Australian Government
Department of the Environment

2010 NOMINATION – *Carcharinus leucas*

Section 1 - Legal Status, Distribution, Biological, Ecological

Conservation Theme

1. The conservation themes for the assessment period commencing 1 October 2009 (for which nominations close 26 March 2009) are **'terrestrial, estuarine and near–shore environments of Australia's coast', and 'rivers, wetlands and groundwater dependent species and ecosystems of inland Australia'**. *How does this nomination relate to the **conservation theme**?*	*Carcharinus leucas* is one of the few truly euryhaline shark species present in tropical and temperate estuarine, riverine and near shore environments in Australia. As a keystone predator in such ecosystems, *C. leucas* fits the conservation theme for this assessment period.

Taxonomy

2. *What are the **currently accepted scientific and common name/s** for the species (please include Indigenous names, where known)?* *Note any other scientific names that have been used recently. Note the species authority and the Order and Family to which the species belongs (Family name alone is sufficient for plants, however, both Order and Family name are required for insects).*	Scientific Name: *Carcharinus leucas* (Müller & Henle, 1839) Common Name: • Bull Shark • Freshwater Whaler • River Whaler • Swan River Whaler • Bull Whaler Indigenous Names (Morgan et al, 2002): • Ngangu (Bunuba and Walmajarri language) • Ngawoonkoo (Nyikina language)
3. *Is this **species conventionally accepted**? If not, explain why. Is there any controversy about the taxonomy?*	This species is conventionally accepted.
4. *If **the species** is **NOT conventionally accepted**, please provide:* *(i) a taxonomic description of the species in a form suitable for publication in conventional scientific literature; **OR*** *(ii) evidence that a scientific institution has a specimen of the species and a written statement signed by a person who has relevant taxonomic expertise (has worked, or is a published author, on the class of species nominated), that the person thinks the species is a new species.*	Not applicable

5. *Is this species **taxonomically distinct** (Taxonomic distinctiveness – a measure of how unique a species is relative to other species)?*	*C. leucas* is taxonomically distinguished from other distinct species due to particular morphological attributes, however due to the often subtle differences of morphology between *Carcharhinus spp.*, this distinction is not always clear to the untrained eye. In particular, *C. leucas* can be mistaken for *Carcharhinus amboinensis* (Pigeye Shark) (Thorburn et al, 2004). As a result, it is important that protection is given to all whaler sharks to ensure it can be effective.

Legal Status

6. *What is the species' **current conservation status** under Australian and State/Territory Government legislation?*	*C. leucas* is not listed under any Australian or State/Territory Government legislation.
7. *Does the species **have specific protection** (e.g. listed on an annex or appendix) under other legislation or intergovernmental arrangements, e.g. Convention on International Trade in Endangered Fauna and Flora (CITES), Convention on Migratory Species (CMS).*	*C. leucas* is listed as *Near Threatened* under the International Union for Conservation of Nature (IUCN) Red List (Simpfendorfer & Burgess, 2005).

