be there whenever I needed a friend. I also want to thank the dept.'s admin team, Jennifer Rowland, Aida and Phil. You guys have shown great kindness and support since day one. I look forward to bumping into you guys more in future.

Funding

This research was supported by an International Macquarie University Research Excellence Scholarship for Master of Research and Citizen Science Grant: Eastern Arnhem Land Cross Cultural Biodiversity Project (Awarded to Dr. Emilie Ens, by The Australian Government Department of Industry, Innovation and Science).

Contents

Abstract

Freshwater turtles play a significant role in Indigenous culture as food and totems. Following requests by Indigenous communities of the South East Arnhem Land Indigenous Protected Area (SEAL IPA), this project documented freshwater turtle knowledge of Traditional Knowledge Custodians (TKCs) to gain a better understanding of freshwater turtle species distribution, habitat preferences, potential threats and cultural values. Through participatory mapping workshops and semi-structured interviews, three turtle species were recorded in the IPA: Northern Long-neck Turtle (*Chelodina oblonga)*, Short-neck Turtle (*Emydura worrelli*) and Stinky Turtle (*Chelodina canni*). Freshwater turtles are embedded in local Aboriginal culture which is expressed in this region mainly through stories and songlines. TKCs mentioned four main threats to freshwater turtles: climate change, natural predators, feral animals and habitat change. Climate change impact was primarily attributed to lower rainfall. Natural predators were dingo and birds of prey, while feral animal threats were mentioned as buffalo, pig and cattle. The eco-cultural and participatory approaches used in this project greatly improved knowledge of freshwater turtle distribution, cultural association and threats for which there was previously very little documented data in this remote part of northern Australia.

1. Introduction

1.1 Recognition of Indigenous Ecological Knowledge in conservation

Definitions of "Indigenous" people vary around the globe and are often contentious (Thornberry, 2002; Corntassel, 2003). The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) also doesn't define 'Indigenous' peoples, rather leaves it for nation-states to set criteria and make decisions about who has rights as an Indigenous person or community (Champagne, 2013). The International Labor Organization Convention No. 169 (1989) used the following definition of Indigenous peoples: "peoples in independent countries who are regarded as Indigenous on account of their descent from the populations which inhabited the country, or a geographical region to which the country belongs, at the time of conquest or colonisation or the establishment of present state boundaries and who, irrespective of their legal status, retain some or all of their own social, economic, cultural and political institutions". A number of other terms are also used to describe Indigenous Peoples, for example, Australia accepts the term 'Aboriginal and Torres Strait Islander', 'First Nations' are used in Canada for Metis and in the United States of America Indian and Inuit are terms used to describe Indigenous populations (Cunningham & Stanley, 2003).

It is generally acknowledged that Indigenous peoples are the first people to have inhabited a region and tend to have deep connections to the surrounding landscape and have since developed complex interrelationships between local environments and their identity, kinship, social organization, governance and economy (Wohling, 2009, Stevens, 1997). Indigenous peoples' natural resource utilisation and management techniques draw on their intimate knowledge of surrounding ecosystems and environmental phenomena (Stevens, 1997, Berkes et al., 2000). From an international perspective, The Brundtland Report recognized the importance of Indigenous traditional knowledge in modern times, stating that: *"these communities (Indigenous) are repositories of traditional knowledge... (larger society) can learn a great deal from their traditional skills in sustainably managing very complex ecological systems"* (Brundtland, 1987).

To recognize Indigenous peoples' rights to maintain and use their knowledge, cultural practice, and traditional practices, Article 31 of the UNDRIP stated: *"Indigenous peoples have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural*

expressions, as well as the manifestations of their sciences, technologies and cultures, including human and genetic resources, seeds, medicines, knowledge of the properties of fauna and flora, oral traditions, literatures, designs, sports and traditional games and visual and performing arts. They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions" (United Nations, 2011).

The UN called upon its members to take effective measures to recognize and safeguard the implementation of these rights. The Convention on Biological Diversity (CBD) echoed the UN declaration by recognizing Indigenous peoples' right to use biological resources and their role in conservation. Article 8(j) of the CBD stated that*: "Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of Indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices".*

In the era of anthropogenic environmental crises, the "Western" world has been gradually turning to recognize the values of Indigenous knowledge and sustainable use of natural resources. There is mounting evidence demonstrating that Indigenous knowledge has been proven beneficial to combat ecological issues, for example, in bushfire management (Yibarbuk et al., 2001), biodiversity conservation (Ens et al., 2016b, Gadgil et al., 1993), rare and threatened species conservation (Colding, 1998, Renwick et al., 2017) and climate change adaptation strategies (Green et al., 2010).

Archaeological evidence recently suggested that Indigenous peoples occupied what is now known as Australia for over 60,000 years (Roberts et al., 1994). At the time of European occupation, there were over 250 language groups spread across the continent (Thieberger & Mcconvell, 2006). After European settlement, many Indigenous groups experienced loss of culture and language due to restriction and suppression (Keen, 1988, McConvell & Thieberger, 2001). This resulted in a significant loss of Indigenous ecological knowledge that is often encoded in language, dance, song and stories. However, as a signatory of the CBD, Australia recognizes the rights of Indigenous peoples and aims to promote a balance between conservation and sustainable cultural practices of the Indigenous communities (Stevens, 1997). Following this commitment, Australia has developed Indigenous specific programs that promote Indigenous land, knowledge and people in the National Reserve System (NRS). This system includes

Indigenous Protected Areas (IPAs). IPAs are voluntary declarations of land by Traditional Owners to the National Reserve System under IUCN categories V and VI that promote biodiversity conservation, cultural and social benefits. In 2017, there were 75 dedicated IPAs in Australia covering more than 67 million hectares, forming 44.6% of the National Reserve System (Figure 1) (Australian Government, 2017). Complementing the IPA program, the Australian Government established the Working on Country program (Indigenous Rangers) which was established in 2007. In 2018, there were 118 Indigenous ranger groups and 831 full-time Indigenous rangers (Australian Government, 2018). This initiative employs Indigenous people and facilitates further economic benefits through management of land, sea and culture in combination with traditional knowledge. In line with these initiatives, documentation of Indigenous knowledge has become increasingly important to record traditional knowledge and practices and bring them into contemporary natural and cultural resource management.

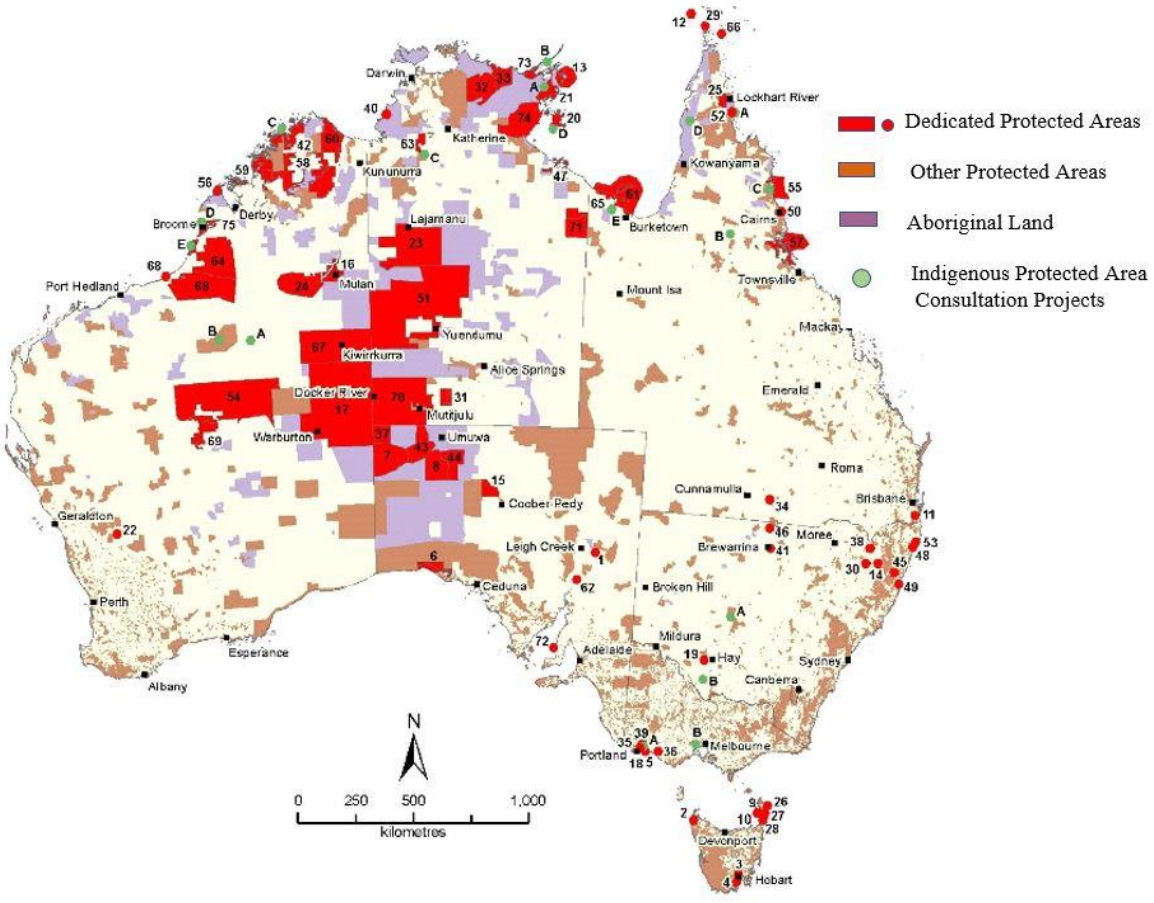


Figure1. Australian Indigenous Protected Areas, Aboriginal Lands and other Reserve areas, 2017. Source: Commonwealth of Australia, Department of the Prime Minster and Cabinet (2018).

1.2 Bridging the gap between Indigenous Ecological Knowledge and Western Science

There is a vast body of literature that compared between the similarities and differences between Indigenous Ecological Knowledge and Western science and identify ways to deploy both knowledge systems together (Mazzocchi, 2006). Indigenous Ecological Knowledge (IEK), also sometimes referred to as local, traditional or folk knowledge, is the information that people of a given community have developed over time through experience and adaptation to local ecosystems and has shaped and been shaped by cultural practices and beliefs (Davies, 2007, Bala & Gheverghese Joseph, 2007). IEK is equipped with tools for long-term sustainability and resource conservation and is passed onto young generations (Menzies, 2006, Davies, 2007). Therefore, IEK is often regarded as sustainable (Berkes et al., 2000, Berkes, 1999) and in the modern context, is increasingly used to inspire resource management (Martin et al., 2010). IEK is often orally transferred to young generations by the Elders. In present times due to socio-political changes, globalisation and commodification, Indigenous knowledge transmission pathways have been disrupted in many parts of the world, including Australia (Davies, 2007, Singh et al., 2010). Additionally, Indigenous cultures have experienced suppression and been refrained from practice which has hampered the smooth knowledge transmission and resulted in knowledge gaps (Patterson & Hunt, 2012). Therefore, there is a growing need and interest in the use of IEK in ecological research (Berkes, 1999, Johnson et al., 2016, Zurba & Berkes, 2014). Following the UN Declaration of the Rights of Indigenous Peoples, Indigenous peoples are increasingly playing active roles in every layer of ecological research, including planning, decision-making and governance (Hill et al., 2012).

On the other hand, Western science tends to favour analytical and reductionist methods and separate observations into different disciplines (Iaccarino, 2003). Western science is objective and quantitative and based on an academic and literate transmission (Mazzocchi, 2006). Western methods are often criticized as not being open to methods derived from different knowledge systems, e.g. sacred knowledge (Berkes, 1999). Western science tends to be more analytical and builds on general explanations that result in insights to be used for problem-solving in different contexts yet are often separated from the daily lives of people. Western science considers ‘separation’ and the notion of reductionism as a basis for understanding nature, whereas, Indigenous knowledge is developed through the strong connection with all aspects of nature, both physical and spiritual (Muller, 2012). For instances, in case of climate change, Berkes (2009) mentioned that Western Science use statistics to describe climate change whereas Indigenous Knowledge tends to build a knowledge base of climate change as they develop sensitivity towards the critical signs and signals of unusual changes in nature.

Increasingly, Western science is returning to ideas of sustainability which explore wisdom from human-nature interactions, such as from Indigenous cultures (Johnson et al., 2016). For example, local knowledge has been used in combination with Geographic Information Systems (GIS) to map dugong population, habitat suitability and risks in Malaysia (Hashim et al., 2017) and to assess distribution of marine mammals (dugong and dolphins) in the remote Yanyuwa sea country of the southwest Gulf of Carpentaria (Grech et al., 2014). McGregor et.al. (2010) used the Bayesian Belief Network method and remote sensing technology in combination with Indigenous fire management of wetlands in Kakadu National Park to manage and monitor culturally and naturally important resources. In the Northern Territory of Australia, Ens (2012) and Ens et. al. (2010) combined Indigenous knowledge with Western Science technology to monitor feral buffalo activities for buffalo control and management (Ens, 2012, Ens et al., 2012). Similarly, Sloane (2017) conducted an eco-cultural investigation on *Melaleuca* dieback in collaboration with Yolngu Traditional owners and found that feral animals are creating erosion and trampling the ground which is facilitating salinity intrusion and resulting *Melaleuca sp.* decline (Sloane, 2017, Saintilan et al., 2018).

1.3 Ethics of working with Indigenous People

Given the amplified effort to include IEK in various scientific actions and efforts, protocols and guidelines have been developed to ensure benefit to Indigenous communities and to facilitate ethical engagement (Holcombe, 2009, AIATSIS, 2012).

The Australian Institute of Aboriginal and Torres Strait Islanders Studies (AIATSIS) has set up 14 Principles of ethical guidelines for Australian Indigenous studies to promote Indigenous rights to full and fair participation in research and promote their right to control their culture and heritage (AIATSIS, 2012). Principle 1 states recognition of the diversity and uniqueness of peoples, as well as of individuals, is essential. This research recognised the diversity within the Indigenous communities living in Ngukurr and Numbulwar of SEAL IPA as stated in Principle 1. Principle 2 mentions that the rights of Indigenous peoples to self-determination must be recognized. In accordance to Principle 2 the research complied with the rights of Indigenous peoples to self-determination. Principle 3 advocates the rights of Indigenous peoples to their intangible heritage recognition. Principle 4 and 5 noted that rights in the traditional knowledge and traditional cultural expressions of Indigenous peoples and Indigenous knowledge, practices and innovations must be respected, protected and maintained. The research acknowledged that

Indigenous peoples are rightful owners of the traditional knowledge and cultural heritage. Principle 6, 7, 8 and 9 emphasis on the consultation and negotiation with the Indigenous communities prior to any activity should be in pen and paper with a focus to achieve mutual understanding. Principle 10 and11 stress on the Indigenous peoples right to participate in any research project in accordance to their skills and experience and on the benefit. Principle 12, and 13 emphasis on the research outcomes that should serve the need and interest of the Indigenous communities and ensures Indigenous people's access to the research results. Principle 14 ensures that the research projects comply with the AIATSIS guidelines.

Ethics is explicitly part of the traditional approach, as relationships are based on reciprocity and obligations towards community members (Mazzocchi, 2006). Indigenous kinship guides how and why certain Traditional Knowledge Custodians (TKCs) want to work or cannot work with others (Moorcroft et al., 2012). Ethical guidelines for working with Indigenous people also note that not all Indigenous people are equally knowledgeable and not everyone wants to document their knowledge. Some knowledge is also sacred and thereby restricted and cannot be documented (Patterson & Hunt, 2012).

1.4 Freshwater turtles' status and ecology

Turtles (class Reptilia) are one of the most ancient tetrapod vertebrates. Globally more than 317 freshwater turtle species are recognized (Buhlmann et al., 2009) by the IUCN. Freshwater turtles' typical habitat includes large rivers, lakes, estuaries, swamps, marshes, bogs, occasionally brackish waters, while some species are nearly terrestrial, although require a very damp environment (Bour, 2008). Freshwater turtles are very sensitive to habitat alteration (Bour, 2008) and are therefore one of the most threatened vertebrates with 10% of species listed as critically endangered worldwide (Buhlmann et al., 2009). Harvesting and unregulated pet trade along with habitat degradation and habitat loss are the prime reasons for the sharp decline of the freshwater turtle globally (Turtle Conservation Fund, 2002). Due to this, about 60% of global freshwater turtle species are threatened (IUCN, 2006). Changes in the freshwater ecosystems along with climate change have resulted in severe and prolonged drought in many places which have also contributed to habitat loss for freshwater turtles (Roe et al., 2009). Dry periods can also impact freshwater turtle habitats, diet, nesting and aestivation (Chessman, 2011).

Twenty-five freshwater turtle species have been described in Australia, though their taxonomy remains understudied (Wilson & Swan, 2013, Joyce et al., 2004). There are significant knowledge gaps surrounding the occurrence of freshwater turtles in tropical northern Australia especially in Indigenous

Protected Areas (Cann & Sadlier, 2017). According to the Atlas of Living Australia (2018) only two species have been recorded in the SEAL IPA: The Northern Long-neck Turtle (*Chelodina oblonga;* 2 records) and the Stinky Turtle (*Chelodina canni;* 2 records) (Figure2).

Previous research has shown that freshwater turtles can live in stagnant, permanent water bodies as well as temporary water (Bour, 2008, Buhlmann et al., 2009, Turtle Conservation Fund, 2002). Some species also bury themselves in mud and aestivate during dry periods. The literature suggests that within the Northern Territory about five species have been recorded to date, although there is some taxonomical debate (Cann & Sadlier, 2017). The species so far recorded in the South East Arnhem Land Indigenous Protected Area (SEAL IPA) have experienced nomenclatural changes. For example, the Northern Long-neck Turtle (*Chelodina oblonga*) was previously known as *Chelodina rugosa* (Kennett et al., 2014). This species' preferred habitat includes floodplains, swamps, watercourses and rivers (Kennett et al., 2014). The color of the carapace is dark brown to black and is egg-shaped in hatchlings and oval in adults. The plastron is narrower than the carapace and white or yellowish in colour. The Short-neck Turtle (*Emydura worrelli*) is synonymous to *Emydura subglosa* based on molecular similarity (Iverson et al., 2001). Cann's Long-neck Turtle (*Chelodina canni*), previously known as *Chelodina novaeguineae*, has a very distinct large and strong rounded head with a broader maxillary and wider mandibular surface easily distinguished from *Chelodina steindachneri* and *Chelodina longicolis* (McCord & Thomson, 2002). The anterior edge of the plastron is rounded and extends to the inner edge of the marginal shields. This species is popularly known to Aboriginal people as 'Stinking Turtle' or "Stinky Turtle" due to the distinct pungent odour produced during handling (McCord & Thomson, 2002).

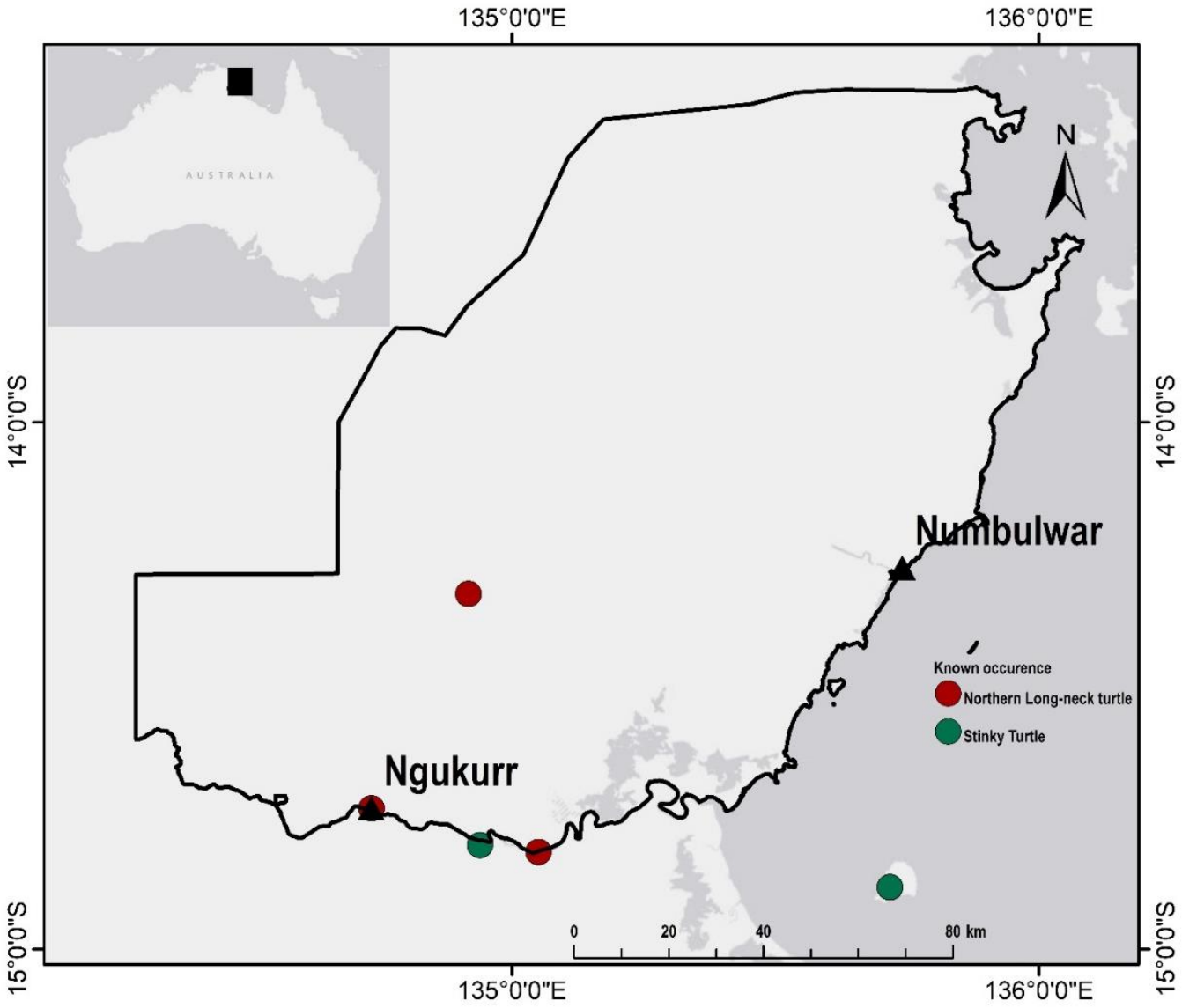


Figure 2. Previous records of freshwater turtles in the SEAL IPA according to the Atlas of Living Australia (accessed 19/02/2018).

1.5 Indigenous culture and freshwater turtles

Freshwater turtles play a very significant role in Indigenous people's life as food, in ceremony and other cultural expressions. Indigenous people use diverse ways and methods to hunt turtles including on fishing lines baited with meat, fish or cashew nuts (Georges et al., 2006), and during the dry season with a steel-bladed arrow or a bush-knife to hunt aestivating turtles (Georges et al., 2006, Fordham et al., 2006). In the nearby Daly River catchment area, the Long-neck Turtle makes up 19% of the diet of Indigenous people and is also shared extensively within the communities (Jackson et al., 2012). Naughton et. al.

(1986) found that the liver, fat and eggs of the Long-neck Turtle provide Indigenous people with important dietary elements of fat and protein which accounted for 17% of the total energy intake.

Indigenous people also have cultural ties with freshwater turtles as totems and through ceremonies (Davies et al., 2010). A totem is defined as an animal as ruler (whether edible and harmless or dangerous and feared) and more rarely a plant or a natural phenomenon (such as rain or water), which stand in a peculiar relation to the whole clan (Freud, 2013). Freud (2013) further mentioned that a totem can be a guardian spirit or helper for an Indigenous group. In Northern Australia, totems in Aboriginal groups such as the Larakia, Worgait and Wul-wullum, descend in the paternal line, while the Waduman, Mudburra, Ngainman and Bulinara groups totemic group descends in the maternal line (Spencer, 2010). As Freud (2013) mentioned, Indigenous peoples often celebrate the motions and attributes of their totems in ceremonial dances.

1.6 Potential threats to freshwater turtles

In northern Australia, known threats to freshwater turtles includes feral animals' such as: pigs (*Sus scrofa*), Asian water buffalo (*Bubalus bubalis*), cattle (*Bos taurus*), donkey (*Equus asinus)*, horse (*Equus caballus*), cane toads (*Rhinella marinus*) and anthropogenic climate change (Cann & Sadlier, 2017, TSSC, 2005, Fordham et al., 2006).

(a) (b)

Figure 3: A number of Asian water buffalo were observed within the SEAL IPA. Figure (a) and (b) are showing water buffalo damaging the road and a shallow water hole respectively.

Asian water buffalo was introduced to northern Australia about 200 years ago (between 1826 and 1866) (Ridpath & Waithman, 1988) and has since occupied most of the floodplains of Northern Territory (Petty

& Werner, 2010). Asian water buffalo damage soil and ground vegetation by trampling (Werner, 2005). Trampling impacts aestivating Long-neck Turtles by direct killing and/ exposing the turtles to the heat. Feral pig invasion is also threatening freshwater turtles. Pig gut analysis has confirmed that both male and female pigs extensively prey on aestivating Long-neck Turtles (previously known as *C. rugosa*) specifically during the dry season when the billabongs have dried up (Fordham et al., 2006).

Cane Toad toxin is also considered a threat to freshwater turtles, specifically Northern Long-neck Turtle and Snapping Turtle in the south of Darwin (McArthur & Young, 2005). This species was introduced to Australia 83 years ago (in 1935) to control insect pests in sugar-cane fields in Queensland and over this period has expanded its range to the Northern Territory (Easteal et al., 1985) (Figure 20).

Research on Cane Toad impacts on ecosystems and native species showed that the Cane Toad has three primary impacts: predation on native species, competition with native species and poisoning native species (Shine, 2010). The Cane Toad is a vivid predator, its diet includes about 200 species, mainly arthropods (ant, termite, beetle) and has been linked to the decline of many invertebrate taxa (Greenlees et al., 2006). The Cane Toad has also been linked to population declines in reptiles such as the freshwater crocodile (*Crocodylus johnstoni*) (Letnic et al., 2008), several species of snakes (Phillips et al., 2003), lizards such as spotted goannas (*Varanus panoptes*) and water monitors (*Varanus mertensi*) (Shine, 2010), as well as freshwater turtles, especially Northern Long-neck Turtle (Greenlees & Shine, 2011, Covacevich & Archer, 1975, Boll, 2006).

Wetland drying due to climate change was suggested by Chessman (2011) as a potential threat to other freshwater turtle species, *Chelodina longicollis* and *Emydura macquarii,* impacting on feeding, nesting and dormancy behaviour. During the dry period freshwater turtles aestivate but prolonged dry periods of up to nine months may result in death from starvation and or dehydration (Roe & Georges, 2008). On the contrary, turtles living in suburban areas subject to regular water availability remain relatively active throughout the year (Rees et al., 2009, Roe et al., 2011). Aestivation and migration to permanent waters during long dry periods may also expose the freshwater turtles to predation by terrestrial carnivores (Chessman, 2011). A Long-neck Turtle study in the Murray-Darling basin showed low stomach content due to suitable food scarcity (Chessman, 2011). Salt water intrusion can be another important threat to the freshwater turtles as the sea level in the Gulf of Carpentaria is rising, about 10-11mm year1 since 1993 (White et.al., 2014). Previous studies have also showed that buffalo presence in Northern Territory can create swim channels that drive saltwater intrusion into freshwater billabongs and floodplains

(Bowman et. al. 2010, Skeat et. al., 1996, Fogarty 1982, Stocker, 1970) which could further threaten floodplain turtle populations.

1.7 Research questions and aims

Knowledge of freshwater turtles across northern tropical Australia is scarce. Research on freshwater turtles in the Northern Territory include feral animals' impact on Long-neck Turtle (Fordham et al., 2006); demographic response of Long-neck Turtle to pig predation and traditional harvesting (Fordham et al., 2007) and a new species *Elseya flaviventralis* discovery the Mary, South Alligator, East Alligator, Goyder and Mann river drainages of the north east of the Northern Territory (Thomson & Georges, 2016). In south east Arnhem Land, local Indigenous people have expressed concern for freshwater turtle populations due to the invasion of feral ungulates and climate change. Freshwater turtles are a favored food source for people of this area and therefore, they are expected to have valuable knowledge on turtle species distribution, habitat and threats. Therefore, a participatory research project was discussed with local people that would benefit both local and broader understanding of the population health of freshwater turtles in northern Australia. The primary focus of this research was therefore to work with communities living in the SEAL IPA to document freshwater turtle's occurrence, possible threats and cultural significance. Therefore, this thesis sought answers to the following research questions from Indigenous people in the SEAL IPA:

1. Where have you caught freshwater turtles? (what is the known distribution)
2. What habitat do freshwater turtles prefer?
3. Are there any threats to freshwater turtles?
4. Are freshwater turtles culturally important?

2. Methods

2.1 Study sites

The SEAL IPA is located in the south-western edge of the Gulf of Carpentaria in the Northern Territory (Figure 4). It encompasses large parts of the Central Arnhem, Arnhem Coast, Gulf Coast and Gulf Fall and uplands bioregions (Gambold 2015). The IPA is about 19,170km^2 and overlaps with the Laynhapuy IPA (341.16 km^2). The SEAL IPA boundary expands from the Walker River in the north to the Roper River in the south and includes the Wilton, Rose and Phelp River catchments (Figure 4). The Wongalara Conservation Reserve lies to the west. The IPA accommodates the traditional estates of the *Ngalakgan, Ngandi, Yugul, Wandarrang, Nunggubuyu* and *Ritharrngu* language groups (Daniels et al., 2012). The SEAL IPA was declared as a dedicated IPA under IUCN Category VI in 2016.

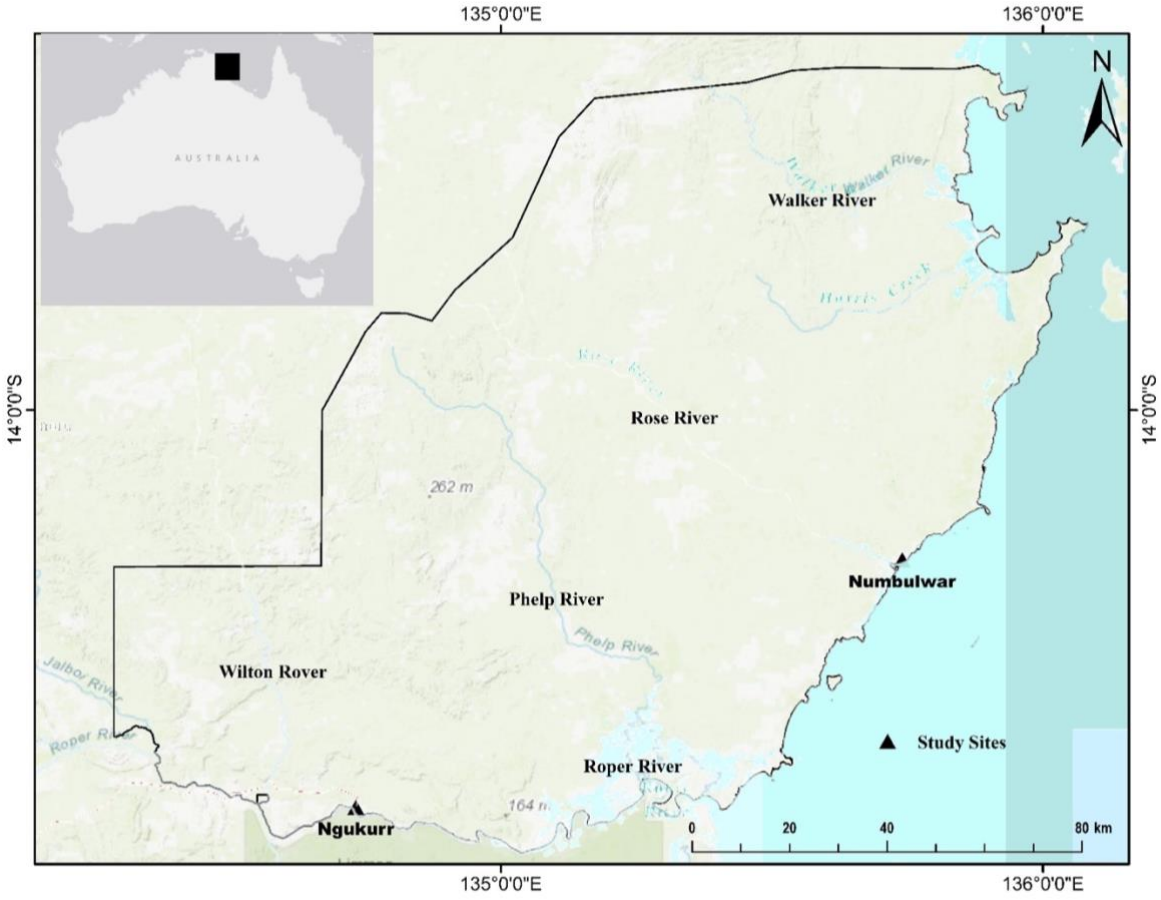


Figure 4. Map of the SEAL Indigenous Protected Area showing the two main Indigenous communities of Ngukurr and Numbulwar where this study was conducted.