Description

8. *Give a brief description of the species' **appearance**, including size and/or weight, and sex and age variation if appropriate; social structure and dispersion (e.g. solitary/clumped/flocks).*	*Carcharhinus leucas* is a large, solidly built shark from the family *Carcharhinidae* with a blunt snout, small eyes, a relatively large second dorsal fin, no interdorsal ridge and broadly triangular serrated teeth. Dorsal surface is grey with a pale to white underbelly. (Last & Stephens, 2009). See Figure 1 for a picture of *C. leucas*. Juveniles are born at 55 – 80cm. Maximum length estimated at up to 340cm total length, with females slightly larger than males, although a female *C. leucas* was officially measured at 400cm total length with an estimated weight of over 600 kg (McCord and Lamberth, 2009; Last & Stephens, 2009). Mass at length can vary greatly for both males and females, with an estimated maximum weight of between 230 - 419kg (Camhi et al, 2007). Maximum age is estimated at 49 years, with sexual maturity occurring at approximately 14 - 20 years, and 160 – 230cm in length (Cruz-Martinez et al, 2004). Little is known about the social behaviour of *C. leucas*, however it appears to be a primarily solitary or paired species which gathers to aggressively compete for plentiful food sources. The species gives birth to 1 -13 young in estuarine environments, and juveniles spend considerable periods in environments of low salinity, although this is likely a method of predator avoidance and/or increased food abundance rather than a physiological constraint (Pillans et al, 2005). Little is known about the movements of adult bull sharks in Australian waters, but there are reports of both sedentary and migratory behaviour internationally. *C. leucas* is considered a very dangerous shark, due to its extremely aggressive nature, powerful jaws, broad diet, abundance and its preference for shallow, murky inshore habitats. The species is probably responsible for most of the attacks in and around Sydney Harbour (Last & Stevens, 2009).
9. *Give a brief description of the species' **ecological role** (for example, is it a 'keystone' or 'foundation' species, does it play a role in processes such as seed dispersal or pollination).*	As one of the few species of shark that comfortably range between freshwater and hypersaline environments, *C. leucas* plays an important role as an apex and keystone predator in freshwater, estuarine and marine environments. Population declines of large sharks such as *C. leucas* have been correlated with detrimental ecological cascades from both environmental and economical perspectives (Myers and Worm. 2003).

Australian Distribution

10. *Describe the species' **current and past distribution in Australia** and, if available, attach a map.*	*C. leucas* is a wide-ranging species that occurs in tropical and coastal regions of Australia, as far south as Sydney on the east coast around the northern coastline to Perth on the west coast. It prefers shallow waters, but has been found in waters to a depth

	of at least 150m (Camhi et al, 2007). As a euryhaline species, it is highly tolerant of salinity variations, and has penetrated far inland via river systems (Neer et al, 2005; Pillans et al, 2005). Last and Stevens (2009) state that *C. leucas* has been reported from numerous freshwater systems in warm temperate and tropical Australia, including the Fitzroy, Ord, Adelaide, Daly, East Alligator, Mitchell, Normanby, Herbert, Brisbane, Clarence and Swan Rivers, as well as Lake Macquarie. It is rarely recorded in the sea off Australia, most probably due to confusion with other whaler sharks.
11. *What is the* ***extent of occurrence*** *(in km^2) for the species (described in Attachment A); explain how it was calculated and datasets used.*	
a. *What is the* ***current*** *extent of occurrence?*	The extent of occurrence of *C. leucas* has not been determined in terms of square kilometres. The Australian distribution of the species has been described as extending between Sydney (NSW) and Perth (WA) in coastal, estuarine, riverine and lacustrine habitats. In marine environments *C. leucas* occurs near the bottom from the surf zone down to a depth of at least 150 metres. (Last & Stevens, 2009) Based on maps of hypothetical distribution, *C. leucas* occurs within an estimated 50% of Australia's Exclusive Economic Zone (EEZ). Due to the inherent lack of data regarding extent of occurrence of *C. leucas*, a definitive extent of occurrence cannot be given.
b. *What data are there to indicate* ***past declines*** *in extent of occurrence (if available, include data that indicates the percentage decline over the past 10 years or 3 generations whichever is longer)?*	There is currently insufficient data available to indicate past declines in extent of occurrence.
c. *What data are there to indicate* ***future changes*** *in extent of occurrence (if available, include data that indicates the percentage decline over 10 years or 3 generations whichever is longer (up to a maximum of 100 years in the future) where the time period is a continuous period that may include a component of the past)*?	Due to insufficient data and the broad habitat tolerance of *C. leucas,* there is little to indicate that the potential extent of occurrence will change significantly in the future.
12. *What is the* ***area of occupancy*** *(in km^2) for the species (described in Attachment A); explain how calculated and datasets*	