The total population of Ngukurr community is 1,077 (89.9% Aboriginal and both non-Aboriginal 10.1%) of which the male and female ratio is 51:49 with a median age of 21 (Australian Bureau of Statistics,

2016a). The Numbulwar community has a population of 686 (95.9% Aboriginal and both non-Aboriginal 4.1%) and the male and female ratio is 47:52 with a median age of 26 (Australian Bureau of Statistics, 2016b). In Ngukurr, the most populous age group is 5-14 years (253; 23.4%) (Figure 5). On the other hand, in Numbulwar, the most populous age group is the 25-34 years group (141; 20.6%) (Figure 5). The number of elderly people aged 65+ is 21 (1.9%) in Ngukurr and 29 (4.2%) in Numbulwar. According to the Australian Bureau of Statistics 2016 census, Indigenous people in Ngukurr mainly speak Kriol (77.8%). Kriol is also the highest spoken language in Numbulwar (42%) followed by Nunggubuyu (34.8%), Anindilyakwa (10.4%) and Wagilak (2.6%). Again, according to the Australian Bureau of Statistics Census (2016), in Ngukurr, 11.5% of the total population is employed full time, 24.8% part-time and 33.5% are unemployed. In comparison to Ngukurr, 30% of the total population in Numbulwar are working full-time, 34.7% are part-time workers, 28% are unemployed. In Ngukurr, the most common occupation were professionals (21.6%) followed by Community and Personal Service Workers (18.2%), and Labourers (12.2%). Unlike Ngukurr, the top-rated occupations in Numbulwar are Community and Personal Service Workers (23.9%), Professionals (22.7%) clerical and Administrative Workers (11.4%) and Labourers (9.1). According to the Australian Bureau of Statistics Census (2016), the most common industries of employment for these two study sites are Local Government Administration, Supermarket and Grocery shops, combined primary and secondary education, and primary education.

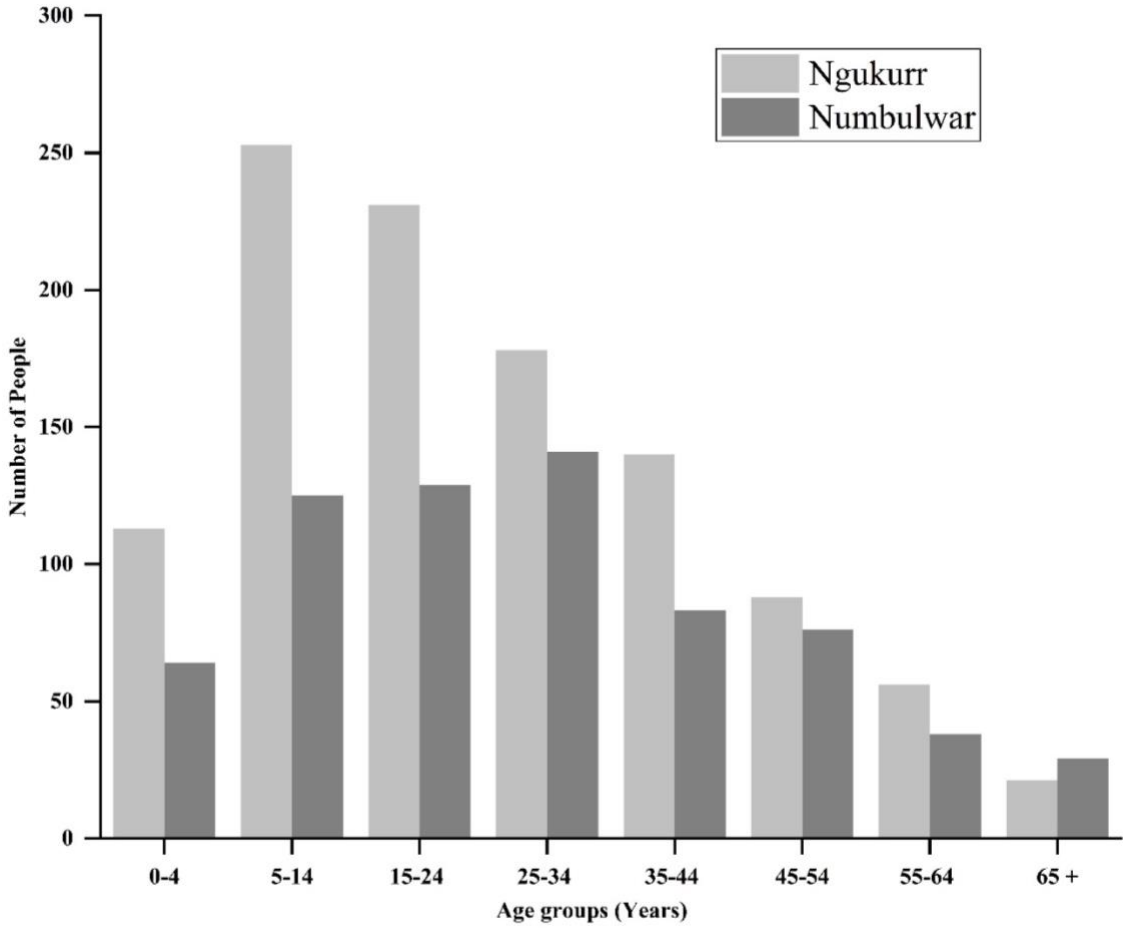
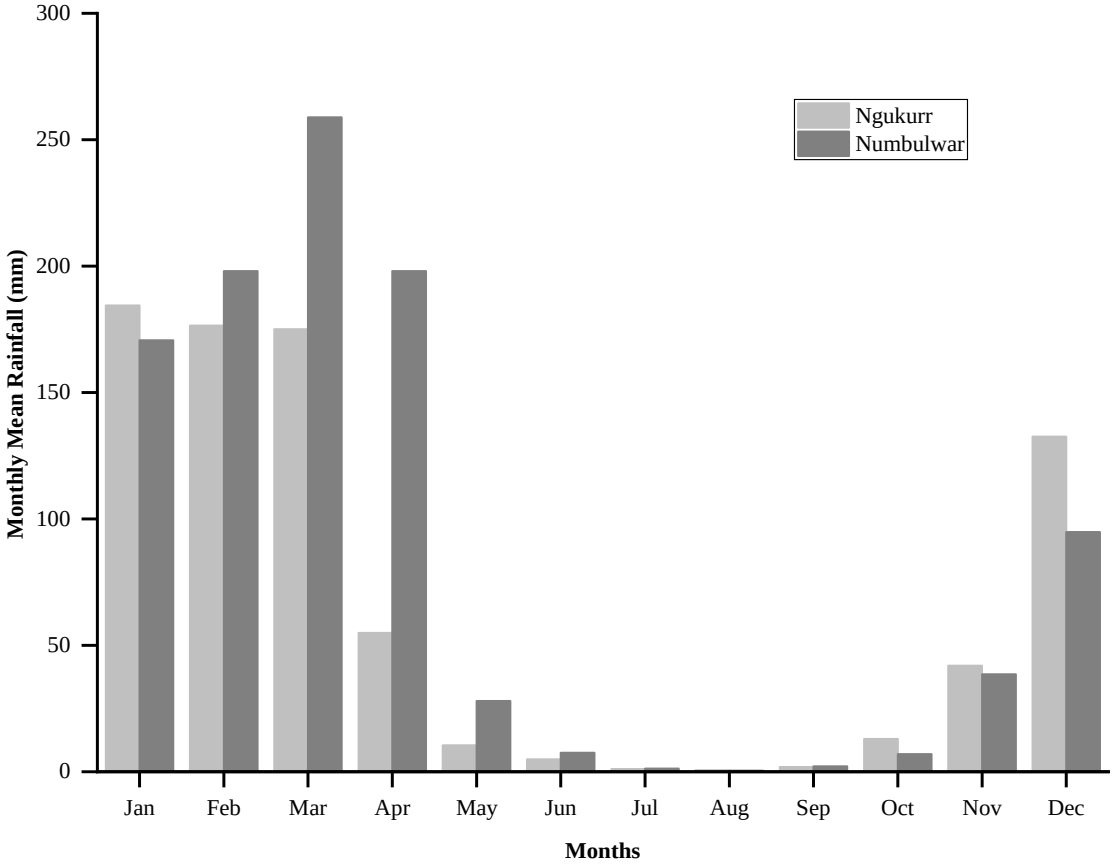
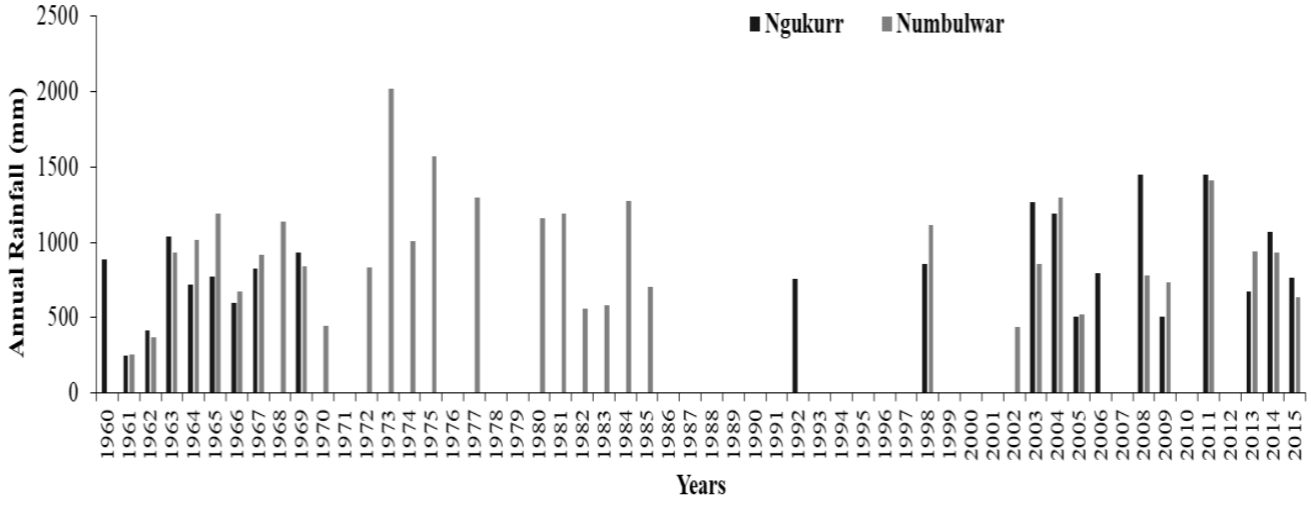


Figure 5. Human population demographics of Ngukurr and Numbulwar. Data Source: Australian Census, Australian Bureau of Statistics, 2016.

Like the rest of northern Australia, the SEAL IPA experiences heavy rainfall during the wet season, with average mean annual rainfall of 774.3mm (BOM, 2018). Rainfall data from 1960-2015 collected from Ngukurr and Numbulwar weather stations showed that the wet season generally occurs from November to April and the dry season occurs from June to September (Fig. 6a). Figure 6 (b) shows variation in annual rainfall between 1960 and 2015 for Ngukurr and Numbulwar. The annual mean maximum temperature for Ngukurr was 41.2°C (in November) and the mean minimum was 12.6°C (in August) (Fig.7).



(a)



(b)

Figure 6. Monthly mean rainfall (mm) in Ngukurr and Numbulwar from 1960-2015 (a) and long-term annual rainfall between 1960 and 2015 (b). Data source: The Australian Bureau of Meteorology (2018).

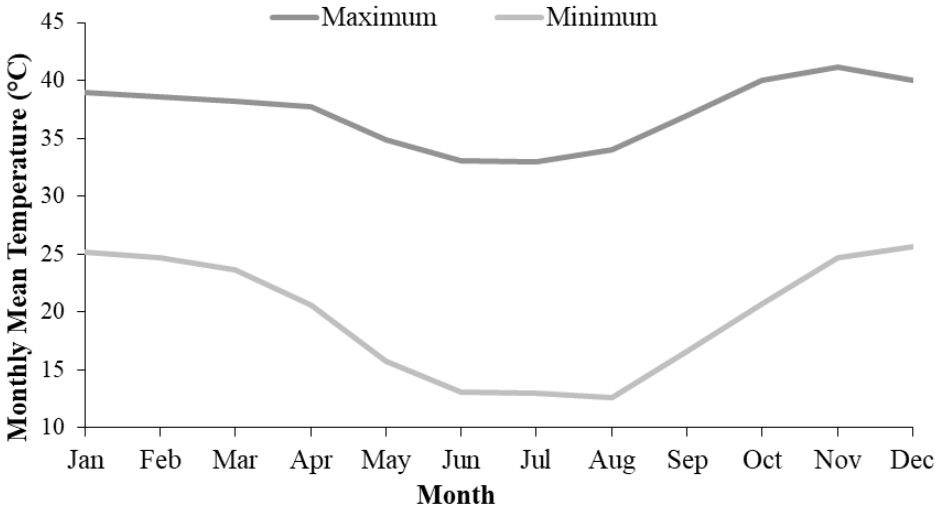


Figure. 7. Monthly mean maximum and minimum (°C) temperature at Ngukurr Airport between 2012 and 2017. (Data source: The Australian Bureau of Meteorology, 2018).

2.2 Field data collection

Best practice research with Indigenous People requires the use of ethical and mutually beneficial methods that serve the interest of both the researchers and communities. Before designing methodology for this research, we considered the cultural context where the interactions would take place (Briggs, 1986) and ethical principles of research following Macquarie University and AIATSIS regulations (AIATSIS, 2012). We used semi-structured interviews and collaborative knowledge mapping workshops to collect data. Mapping workshops have been described as particularly beneficial to encourage memory recall of the participants to locate sites of interests (Grech et al., 2014). The interviews were both audio-recorded and video-recorded in addition to taking paper notes.

The grounded theory method was applied for the data collection. In grounded theory, data collection involves interviews, observations and other sources such as documents, audio and video clips that may be relevant to the research questions (Corbin & Strauss, 1990). Data for this project was drawn from two sources: 1) preliminary data from Ngukurr community (collected by Macquarie University student Shaina Russell in 2016); and 2) data from Numbulwar community (collected by the author in 2018). The author also re-interviewed some people from Ngukurr and checked similarities and differences with the recording of Shaina Russell to check and align questioning, especially for the cultural information. Ngukurr and Numbulwar are the main communities in the SEAL IPA and they were selected purposively for the survey. During the month of June-July in 2016 about five (5) weeks were spent by Shaina Russell

in Ngukurr to collect data. In 2018 about three weeks were spent in both Ngukurr (1 week) and Numbulwar (2 weeks) by me, Rukshana Sultana.

2.3 Mapping workshop

A series of mapping workshops were conducted with the TKC's of Ngukurr and Numbulwar and members of the Ngukurr Yangbala (young people) Ranger group. The young people from Ngukurr were involved in all interviews to facilitate the intergenerational transmission of Indigenous knowledge from Elders and assist with interpretation. The workshops were often conducted in groups (see groupings in Results section).

The purpose of the mapping workshop was to document freshwater turtle occurrence within the SEAL IPA. The participants were asked to locate the places they usually go to hunt for turtles. Additionally, TKCs were asked to identify locations on an A0 size laminated, topographic map. They were asked to place stickers at places where they recall catching freshwater turtles either in water bodies or those that were aestivating in the mud. Three different colour stickers were used for the three different freshwater turtle species expected to occur in the region. Red, blue and yellow stickers were used for Northern Long-neck Turtle, Stinky Turtle and Short-neck Turtle, respectively. The knowledge holders were asked to put the stickers on the location where they had caught the freshwater turtle species. The researcher geocoded the locations of these stickers and uploaded the data to ArcMap version 10.5 (ESRI Inc.). Geocoding in ArcMap was done by uploading images of the laminated topographic map (with the stickers) and creating raster files for each mapping workshop, followed by creation of a feature class using the 'data management tool'. The Field Calculator was used to identify Latitude (X) and Longitude (Y) for each dot point on the images. As a final step, the projected coordinated system was transformed into Geographic Coordinate System Geocentric Datum of Australia (GDA) 1994. In total, 30 mapping workshops were conducted in Ngukurr by Shaina Russell; 3 were cross-checked by me. In Numbulwar, a total of 14 mapping workshops were conducted by me – all in collaboration with the Ngukurr Yangbala Rangers (Figure 8).

Figure 8. Illustration of typical setting of mapping workshop in Ngukurr and Numbulwar. The TKCs are putting colour-coded sticker on a hard copy map to record their freshwater turtle harvesting sites.

2.4 Semi-structured interviews

Semi-structured interviews are suitable to explore the attitudes, values, beliefs and motives of the respondents (Barriball & While, 1994). Another merit of using the semi-structured interview method is that it offers flexibility to collect a wide range of information to facilitate more nuanced understanding than a structured questionnaire. The language barrier between researcher and interviewees was an important consideration when planning and conducting semi-structured interviews in this project because the respondents mainly use English as a second language. Local translators, who were members of the Ngukurr Yangbala Project, were paid to be involved in this project. Careful choice of words ensured that valid and reliable data was obtained from the interviewees (Barriball & While, 1994). My Masters supervisor, Dr. Emilie Ens, assisted to form a team of young collaborators and translators from the Ngukurr Yangbala Team. There are many benefits of using a co-research team from the community. Firstly, knowledge transfer: while the Elders were answering questions on the freshwater turtles hunting grounds, hunting process, threats and the cultural association with the freshwater turtles, the young people listened to their stories which a direct transfer of knowledge was. Secondly, the team learnt about research and interview methods through experiential "learning by doing", the semi-structured interviews and mapping workshops. Thirdly, they gained experience in documentation methods, like video and audio, as they were responsible for documentation of the interviews. They were trained in use of audio and video recording prior conducting interviews. The Yangbala team also worked as interpreters by translating the questions and answers that allowed for more accurate documentation. The output of the research has been shared with the communities for their knowledge and IPA management planning.

Elders are generally regarded as having the most ecological and cultural knowledge (Horstman & Wightman, 2001). The snowball method (Atkinson & Flint, 2001) was used with the Yangbala team and local Indigenous IPA Rangers to identify the most knowledgeable people in each community. By this approach, we were able to identify well-known knowledge holders and they were then asked who else had strong knowledge on the research topics and should also be interviewed.

TKCs generally requested to be interviewed in groups. Therefore, data were analyzed as "TKC group data", and if individuals were interviewed independently, they were also considered a "group" for the analysis.

To document local Indigenous knowledge of freshwater turtle habitat, threats and cultural knowledge, the following semi-structured questions were asked:

Identifier questions:

1. What is your name?
2. How old are you?
3. What is your language group?

Questions on threat:

4. Do you know of any threats to freshwater turtles?
5. Do you know if feral ungulates (e.g. Asian water buffalo, pig, bullocky, horse) are threatening turtles?
6. Do you think climate change is threatening turtle populations?

Questions on personal and cultural associations with freshwater turtles:

1. Do you have any relationship with freshwater turtles?
2. Are there any dreaming stories associated with the freshwater turtles?
3. Are there any ceremonies ties to freshwater turtles?
4. Is there any artwork of freshwater turtles?
5. Do you know any songs about freshwater turtles?
6. Do you know any songlines of freshwater turtles?
7. Do you know any dances that include freshwater turtles?

Interview data were documented through video, audio recording and photos (in line with Macquarie University Human Research Ethics- approval, reference number 5201800178). During the interview, the interviewer was cautious not to lead the conversation to a potential answer but make sure that the research

question was fully understood by the interviewee through the local interpreters who had translated the questions in Kriol. The researchers paid proper respect to the TKCs when they expressed their concern regarding sacred information not to be shared with the research team.

2.5 Data analysis

2.5.1 Mapping workshop

To digitize the coloured sticker locations of freshwater turtles, control points were located on the map from the survey and their corresponding point on an ArcMap base map: the Roper River, the coastline boundary and road from Ngukurr to Numbulwar as other well-defined objects in the images. The turtle locations were then digitised from the georeferenced images. A new shape file was created using the 'editing' tool. Image number, turtle species and location were recorded for each point. All the interviewee "group" map layers were later merged to create a single map layer to display all known freshwater turtle locations within the SEAL IPA.

Turtle distribution data was also mapped against elevation and hydrology data. A one second Shuttle Radar Topography Mission (SRTM) raster layer of a Digital Elevation Model (DEM) was rendered to display different elevations. The DEM was classified into categories by natural breaks (Jenks) to find adjacent feature pairs between which there was large difference in elevation. DEM data was sourced from the Elevation- Foundation Spatial Data website (http://elevation.fsdf.org.au/). In addition, surface hydrology layer data was imported into ArcMap. The relationships between turtle occurrence and DEM and hydrology types were visually inspected and qualitatively described.

The turtle occurrence data was also mapped against Major Vegetation Group (MVG) data. From the turtle occurrence data, the 'extract by points' tool in ArcGIS Spatial Analyst Toolbox was applied to extract values for the MVG associated with each turtle location. Vegetation data were analysed using SPSS (IBM) v.23 (2015) software. Chi-squared Independence tests (Pearson, 1900) were performed to examine the relationship between turtle's species and vegetation. This analysis was conducted to determine whether the turtles' species had an affinity to a particular vegetation type.

2.5.2 Semi-structured Interviews

A total of 30 TKC groups were interviewed by Shaina Russell at Ngukurr in 2016. During my field visit, I re-interviewed 3 TKC groups from Ngukurr to review the data and align my questioning. To achieve

this, I played the audio recording to the original interviewee groups and listened to their feedback. By doing this I was training myself (and they were training me) in the original interview methods and I became familiar with the way interviewees responded. I then applied the same interview techniques in Numbulwar, where I interviewed 14 TKC groups. Among these interviews six (6) were in groups and eight (8) were solo. I transcribed 18 interviews from south east Arnhem Land communities and Shaina transcribed 28. The interview timing varied from a minimum of 22 mins to a maximum of 93 mins. For the interview data analysis, NVivo 11 software was used (Gibbs, 2002). This semi-automated coding software boosts the researcher's interpretive capacity to analyze the qualitative interview data using a semi-quantitative method (Bazeley & Jackson, 2013). The data was manually coded according to the main questions of the questionnaire: freshwater turtle's distribution, habitat threats and cultural values. Furthermore, cultural significance data was broken into sub-codes: ceremonies, dreamings/Totems, songline, artwork and dance. NVivo is increasingly used in social science research to analyze Indigenous knowledge (Barber et al., 2014).

3. Results

3.1 Mapping workshop

A total of 74 Traditional Knowledge Custodians (TKC) were interviewed. The highest number of TKCs (49) were interviewed in Ngukurr (about 66% of the total interviewees) and 25 (about 34%) were interviewed in Numbulwar (Table 1). There were 38 male participants (51% of total) and 36 were female participants (49%). This research included people from 14 different language groups. All interviewees spoke Kriol, followed by Nunggubuyu (25), Ngandi (8), then Alawa, Warndarrang and Rittarrngu (all 6) speakers. The most interviewees (20; 40% of total) were in the age bracket 65+ years followed by seventeen (17) interviewees from age group 45 to 54 (Table 1). Thirteen interviewees were aged 55 to 64. The interviewees typically gave more than 'yes' or 'no' answers to questions. The older interviewees often elaborated on relevant topics while speaking to the young people from a "teachers" perspective, as is the cultural norm.

		Traditional Knowledge Custodians
	Total *n*	74
Gender	Male	38
	Female	36
Location	Ngukurr	49
	Numbulwar	25
Language Groups	Alawa	6
	Wagilak	5
	Nunggubuyu	25
	Marra	3
	Anandilyakwa	1
	Ngandi	8
	Rembarrnga	2
	Ngalakan	5
	Gupapuyngu	1
	Warndarrang	6
	Nunjurrpi	1
	Mangarrayi	2
	Rittharngu	6
Age Cohorts	15-24 years	7
	25-34 years	5
	35-44 years	12
	45-54 years	17
	55-64 years	13
	65 years and over	20

Table 1. Demographic profile of interviewees for semi-structured interviews and mapping workshops.

The TKC groups within the SEAL IPA identified three different freshwater turtle species that they have been harvesting as food and use for cultural purposes. These are the Northern Long-neck Turtle (*Chelodina oblonga*), Short-neck Turtle (*Emydura worrelli)* and Stinky Turtle (*Chelodina canni*). Figure 9 shows the number of total mentions of these three freshwater turtle species during the mapping workshops. The Northern Long-neck freshwater turtle was the most mentioned species (487 mentions) followed by Short-neck Turtle (253 mention) and Stinky Turtle (58) (Figure 9).

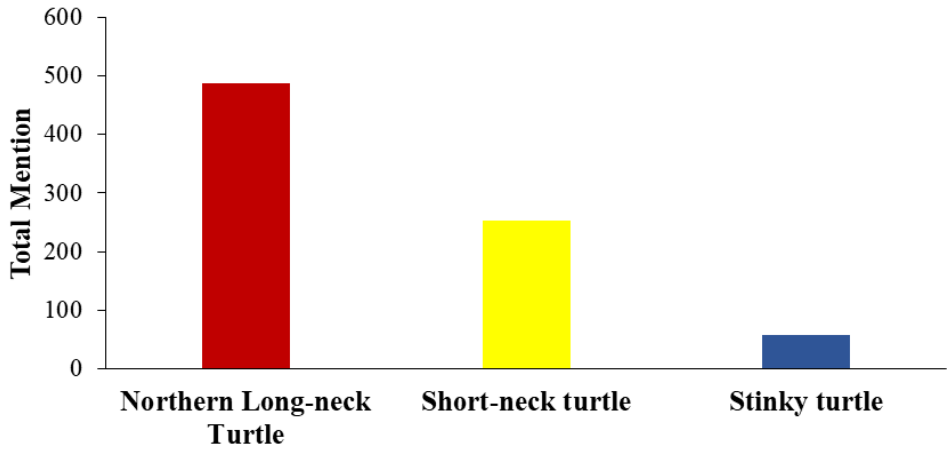
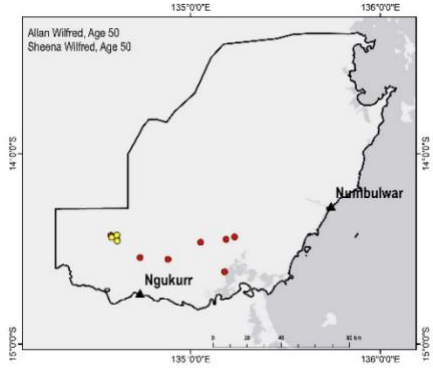


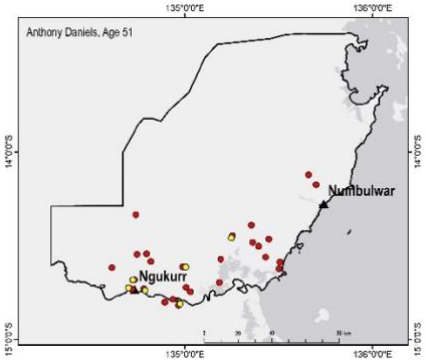
Figure 9. Frequency of mentions of the three freshwater turtle species occurring in the South East Arnhem Land Indigenous Protected Area by local TKCs.

The interviewee with the most knowledge of turtle locations was Walter Rogers, with 55 locations of turtles (Northern Long-neck-32, Short-neck-12 and Short-neck-11) (Figure 10). The second highest was Cherry Daniels with 43 locations (Northern Long-neck-31, Short-neck-12); followed by the Cara Rami, Davis Daniels, and Doreen Daniels group with a total mention of 42 turtle locations (Northern Long-neck-21, Short-neck-18 and Short-neck-2). Figure 10 details the turtle location knowledge of each TKC group.

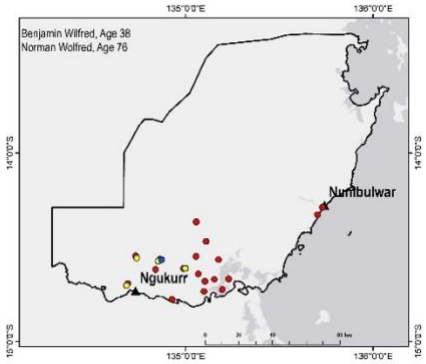
Allan Wilfred, Age 50
Sheena Wilfred, Age 50



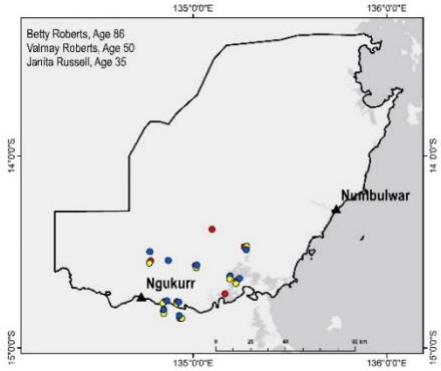
Anthony Daniels, Age 51



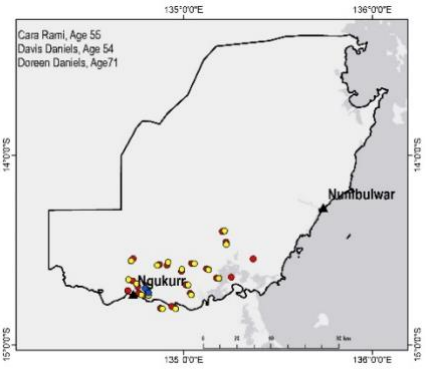
Benjamin Wilfred, Age 38
Norman Wilfred, Age 76



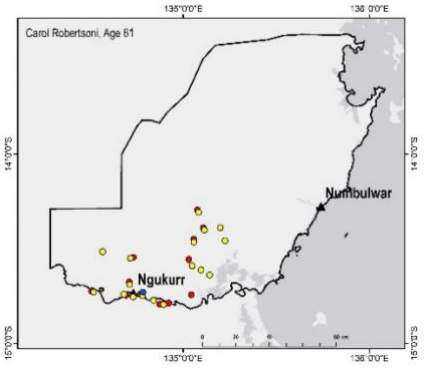
Betty Roberts, Age 86
Valmay Roberts, Age 50
Janita Russell, Age 35



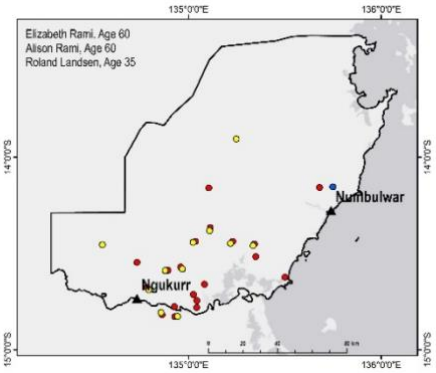
Cara Rami, Age 56
Davis Daniels, Age 54
Doreen Daniels, Age 71



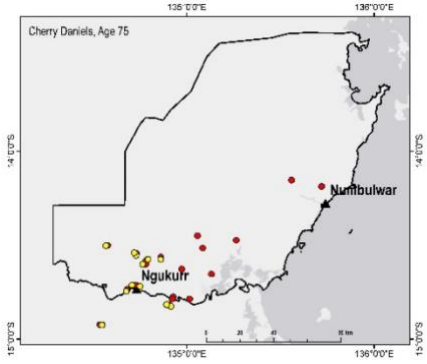
Carol Robertson, Age 61



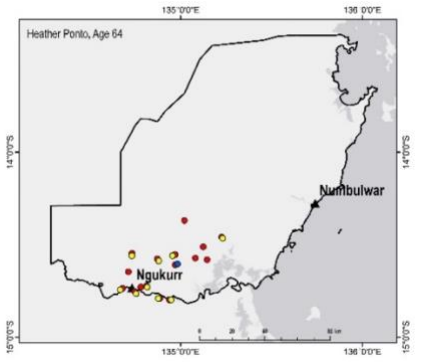
Elizabeth Rami, Age 60
Alison Rami, Age 60
Roland Landsen, Age 35



Cherry Daniels, Age 75



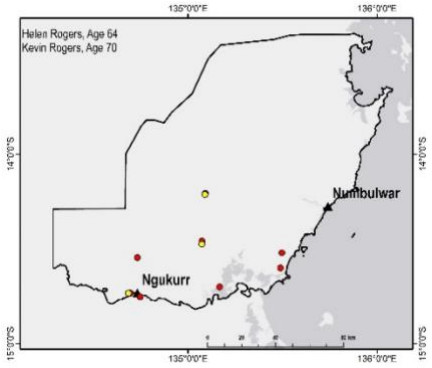
Heather Ponto, Age 64

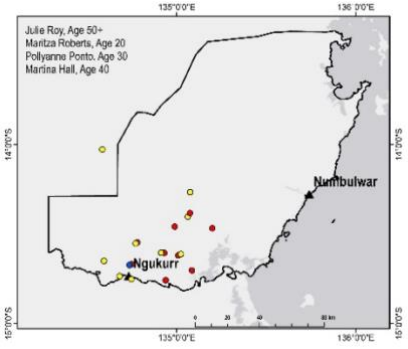


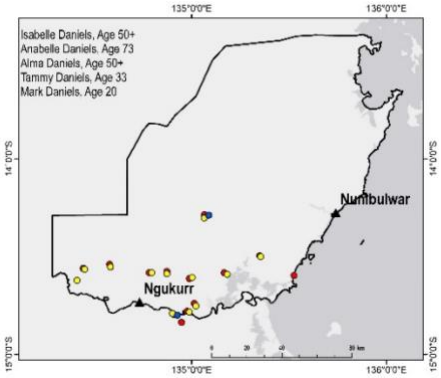
Julie Roy, Age 49
Maritza Roberts, Age 20
Pollyanne Ponto, Age 30
Martina Hall, Age 40

Anabelle Daniels, Age 73
Alma Daniels, Age 50+
Tammy Daniels, Age 33
Mark Daniels, Age 20
Isabelle Daniels, Age 50+

Helen Rogers, Age 64
Kevin Rogers, Age 70



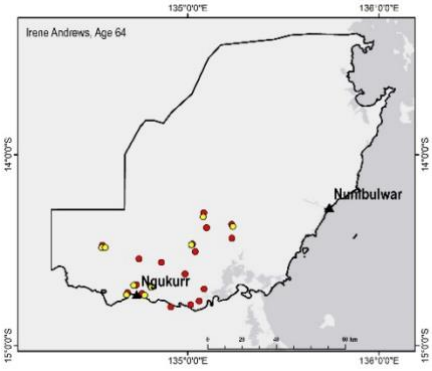


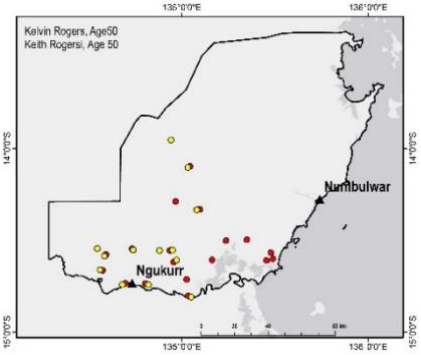


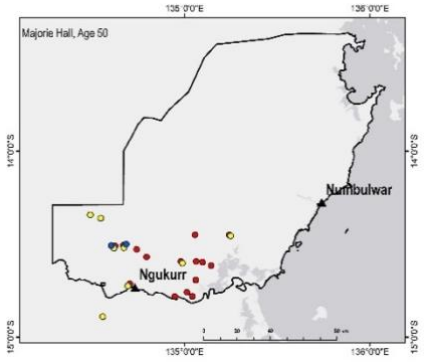
Irene Andrews, Age 64

Kelvin Rogers, Age 42
Keith Rogers, Age 58

Marjorie Hall, Age 50



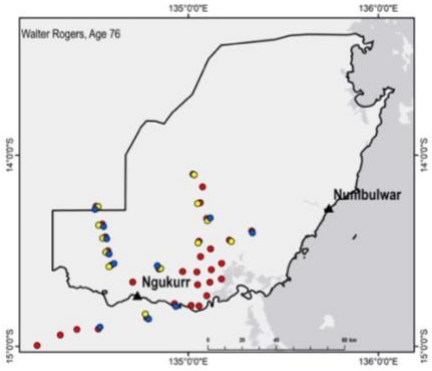


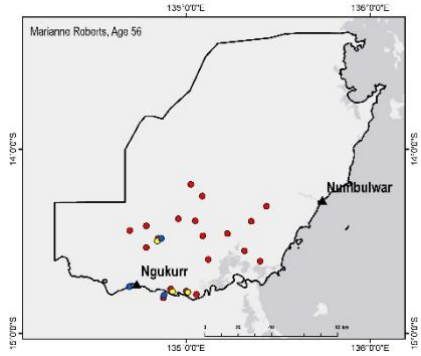


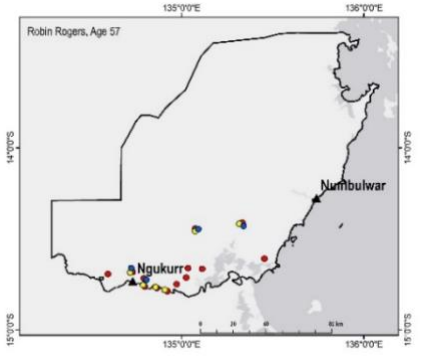
Walter Rogers, Age 76

Marianne Roberts, Age 56

Robin Rogers, Age 57

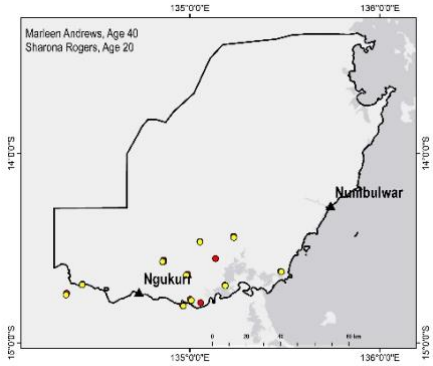




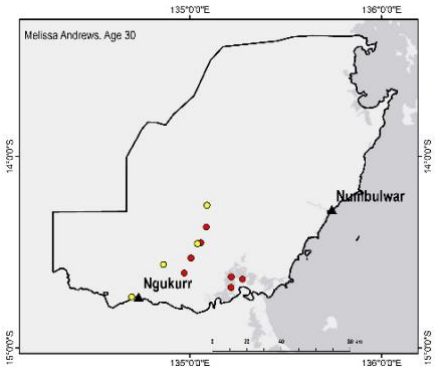


Marlene Andrews, Age 40

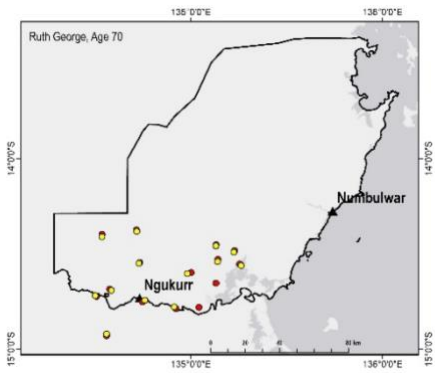
Sharona Rogers, Age 26



Melissa Andrews, Age 22

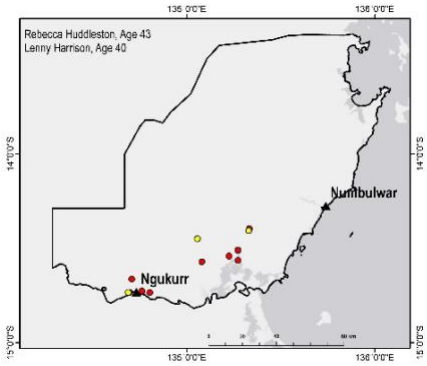


Ruth George, Age 70

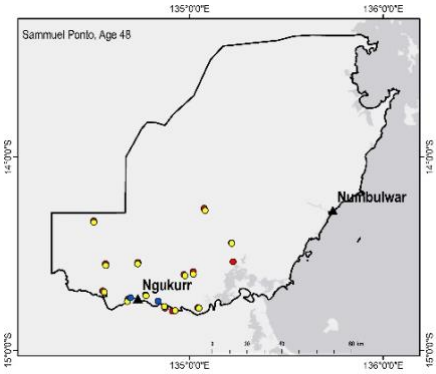


Rebecca Huddleston, Age 43

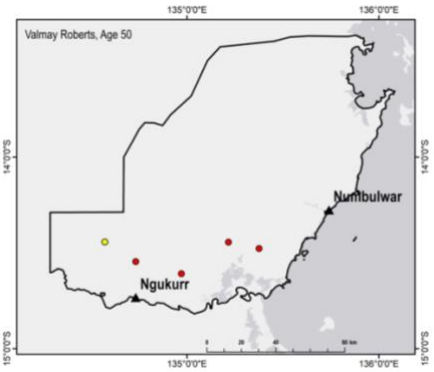
Lenny Harrison, Age 40



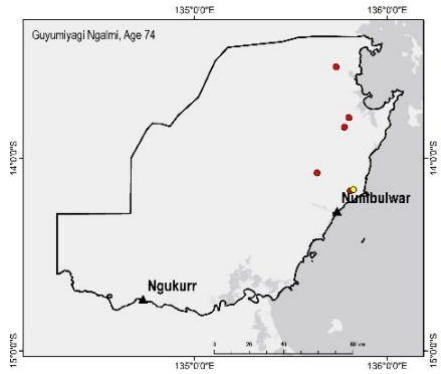
Samuel Ponto, Age 48



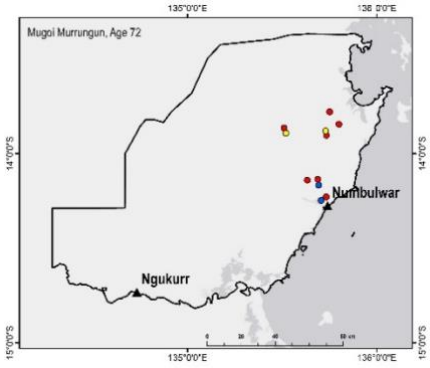
Valmay Roberts, Age 50



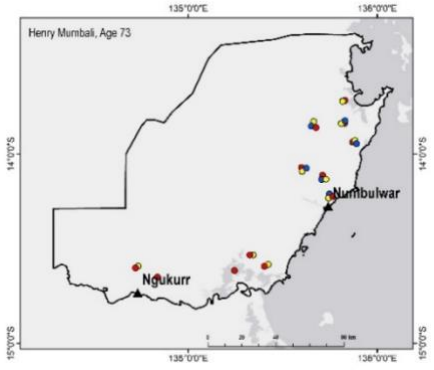
Guyumiyagi Ngalmi, Age 74



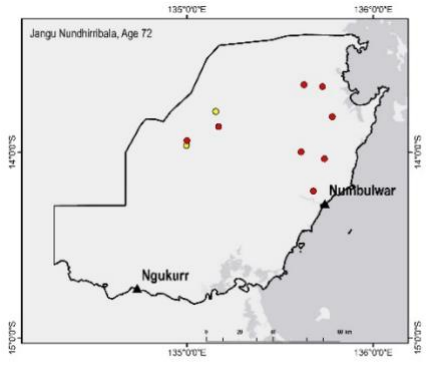
Mugoi Murrungun, Age 72



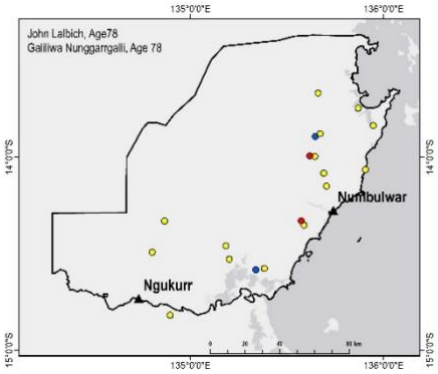
Henry Mumbali, Age 73



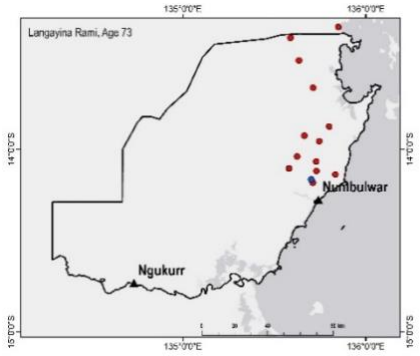
Jangu Nundhirribala, Age 72



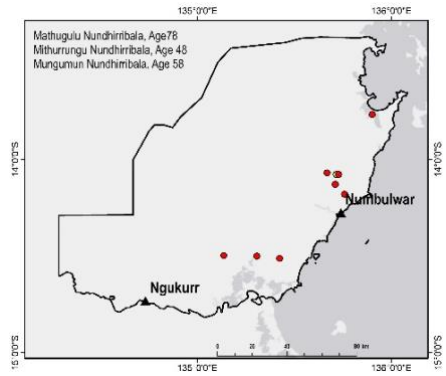
John Lalbich, Age 78
Galiliwa Nunggarrgalli, Age 78



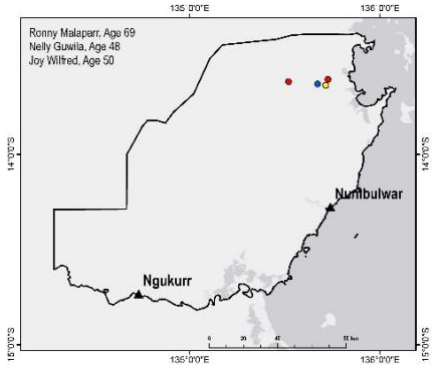
Langayina Rami, Age 73



Mathugulu Nundhirribala, Age 78
Mithurrungu Nundhirribala, Age 48
Mungumun Nundhirribala, Age 58



Ronny Malaparr, Age 69
Nelly Guwila, Age 48
Joy Wilfred, Age 50



Lucllie Wilfred, Age, 74
Rena Wayayun Gugula, Age 50
Virginia Wilfred, Age 47
Rose Wilfred, Age 42

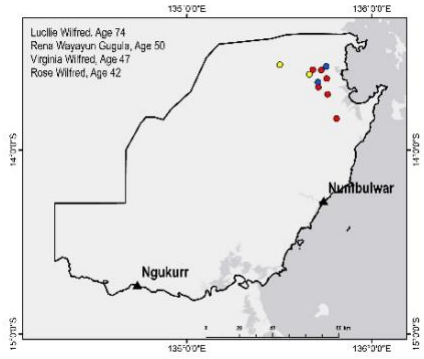


Figure 10. Mapped turtle distribution knowledge of each TKC group showing knowledge about freshwater turtle harvesting sites.

3.2 Freshwater turtles' occurrences within SEAL IPA

By recording turtle harvesting sites of TKC groups through the mapping workshops we gathered Indigenous knowledge distribution data for Northern Long-neck Turtle (red dot), Short-neck Turtle (yellow dot) and Stinky Turtle's occurrence within and bordering areas of the SEAL IPA (Figure 11). Figure 11 also shows that TKCs also travelled areas outside the IPA boundary for freshwater turtle harvesting. Figure 11shows that Northern Long-neck Turtles were encountered much more than Short-neck Turtle and Stinky Turtles. The map also gives an impression that Northern Long-neck Turtles mostly occurred around Ngukurr area than Numbulwar (although this could be due to the higher number of interviewees from this community). The other two species occurrence are similar within the study sites. Figure 11 also shows the recorded Indigenous knowledge of turtle locations versus the records held

in the ALA. Additionally, it is clear that most people go hunting to the east of the IPA near the coast, as opposed to the upland western regions of the IPA. This is also shown when the occurrence data is mapped against elevation below (Figure 12). Furthermore, this data shows that people from Numbulwar tend to hunt for turtles within 100 km or so to the north of the community. People from Ngukurr tended to also hunt within 100km or so from Ngukurr but in a radius around the community and mainly north of the large Roper River.

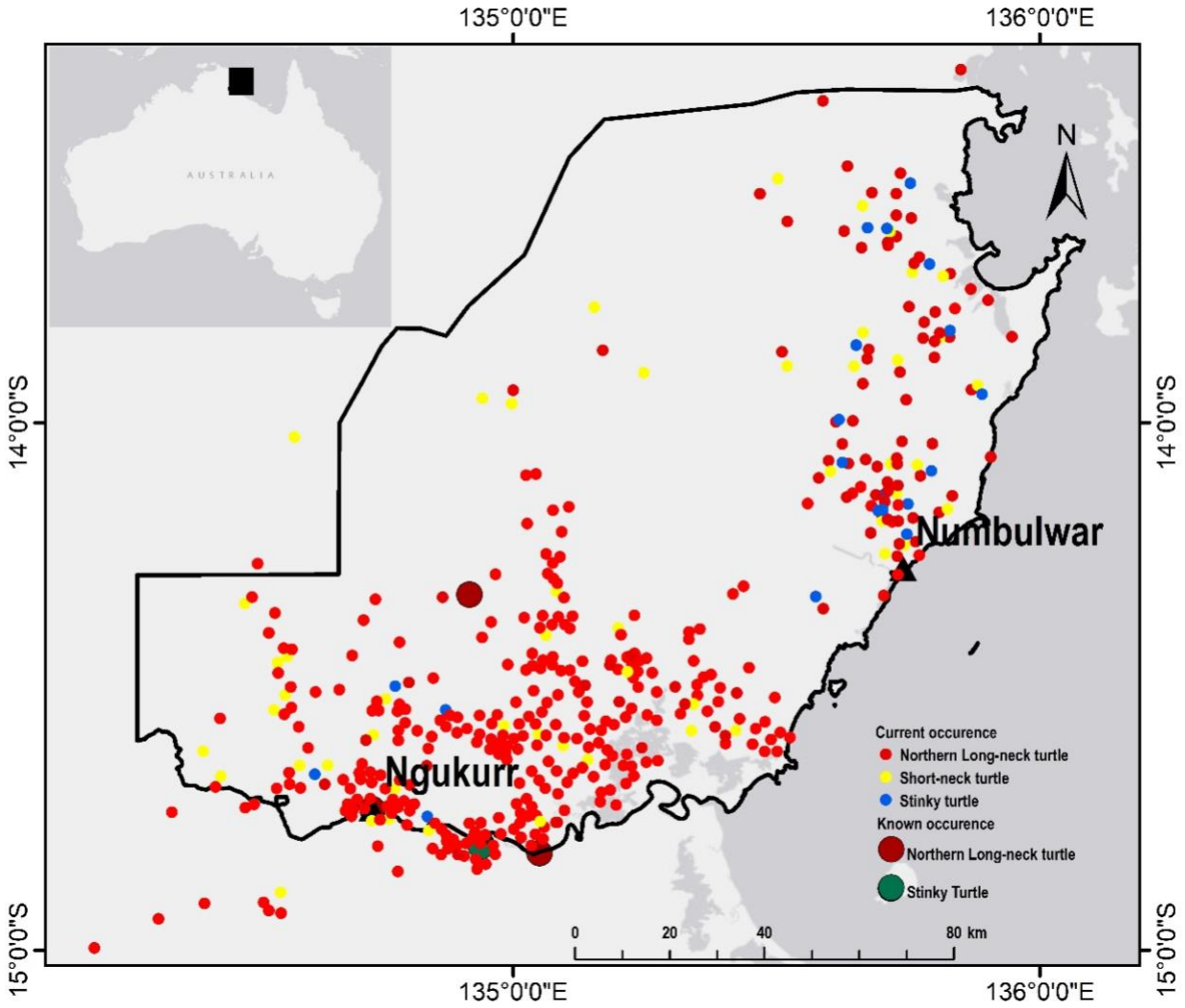


Figure 11. Map of combined TKC group knowledge of freshwater turtle species distributions within the SEAL IPA (small dots) as well as previous turtle records from the Atlas of Living Australia (big dots).

3.3 Freshwater turtles' habitat preferences within the SEAL IPA

The digital elevation map with freshwater turtle locations shows that freshwater turtles were mainly found in low elevation areas, which are the floodplains. Not many records occur on the high country possibly due to the rocky terrain, the lack of permanent or ephemeral waterholes, and because this area is harder for people to access by vehicle.

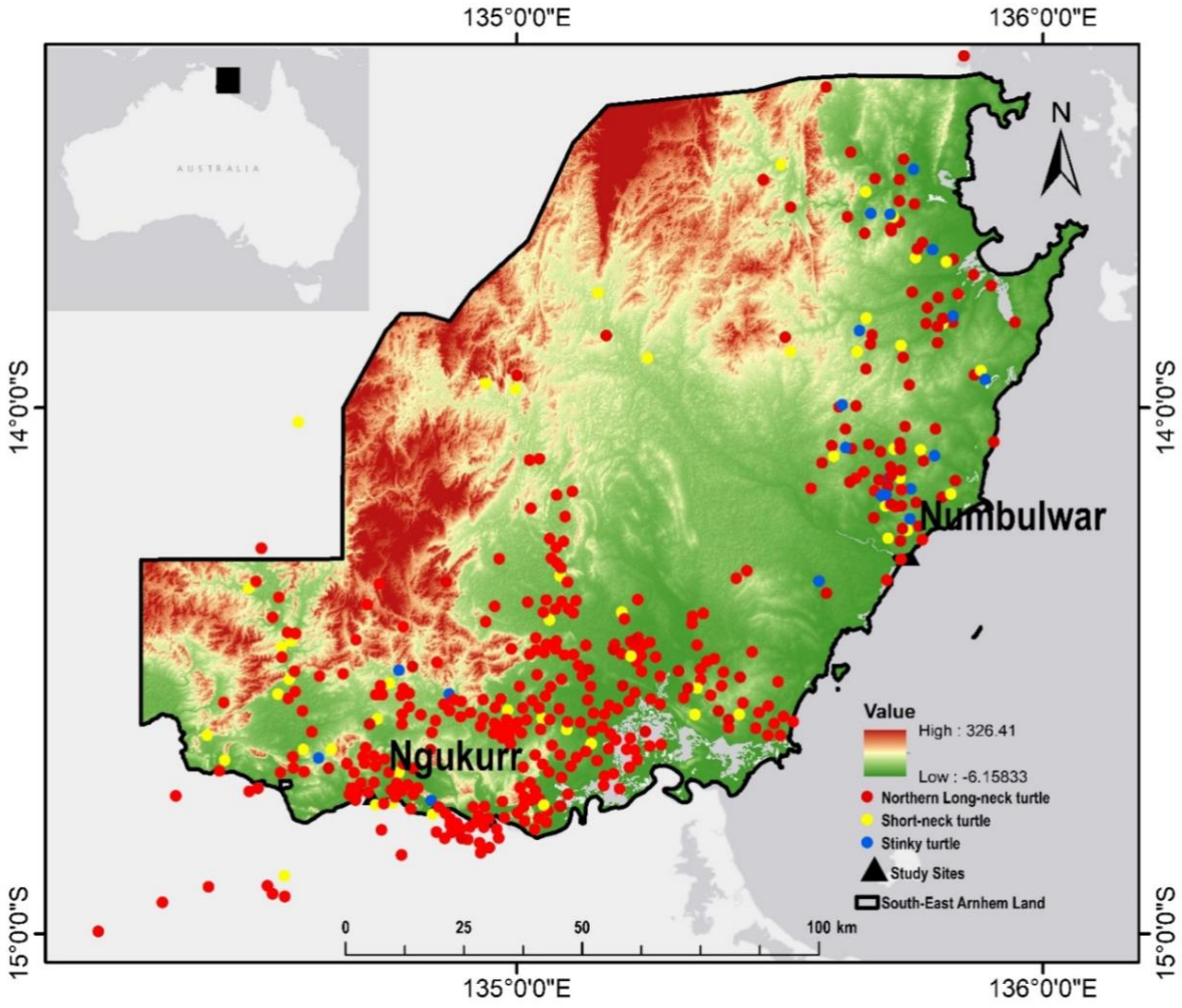


Figure 12. Digital Elevation map of SEAL IPA also showing occurrence of the three freshwater turtles caught by TKCs.

Figure 13 illustrates that the freshwater turtles occur in many different hydrology types within and around the South east Arnhem Land IPA. Warndarrang speaker and respected Elder, Kevin Rogers said that freshwater turtles live in '*mainly billabongs, lakes and rivers.'* Whereas, Ngandi Elder TKC Cherry Daniels said, '*long-neck* [Northern Long-necked Turtle] *occur at the floodplains only, we don't find that*

short-neck turtle, they breed separately and they, like their habitats, is separate'. Elder Gwen Rami said: '*if you want to catch a turtle, short-neck and long-neck down in the river there'.*

Long-neck Turtles are common on the saline coastal flood plain, specifically around Numbulwar and Ngukurr (Figure 13). Three TKCs suggested that Long-neck Turtle's occur in brackish water whereas 12 TKCs mentioned that Northern Long-neck Turtle are only found in freshwater. Around Numbulwar, TKCs variably mentioned Northern Long-neck Turtles occur in brackish, salty and fresh water. TKC Ezekiel Manggurra said '*long-neck turtles present in both clean and brackish water*'. Another TKC Kathy Anne Numamurdirdi informed us that there '*used to be a big swamp and that's where we use to see dhalmarang* [Northern Long-necked Turtle]. *The water wasn't really salty when it was rain season. In the water, the water was brackish from the swamp'.* The Northern Long-neck Turtle's known location along the coast (Figure 12) supports the TKCs statements that Long-neck Turtle are found in both saline and freshwater (see Figure 13).

TKCs mentioned that they have found Short-neck Turtle only in freshwater and sometimes in brackish water. TKC Ezekiel Manggurra said that '*wirney* [Short-neck Turtle] *hang around in both salt and fresh water'.* TKCs mentioned that the stinky turtle was present only in freshwater. TKC Ezekiel Manggurra mentioned that '*The smelly one just fresh water, hang around fresh water'.* Numburindi Ranger, Adam Manggurra echoed the previous TKC Ezekiel: '*the smelly one* [Stinky Turtle] *is just in freshwater'.* This suggestion that Stinky Turtle only occurs in freshwater habitats is reflected in Figure 13.

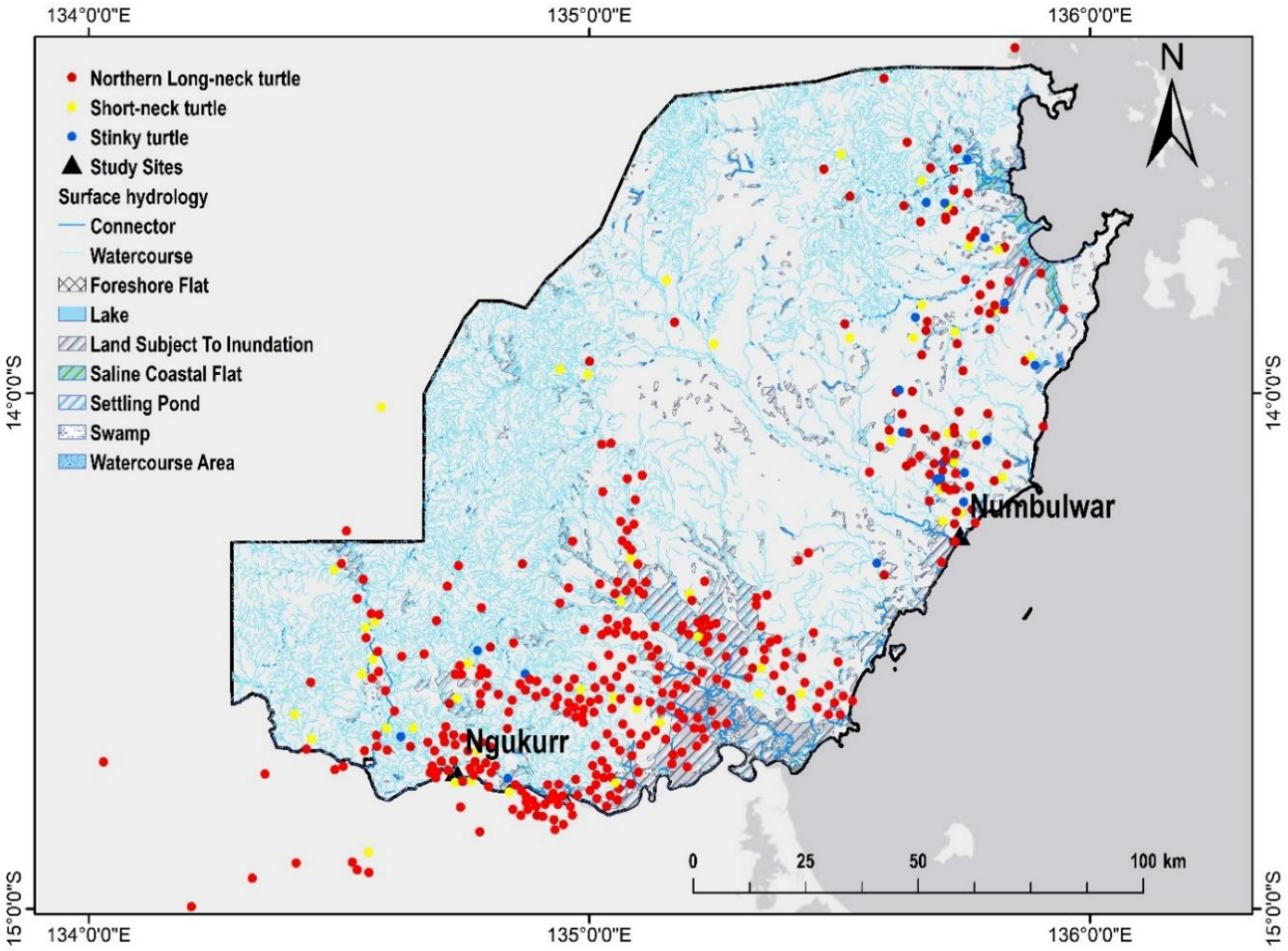


Figure 13. Surface hydrology of SEAL IPA and the occurrence of the three freshwater turtles in different water bodies.

The hydrology map (Figure 13) shows different freshwater turtles' presence in different types of wetlands. Elder Cherry Daniels said, '*floodplains are only long-neck's'* [Northern Long-necked Turtle] *we don't find short-neck turtle'.* Young TKC Dimetris Ashley (age, 20+) mentioned that Northern Long-necked Turtles are found in '*freshwater, spring-water and they hide in the creek'.*

(a) (b)

Figure 14. Northern Long-neck Turtle habitat near Ngukurr. (a) Lowland floodplains are typical habitat that dry up completely during dry season. (b) Billabong showing the big trees at the banks ideal place for the turtles to aestivate when it dries up.

(a) (b)

Figure 15: Northern Long-neck turtle's preferred habitat near Numbulwar. (a) Andanangki Billabong, it gets dried up completely during dry season. Turtles estivate under the big trees on the site. (b) Abalu Billabong, peripheral wetland, suitable habitat of Northern Long-neck turtles.

Northern Long-neck Turtle habitat including billabongs and floodplains where the species aestivates to survive the dry period (Figure 14 and 15). The Northern Long-neck Turtle has its own survival techniques during aestivation which includes: 1) it goes under the mud when it's wet, 2) creates space inside the burrow for free-moving, and 3) it drinks enough water to survive during the dry period. This information came from Traditional Knowledge Custodians, Marra speaker, Kiefer Hall, he said that: *'the long-neck turtle, that is called nangga turtle* [aestivating Northern Long-neck Turtle]. *When they bury themselves, they go under the ground when the ground is wet, that's the time to go in the mud and they start scratching*

around inside the mud to make space and is too they can move around inside. Before they go in the mud, they drink water, to fill that water bag inside. When you get the turtle from the ground, that nangga turtle, when you cook that, and you take the gut out and then you can see it's clean, no food inside the turtle'.

Figure 16 illustrates freshwater turtle's distribution (according to TKCs) colour coded by co-occurring vegetation types. Within the SEAL IPA, there are ten different vegetation types of which most freshwater turtles were found in Eucalypt woodlands and/or open forests (yellow and light green dots). A Chi-square Test of Independence found that there was no significant correlation between turtle distribution and vegetation type (Chi-square = 28.9, df = 24, P = 0.11; Figure 16). However, from visual inspection of Figure 17, it is clear that turtles are commonly found in Eucalypt woodlands (open and low) and further down on the floodplain in the saline chenopod, samphire shrub and forblands.

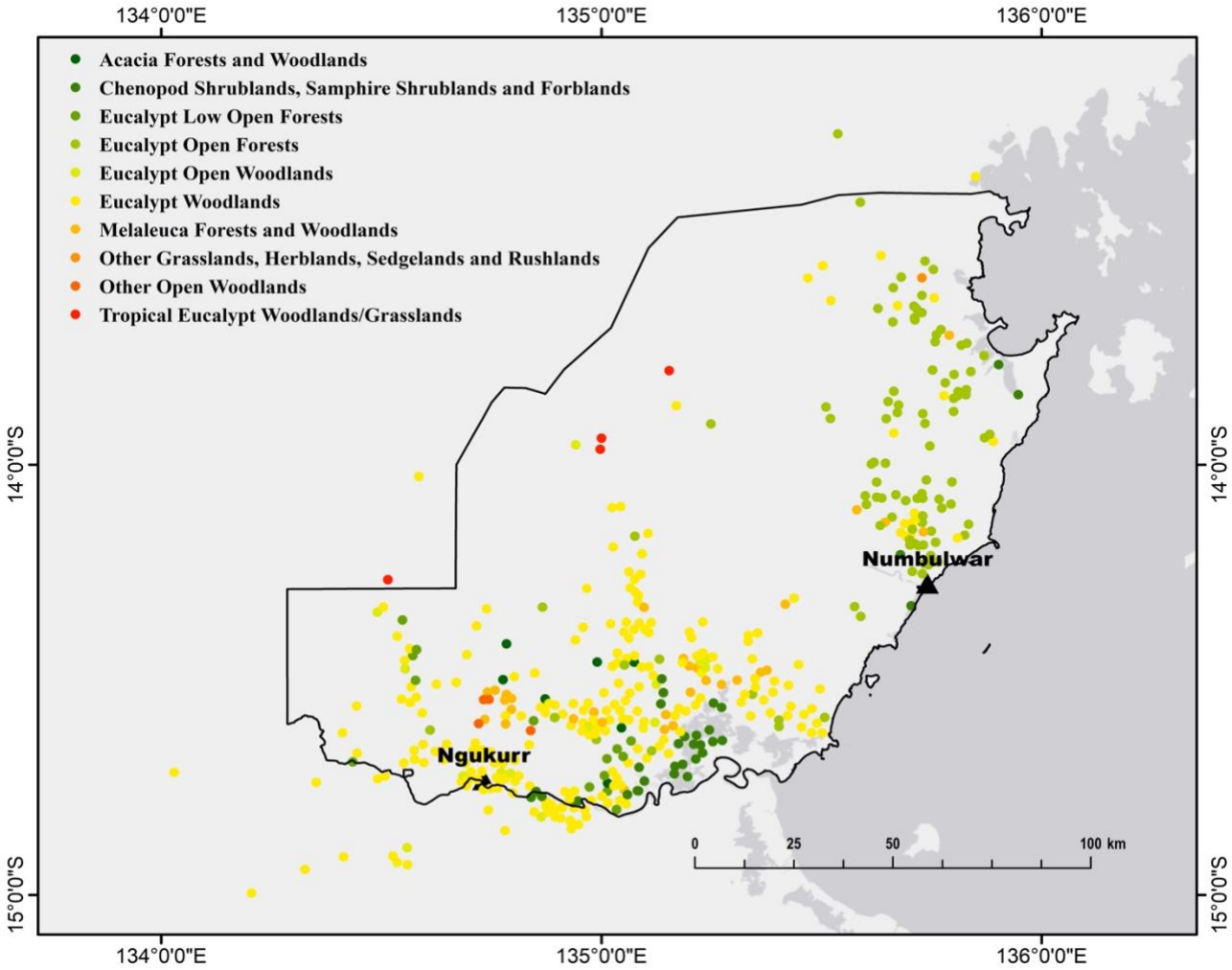


Figure 16. Major vegetation types and freshwater turtle presence as identified by TKCs in and around the SEAL IPA.

3.5 Threats to the freshwater turtles

Figure 17 shows that climate change was most often mentioned by TKC groups (n = 56 mentions) as having a negative impact on freshwater turtles in the SEAL IPA. While, 49 TKC groups said that natural predators posed a threat to the turtles. The third highest threat suggested by TKC groups (n = 39 mentions) was feral animals. Far fewer TKC's believed that habitat change was a threat, while 5 people stated that there were no threats to freshwater turtles in this region (Figure 17).

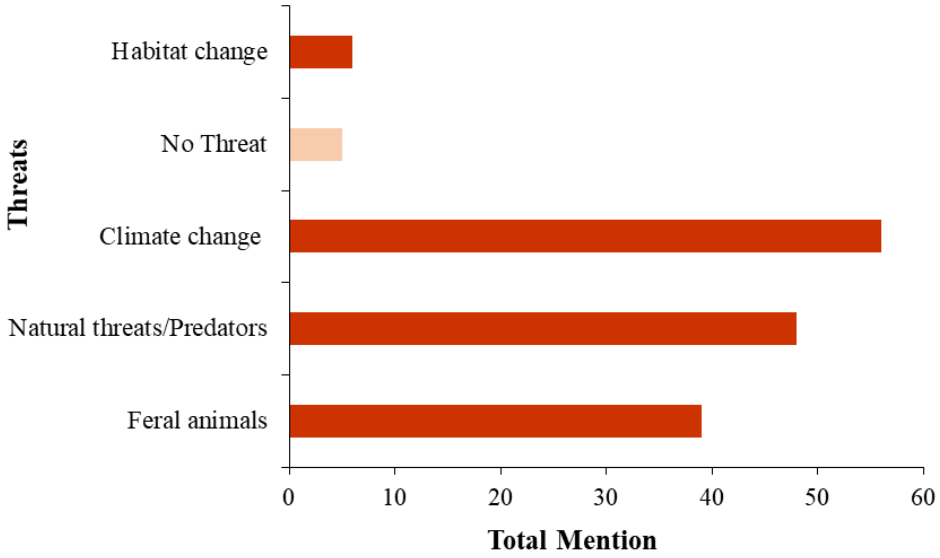


Figure 17. Threats to freshwater turtles in South east Arnhem Land identified by TKC groups.

Regarding climate change, TKC Kathy Anne Numamurdirdi explained: '*we get rain these days, but these come with cyclone warnings, in the past, 43/44 years back we never use to have that'.* Her husband, Hubert Rami Nunggumajbarr said: *'Hardly had any rain at the moment. Get maybe two three months rain in a year and that's it. That's all we get.'* He added how this climate change threatening freshwater turtles: '*turtles are dying may be because of less rain. Because they live in water all the time, water creatures- if there is no water then everything dies. The turtle stays in the mud* [aestivating], *mud gets hard with no rain, then how the turtle going to get out?*

Natural predators of freshwater turtles are carnivores, such as, dingo, birds of prey (eagle and hawk), and crocodile. Twenty-three TKCs mentioned that dingo preys on aestivating freshwater turtles and turtle's egg. TKC Kiefer Hall mentioned: "[threats are] *crocodile, hawk and dingo".* Ngandi woman Martina

Hall said: *"like if I'm lost, walk* [turtles in search of water] *and it can get eaten by dingo".* Ranger Julie Roy said: *"dingoes eat those* [freshwater turtle]". Nine (9) people mentioned that birds (hawk and eagle) prey on freshwater turtles. Elder Cherry Daniels said: "*hawk eat* [freshwater turtles]. Mangarrayi Woman Marjorie Hall said, *"We see a lot dead turtle, hawk daggat* [eat], *turtles crawling away you know the birds find them".* TKC Rebecca Huddleston said they know birds eat turtles because they go under the bird's nest to collect turtle shells: *"We want turtle shell, we know where to get it, and we go straight under that bird nest*".

Eleven TKCs told the research team that crocodiles hunt turtles. Elder Cherry Daniels said that crocodiles have taken over the Yellow Water billabong where they used to hunt for Long-neck Turtles. She said: "*crocodiles love eating anything, greedy animal".* TKC Hubert Rami Nunggumajbarr said: *"if the crocodile is hungry it eats turtle, but we don't see what they eat'.*

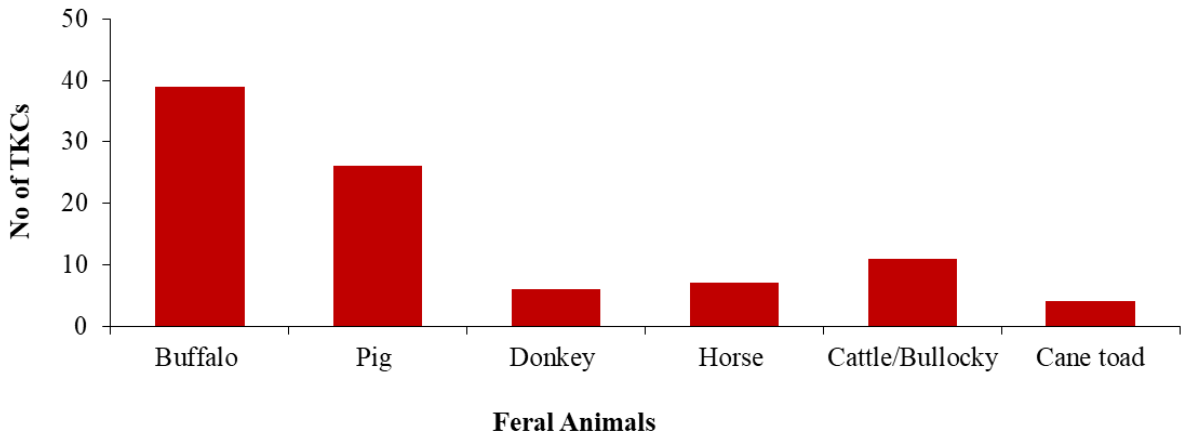


Figure 18. TKC's mentions of feral animals' posing threats to freshwater turtles in Southeast Arnhem Land

In terms of the feral animals, Asian Water buffalo were most often mentioned by TKCs (n=39) as a threat to the freshwater turtles. Asian water buffalo were followed by pig (n=26), bullock/cattle (n=11) and then horse/donkey (n=7) as posing a threat to freshwater turtles (Figure 18). Elder Henry Mambali told the research team how Asian water buffalo are killing the freshwater turtles, '*buffalo walks on the mud and take the turtle out from the mud'.* Elder Cherry Daniels noted: *"Yeah, they* [freshwater turtles] *have threats, from pollution and from other feral animals. Too many cattle and buffalo* [Asian water buffalo] *and then the crocodile. They get trampled by the buffalos and pigs… Trample all over the billabong. They* [freshwater turtles] *get trampled by the buffalos and pigs".* Her son, Anthony Daniel added on how

the ungulates invasion also exposing the freshwater turtles to predation: *'and horse and buffalo and even cattle like bullocks, When, they* [feral ungulates] *find water, they go to that water where the turtle is, that's when they make them* [freshwater turtles] *feel out of place inside and they come out of their nest and they started walking and they get eaten by an eagle'.*

TKC Walter Rogers said: *"They interfere, buffalo and pig with them (freshwater turtles) when they lay their eggs, they interfere with them and when they hibernate, they interfere with them. When they go and jump in that water, when it's still wet, that pig I seen them dig, yeah and then they disturb them you know, they go in the water."*

TKC Kathy Anne Numamurdirdi said on the impact of Asian water buffalo presence on ecosystem and freshwater turtles: '*they* [buffalo] *destroy the land like the vegetation at billabong like we were talking about at the water lily area, they* [buffalo] *go and eat water lily nuts and fruits and destroy the plantation. We know the waters can be polluted* [dung] *when it is small water. When it is low* [water level] *we know we don't touch it. But when in a big billabong like what we have got and rivers, we know it is not polluted, we still wash out in the river. In the deeper water. But in the shallow water it [dung] remains there and it's polluted, and they kill them [freshwater turtles]*'. School teacher Nunggubuyu lady, Jangu Nundhirribala mentioned '*nowadays, people believe that there's hardly anything* [freshwater turtles] *now in it, in the billabong because of pigs and buffalos, a lot of them in the swamps.'* Feral ungulates invasion is also impacting the Indigenous hunting practices. TKC Kathy Anne Numamurdirdi said, *'the goanna hunting and water lily hunting, that all stopped now because of the buffalo and* [TKC Kiefer Hall added] *the cane toad spreading'.*

From Numbulwar, four TKCs mentioned 'Cane Toad' (Figure 19) as a threat to freshwater turtles. Ngandi Woman Cherry Daniels mentioned background of Cane Toad expansion and its lethal impact in the ecosystem, in her words- '*cane toads came from the Amazon, you know sugar plantations here in Queensland, that the farmers grew you know, sugar in Queensland, and those little beetles that ate up the sugar plants, but they were like out natural beetles, whatever you call them. And then they bring them, cane toad, to stop them eating the sugar plantations, and its wasn't our fault, it was the settlers brought those thing to Australia, make the natural things here turn into, I don't know, a lot of them are extinct now, even our snakes, our lizards, I don't see them very much now, because of what, those cane toads, did to our snakes, goannas, True. Way back in the 80s and early 90s there was goannas, and*

towards the middle they started fading, the goannas, true, there's nothing, I think somebody saw some might be couple, I saw one at Namaliwiri, first one in 20 years.'

TKC Hubert Rami Nunggumajbarr said: "*The cane toad, the young toads, tadpoles, nangga turtles* [aestivating Northern Long-neck Turtle] *eat them, I think they* [Cane Toad] *carry poison, I think that kill them* [turtles]*".*

Another TKC Langayina Rami also mentioned cane toad a threat to freshwater turtles. He told the research team that "*cane toad came from Queensland, turtles eat cane toad tadpoles, and started to die"*.

Traditional Knowledge Custodians from Ngukurr also mentioned Cane Toad as a threat to freshwater turtles. Young Alawa woman, Melissa Andrews said that Cane Toad is threatening freshwater turtle populations: '*you go there, to the billabong, you look something eye-shine, you can get turtle and a cane toad'.*

Figure 19: Cane Toad observed at Numbulwar during field work.

Nunggubuyu Elder Walter Rogers said reptiles, like, goanna and other species are impacted by cane toad invasion and this invasion has impacted the groups whose dreamings are goanna culturally: '*When we had goanna they were in that goanna hole, they were everything, bluetongue, goanna, king brown you name it and that python. Just not far from here, that side of Nalawan, Wadagujaja. There was a place*

there, important place for goanna dreaming, this mob woman probably all gone now, only that old Betty Roberts [Wandarrang language group]*, she knows for that area, that goanna dreaming. Frida too, they took us there, they got biggest mob, but* [not anymore] *that cane toad been wipe them out'.*

TKCs from the South East Arnhem Land IPA also showed their concern about salt water intrusion. Traditional Owner of the Northern Long-neck Turtle, Galiliwa Nunggarrgalli said: '*saltwater coming in the billabong, hurting the dhalmarang, the freshwater turtles, Long-neck Turtle'.* He also added: '*billabong sometimes go dry and little bit salty'.* Ngandi man, Hubart Rami Nunggumajbarr said: '*salt water coming in underneath, they* [Northern Long-neck Turtle] *live in the billabong where there is no salt water, it* [salt water] *will kill them'.*

3.6 Cultural relationship with the freshwater turtles

Freshwater turtles are an integral part of Indigenous culture in the SEAL IPA. Freshwater turtles are in their dreaming stories, ceremonies, artworks, songs, songlines and dances and these all are intertwined. Freshwater turtles not only provide local people with food, but they are also a totem. A total of 44 (59%) TKCs named freshwater turtles as their totems or dreaming animal (these terms have a similar meaning). TKC Anthony Daniels said: *"They mean something to me both ways, both ways they mean something to me. Right now, you can eat that animal…But the other one that longneck one we can eat it now, but when we have that ceremony people won't eat that. Dreaming it's a totem".* Anthony's mother, Cherry Daniels added that Short-neck Turtle is her totem and she doesn't eat them during the ceremony. In her words: *"It's in my ceremony, that Short-neck turtle, that pignose, Wirney* [Short-neck Turtle]*, that's his dreaming, my children's dreaming, they can't eat it too when their ceremony is on, like the Gunapipi* [type of ceremony]. Here, totems inherited from one's father, mother's father and mother's brother, link people with land, dreaming tracks and sites and species of those dreaming.

TKC Cherry Daniels and her son, Anthony Daniels told of their dreaming story: *"The long-neck turtle carried the sand ridge goanna on its back, from lake Evella across Mary Lake to Bulman and went through down to Minyerri* [Hudson Downs] *near the billabong. The longneck turtle stopped there then that goanna go right down this way. But the goanna was afraid of getting drowned. So, the goanna stayed on top of the turtle, that why there's that deep mark on that turtles back."* Nunggubuyu speaker Davis Daniels also mentioned the same dreaming story as Cherry and Anthony Daniels: *"This way now that goanna came, that goanna 'im was carrying that turtle, that turtle lazy or something, that goanna*

'im carry that turtle 'im same dreaming, partners that turtle goanna attached. The same dreaming as that turtle and goanna, from Matolo, these mobs here that Hall mob they know that story"

TKC Galiliwa Nunggarrgalli said he is the [Traditional] owner of the Northern Long-neck Turtles, meaning it is his main totem. He said that his hair is important to catch turtles: *"If you cut my hair and put it in the billabong, burn it and put it in the billabong, wait for couple of hours, may be one or two hours, fishing line, you can see lots of turtles looking at you".*

Cherry Daniels added that freshwater turtle's ceremonies tell people about the weather and the best time to hunt freshwater turtles and other animals. According to Cherry, August is the best time to hunt freshwater turtles before the animals aestivate and that is the time when they're at their best health. She also mentioned that freshwater turtles die due to prolonged dry period as they have found shells of freshwater turtles. During May/June turtles hibernate and by the end of July they emerge from aestivation to look for water and if no rain they go back on their way back to their aestivation place they die. Cherry said [They are] *'an important thing, important thing in our ceremony and they tell us about the weather, what season you can get this animal or that animal, yeah, even though you can catch turtle this time of the year, you can get other animals as well, or other fishes, for instance, the catfish is fat now. You can get it from the river or from billabongs. The weather tells you the best time to hunt for out food, especially when you're looking at turtles. Turtles are the best this time of the year now* [August] *to look for them and in the middle right in the middle of May/June, April/ May/ June they hibernate, by the end of July they start to emerge, they look for water. They go back and when there's no rain they got to look for water, by that time they get to the billabong, they are halfway from between the billabong and from where they were hibernating, they die. We see many, lots of turtle shells, yeah".*

TKC Gwen Rami said Short-neck Turtle is her totem. During the ceremonies local, Indigenous people of south east Arnhem Land share their dreaming stories with other communities and then they perform associated rituals. TKC Cherry Daniels said:*" we share them* [stories] *in our ceremony"*. TKC Anthony Daniels added: *"The owner* [of that story] *comes and thing with that and then they tell us" and* "They perform it" both of them added. They have songlines and they sing and dance these during the ceremonies.

Indigenous communities have songs specific to freshwater turtles as well. TKC Ronny Malaparr, John Lalbich and Galiliwa Nunggarrgalli sing those songs in ceremonies. TKCs Kevin and his wife Helen Rogers also mentioned songlines and a storyline that involved turtles. In their words: "*Well I'm storyline too. Like and 'im go through certain countries and created the stories and billabongs, rivers, creeks, they all have names, different names like all this mob this way on the other side and this side too, all have names and wanim stories."* Kevin Rogers said freshwater turtles are part of their cultural heritage: *"It's similar to like all around in our cultural heritage and through our songlines, and we got songs and performance."*

Freshwater turtles are intertwined in the Indigenous culture and are part of the knowledge transfer tradition of South East Arnhem Land. Elders Cherry Daniels, Kevin Rogers and Justine Rogers, described how this system works. Elders promote the young ones through initiation and participation in ceremonies. The responsibilities of continuation of cultural practices like ceremonies, clan group, moieties and skin names are vested to the younger ones by Elders. In the ceremonies they sing songs about turtles and perform dances.

(a) (b) (c)

Figure 20. (a) TKC Jangu Nundhirribala probing the ground with crow-bar to check for aestivating Northern Long-neck turtle. (b) Beef use as a bait to fish turtles. (c) TKC Cynthia Turner threw the fishing hook with the bait in the billabong and waited for a turtle to bite the bait. These are the two techniques people predominantly use to hunt freshwater turtles.

Traditional hunting also places a value in knowledge transfer. Indigenous people hunt turtles throughout the year by fishing in wetlands, and during the dry season when the billabongs and floodplains have dried up, people hunt aestivating turtles using a crow-bar. They use different bait to catch turtle, such as bush bait (mussels) and shop-bought bait including different types of meat and fish (Figure 20). They also swim in the water and hunt turtles by hand. The young people accompanied by Elders in harvesting

turtles learn different hunting techniques, cooking techniques and sharing with the community members. Young people also learned about other bush tucker from Indigenous Elders. As Heather Ponto said: '*the old ladies they would show me how to get turtle. I used to fish; they been teaching me how to get the turtle- you look around you walk. The old ladies sit, and you look them there* [for] *turtle, they used to know the turtle when they used to bury themselves you know, we no more get much Stinky Turtle. We never hunt much for that kind; we mainly go for the Long-neck* [Turtle] *and Short-neck* [Turtle]*.'*

4. Discussion

Through interviews with 74 people, 754 new locations of freshwater turtles were recorded in south east Arnhem Land compared to existing four records held in the Atlas of Living Australia. This Indigenous knowledge offers a significant contribution of species distribution data to the national ALA database that greatly improves species occurrence knowledge in this remote region of Australia. Long-necked Turtles appeared to be most common out of the three turtles identified in the region. These turtles tended to be found on the floodplains rather than in higher elevation areas. Short-necked and Stinky Turtles were less common although still occurred across the lower elevation areas of the IPA. Climate change, natural predators and feral animals were identified as the three main threats to freshwater turtles in this region. This is of significant concern considering the predicted continued rise in sea level and increase in feral animal abundance. Considering the high cultural significance of freshwater turtles in these areas (totems for 59% of TKCs), the findings of this research warrants further on-ground research into current freshwater turtle populations and experimental assessments of threats from sea level rise and feral animals.

Indigenous peoples living within the SEAL IPA are a storehouse of freshwater turtle knowledge, especially older people (Figure 10). By recording known locations of freshwater turtles from local Indigenous experts who have caught these turtles while hunting, we have made significant contributions to the known distributions of these species. In terms of managing IPAs for turtle conservation high turtle abundance areas might be selected as the potential research areas to study systematic turtle abundance and monitoring of threats. Besides, these areas could be considered for feral animal management to protect this important cultural resource of local communities. This participatory research method could be used to assess the occurrence, threats and cultural significance. By recognizing and placing Indigenous knowledge alongside scientific knowledge, this research responds to the UN DRIP, CBD and IUCN calls for Indigenous and Western knowledge integration.

TKCs most commonly identified hunting locations of the Northern Long-necked turtle (487 records), followed by Short-necked Turtle (253 records) and then Stinky Turtle (58 records). Indigenous communities preferred to eat Long-neck Turtle over Short-neck Turtle and Stinky Turtle because it tastes good and the long neck provides more meat. TKCs also mentioned that they don't like the stinky one and if they even caught it they throw it away. That could be a reason why more information was provided on Long-neck Turtle than other two species locations and habitat preferences; although it is likely that

people would remember the Short-neck and Stinky Turtles anyway, so we believe this is a fair representation of comparative freshwater turtle species abundances. The method of knowledge elicitation using a physical map has been used by other researchers (Grech et al., 2014) and shown to be a useful way of collecting location data. Ideally, we would go and ground truth the data to make sure the turtles still occur there. We note here that the "distribution" data we collected, reflects people's memory of freshwater turtle catches. Noting the age of some TKCs, this obviously reflects historical distribution suggesting that current abundance requires verification.

To better understand and quantify turtle habitat preferences, we used three abiotic variables: elevation, hydrology and major vegetation groupings. The digital elevation model data (Figure 12) showed that three different freshwater turtles occurred across all elevations, although were most common on the lower elevation river floodplains. The hydrology map (Figure 13) shows that there are wetlands up in the higher elevation areas where freshwater water turtles could theoretically be found. The absence of freshwater turtles identified by TKCs in the high elevation areas could therefore be an accurate reflection of lower turtle abundance in this area or it could be due to the fact that these areas are less accessible for the communities to travel to and hunt for freshwater turtles (Figure 12). Further on-ground surveys of these areas would allow for a more comprehensive assessment of freshwater turtle presence in high elevation areas. For example, a radio-telemetry study on the Eastern Long-neck Turtle (*Chelodina longicolis*) at Booderee National Park, New South Wales, showed the frequency and spatial scale of terrestrial habitat use and movements within different wetlands (Roe & Georges, 2008, Roe & Georges, 2007, Roe et al., 2011). A similar study could be replicated in the SEAL IPA to understand the movement of the Northern Long-neck Turtle as well as its survival strategy and resource use pattern given extended drying period and long estivating period. Ideally, I would visit the sites the TKCs have mentioned as their hunting locations for two main purposes: one is to ground truth locations and secondly, to capture freshwater turtles (using snorkel traps, baited crab traps, or by hand) to confirm species identification and potentially do genetic and physiological analyses (turtle health assessment).

TKCs most often cited the impact of climate change on freshwater turtles. They were concerned the decline in rainfall and its impact on the natural habitat of freshwater turtles. Ngukurr has the highest rainfall in January and for Numbulwar, it's March (Figure (a)). Long-term rainfall data analysis (see Figure 6 (b), between 1960 and 2015) showed that there's a lack of long-term monitoring data set and tradition of phenological monitoring which hindered understanding climate-change related trends for northern Australia (Hughes, 2003). Therefore, in this research, we have used Indigenous knowledge

about rainfall decline. More detailed research on rainfall, sea level rise and saltwater intrusion into floodplain fringes as well as the drying and salinity tolerance of the different turtle species would be beneficial. However, in terms of salinity tolerance we note that the Long-neck Turtle had been caught by TKCs very close to the coast and on salty floodplains and TKCs spoke about this species occurring in salty and brackish water. So, this species may be more tolerant of salinity than Short-Neck and Stinky Turtle which appear to occur further inland. Cherry Daniels, a well-known knowledgeable Elder of the region (Daniels, 2016) said that Short-Neck Turtle were more often found in freshwater. From this preliminary analysis, it could therefore be hypothesized that the Short-Neck Turtle and Stinky Turtle could be more at risk from sea level rise and salt water intrusion than Northern Long-neck Turtle. This warrants further research, especially given the cultural importance of the Short-Neck Turtle. To gain a better understanding of how turtles respond to long dry periods, multilayer droughts or continuous wet periods or inundation from saltwater, physiological studies are required.

TKCs suggested that natural predators (dingo, birds of prey (eagle and hawk), and crocodile) were more of a threat than invasive animal species (Figure 17). Natural predators such as dingoes and birds of prey were described as eating turtle eggs and preying on turtles when they were out of water. However, of concern are the cumulative effects of invasive non-native animals such as ungulates (mainly buffalo, pig; Figure 18). Buffalo and pig were first introduced to northern Australia between early eighteen to mid-eighteenth century by European settlers and soon became feral after their settlements were abandoned (Freeland, 1990, Skeat et al., 1996). Asian water buffalo, pig, cattle, donkey *and* horse became feral in south east Arnhem Land and their population has increased due to the absence of predators, low susceptibility to pathogens, suitable habitat and presence of large grasslands (Freeland, 1990).

Indigenous communities in the SEAL IPA also kept track of feral invasion in their land. Senior Cherry Daniels called the feral ungulates 'invaders', in her words: '*the invaders, silent invaders, intruders like the buffalo intruding our land, they came and trampled all over the top end of Australia, mucked up everything, taking over.'*

Nunggubuyu woman, Kathy Anne Numamurdirdi mentioned that '*buffalo came from Asia to them, down to rice fields, down there and then they spread out. And then we started see those buffalos late 60s and 70s. They were all spreading wild everywhere throughout Arnhem Land and now they are pest in the bush'.* She also mentioned that *'pigs, they came in the early 90s, not very long ago they came in and then*

they spread out in the bush'. Ngandi speaker, Hubert Rami Nunggumajbarr said *'before 60s and 70s this place no buffalo, hardly any buffalo'.*

Indigenous communities are aware of the impact of feral animals on their land (Ens et al., 2016a). TKCs mentioned that feral ungulates like Asian water buffalo, horses, pigs and bullocks are killing the freshwater turtles by trampling. They also mentioned about pig predation on freshwater turtles and their eggs.

Senior Cherry Daniels has a strong notion about how feral ungulates are polluting the water and destroying the ecosystems at larger scale, she said: '*You know when we went to Mungadjarra yesterday, as we were coming in you saw those dungs, I forgot that part was the plain area, we used to sleep across there, now those dungs are there, just full of dungs, the buffalo leaved them there, I told Valmay, when you go back to Ngukurr, please come back here and take all this [dung] up otherwise rain will come and wash those dung into the billabong, that'll pollute that billabong, Mungadjarra, true, that happens too, you know. Buffalo and horses, donkeys, pigs. I don't like pigs and buffalos. I wish they never came to Australia.'*

Feral ungulates invasion has reportedly declined hunting of freshwater turtle's and altered the timing due to high pig predation (Fordham et al., 2006). Senior Davis Daniels said, *'While I bin hunting all that area, I see pigs and buffalo destroying the billabong and that's why we can't catch much animal these days.'* Kennett and colleagues (2014) found that Asian water buffalo trampling has facilitated saltwater intrusion in low lying floodplain habitat of freshwater turtles by changing the wetland structure and function.

To remove feral animals from being a threat to freshwater turtles, they could be culled. However, culling of Asian water buffalo especially is highly contentious due its local value as meat and potentially as a source of income from live export, pet-meat or safari hunters (for the horns) (Robinson et al., 2005, Ens et al., 2016a) Asian water buffalo population control methods, like helicopter and ground shooting is often used (Bayliss & Yeomans, 1989) however, populations are still increasing. Feral exclusion fencing, targeted Asian water buffalo, pigs and horses, in the Nalawan area of the SEAL IPA showed significant ecosystem recovery of vegetation and expected turtle habitat (Ens et al., 2016a).

Cane toads were rarely suggested as a major threat to freshwater turtles by TKCs in this study. Quantitative studies on cane toad impact on freshwater turtles are limited (Shine, 2010) and some

researchers have suggested that the impact of cane toad on native wildlife can be severe and called for more quantitative research (Altman et al., 2003).

This research showed that Indigenous communities living in the SEAL IPA have strong cultural ties with freshwater turtles as totems, dreaming, ceremonies and songlines. Traditional hunting of freshwater turtles has been shown not to effect turtle population viability (Fordham et al., 2006). Fordham and colleagues (2006) also documented that during ceremonies Indigenous people (of the Maningrida area in northern Arnhem Land) stop harvesting freshwater turtles which provides both temporal and spatial refugia. This is was also evident in Elder Cherry Daniels comment: '*Ceremony time if Gunapipi is on and if we catch Short-neck Turtle, no more duggart* [eat], *because the ceremonies on. If mine mothers is on, I'm not allowed to eat that Long-neck* [Turtle]. Ceremonial Laws guide sustainable resource use and by following the ceremonial traditional, Indigenous communities play a major role in environmental protection. As Elder Cherry Daniels said following "Gunapipi" ceremonies, *'It's our culture that we keep, it teaches us respect and obedience.'*

Local people have time tested systems to ensure sustainability of cultural practices. During the interview with Elders Cherry Daniels, Kevin Rogers and Justine Rogers, they described how this system works (see quotes in results above). These ceremonies also work as a bond with the country. As Elder Kevin said: *'They* [younger generation] a*re related to you* [Elder] *and we follow right back to our ancestors, grandmothers' side, grandfathers' side, we go back we maintain that, coming together as one and then we share that, and everyone is in their own area, in their own, they perform their own women's side too and men. Women have their own area and people that's where they cook whatever we, you know, when we go there, we come back come down from men's performance we come back there, and they give us food we eat. So, we next day reckon gather everybody. All this top end mob we related through storyline, because these things, these are not dreaming really, these are things that created this country, even though, I'm sorry to say this but it's still part of us, that's what makes us who we are.'*

The cultural ties of Indigenous communities living in South east Arnhem Land IPA with freshwater turtles demonstrates their bond with nature. They believe this is how they are connected with the land and that the land is deeply rooted in their identity. As Elder Cherry said: '*those things* [freshwater turtles and other species] *identifies us, we get that identification through all that.'*

This research has drawn data from two researchers which had benefits and also drawbacks. The benefits included that we expand the data set for greater analysis and the latter researcher could follow the protocols of the first researcher to become more familiar with the methods and ethics of working with the Indigenous communities. Some of the interviews at Ngukurr were repeated by me to align the methods and approach in collaboration with three people from the Ngukurr Yangbala Project: Justine Rogers, Kiefer Hall and Sandra Blitner in Ngukurr who also worked with Shaina Russell. We played the audio-recordings to the interviewees to check that we were following a similar method to Shaina. The drawback of this approach was that we needed to follow the same methods applied by the previous researcher, meaning that we couldn't add new dimensions to this research.

5. Conclusions

The main findings of this study were documentation of Indigenous people's knowledge of freshwater turtle' occurrence in the South East Arnhem Land IPA where there was previously little documented evidence. This research also suggested that freshwater turtles' preferred habitats are lowland floodplains, swamps and rivers with Eucalypt woodlands/open forests or saline floodplain vegetation (chenopod and samphire). In addition to that, this research also documented a range of new and precolonial threats to the freshwater turtle. Climate change, especially less rainfall (according to TKCs) is threatening the freshwater turtles' habitat by prolonged drying period (Chessman, 2011, Roe et al., 2009, Roe et al., 2011). Among the introduced feral ungulates, buffalo threatens freshwater turtles by trampling and killing aestivating turtles at dried waterholes (Kennett et al., 2014) and destroys important swamp and jungle habitat on the floodplains (Robinson et al., 2005). Pigs are also threatening the freshwater by praying on them and also destroying the habitats through rooting, as was also found by other researchers (Fordham et al., 2006, Fordham et al., 2007) (Robinson et al., 2005).

The combination of Indigenous knowledge and Western science methods used in this study can be valued as an effective two-way approach to understanding species distribution and threats, especially in remote areas where documented data has been limited (Hashim et al., 2017). Collaborative projects such as this also assist two-way capacity development: they provide economic benefits, new skills and collated knowledge to Indigenous communities, while researchers also gained insight on the value of Indigenous Ecological Knowledge and how it can be integrated with Western knowledge to enhance local decision-making (Grech et al., 2014, Ens et al., 2012). Evidently there are more questions to be answered regarding freshwater turtle's distribution, habitat and threats including further management intervention; however, projects such as this one acknowledges that Indigenous people's knowledge is invaluable to building a more comprehensive knowledge database of species distribution and threats, not only in this region, but globally where different knowledge systems co-exist.

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Appendix 1: Human Ethics Approval

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MACQUARIE University
SYDNEY·AUSTRALIA

17 April 2018

Dear Dr. Ens

Reference No: 5201800178

Title: *Cross-cultural biodiversity surveys in eastern Arnhem Land*

Thank you for submitting the above application for ethical and scientific review. Macquarie University Human Research Ethics Committee (HREC) (Human Sciences & Humanities) considered your application.

I am pleased to advise that ethical and scientific approval has been granted for this project to be conducted by Mr Ben Kitchener, Ms Bridget Campbell and Ms Rukshana Sultana under the supervision of Dr. Emilie Ens.

Approval Date: 17 April 2018

This research meets the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007 – Updated May 2015) (the *National Statement*).

Standard Conditions of Approval:

1. Continuing compliance with the requirements of the *National Statement*, which is available at the following website:

http://www.nhmrc.gov.au/book/national-statement-ethical-conduct-human-research

2. This approval is valid for five (5) years, subject to the submission of annual reports. Please submit your reports on the anniversary of the approval for this protocol.

3. All adverse events, including events which might affect the continued ethical and scientific acceptability of the project, must be reported to the HREC within 72 hours.

4. Proposed changes to the protocol and associated documents must be submitted to the Committee for approval before implementation.

It is the responsibility of the Chief investigator to retain a copy of all documentation related to this project and to forward a copy of this approval letter to all personnel listed on the project.

Should you have any queries regarding your project, please contact the Ethics Secretariat on 9850 4194 or by email ethics.secretariat@mq.edu.au