that are used.	
a. *What is the **current** area of occupancy?*	*C. leucas* moves throughout the extent of occurrence described in Q11. Data do not exist on unoccupied habitats within the extent of occurrence. It is therefore difficult to determine the current area of occupancy for this species.
b. *What data are there to indicate **past declines** in area of occupancy (if available, include data that indicates the percentage decline over the past 10 years or 3 generations whichever is longer)?*	Due to insufficient data and broad habitat tolerances, there is little to indicate that the potential area of occupancy of *C. leucas* has changed significantly in the past.
c. *What data are there to indicate **future changes** in area of occupancy (if available, include data that indicates the percentage decline over 10 years or 3 generations whichever is longer (up to a maximum of 100 years in the future) where the time period is a continuous period that may include a component of the past)?*	There is insufficient data to indicate future changes in area of occupancy. Due to the broad tolerance of environmental conditions by *C. leucas*, it is unlikely that there will be future changes in area of occupancy. However, anthropogenic habitat modification and pollution may lead to a reduction of suitable estuarine and freshwater regions for juveniles (Hazin et al, 2008, O'Connell et al, 2007).
13. *How many **natural locations** do you consider the species occurs in and why? Where are these located?* *The term 'location' defines a geographically or ecologically distinct area.*	*C. leucas* has a very broad range of habitat within its area of occupancy, and thus the species does not occur within any specific geographically or ecologically distinct marine environments. However, *C. leucas* does inhabit a number of freshwater/estuarine systems in Western Australia, including the Fitzroy river and its tributaries, and notably in the Parramatta River in Sydney (Green et al, 2009; Thorburn et al, 2004). It is likely that it capable of inhabiting freshwater reaches of rivers, although these are not necessarily distinct in nature.
14. *Give **locations of other populations**: captive/propagated populations; populations recently re-introduced to the wild; and sites for proposed population re-introductions. Note if these sites have been identified in recovery plans.*	Although *C. leucas* has been successfully kept in captivity elsewhere, there are no instances of captive populations of *C. leucas* in Australia. There has been no recent reintroduction of *C. leucas* populations to the wild. There are no current sites for proposed reintroductions. Despite local observations, Werry et al (2009) observed that canal development for waterfront real estate has not necessarily produced an environment favourable for adult bull sharks.
15. *Is the species' **distribution severely fragmented?** What is the cause of this fragmentation? Describe any biological, geographic, human-induced or other barriers causing this species' populations to be fragmented.* *Severely fragmented refers to the situation in which increased extinction*	Due to the wide distribution of *C. leucas*, it is unlikely that the species' distribution is severely fragmented. However, due to the cohabitation of sharks and humans in coastal environments, human induced fishing pressures may have some impact on genetic isolation. Unfortunately, data on the genetic distribution of *C. leucas* subpopulations in Australia is currently insufficient or unavailable.

risk to the taxon results from most individuals being found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonisation.	
16. *Departmental Use Only:*	

Global Distribution

17. *Describe the species' **global distribution**.*	*C. leucas* is a cosmopolitan species found in most northern and southern temperate, subtropical and tropical waters in all continents except Antarctica and Europe. See Figure 2 for the global distribution map. It is capable of entering freshwater river systems indefinitely, and has been found at least 3000km inland in the Amazon River and Mississippi River, as well as in the freshwater Lake Nicaragua in Central America and the hypersaline St. Lucia Estuary in South Africa (Jensen, 1976; Simpfendorfer et al, 2005; Thorson, 1972). The species' worldwide distribution has resulted in multiple descriptions and numerous common names for the species (including Zambezi Shark, Swan River Shark and Lake Nicaragua Shark) from throughout its range (Simpfendorfer & Burgess, 2005). Simpfendorfer & Burgess (2005) note that the species is native to the following countries: Australia, Bangladesh, Bolivia, Botswana, Brazil, Columbia, Costa Rica, Ecuador, Fiji, Gambia, Guinea, Guyana, India, Islamic Republic of Iran, Iraq, Malawi, Mexico, Mozambique, Nepal, New Caledonia, Nicaragua, Peru, Philippines, Senegal, South Africa, United Republic of Tanzania, United States, Venezuela, Zimbabwe.
18. *Give an overview of the **global population**'s size, trends, threats and security of the species outside Australia.*	The population trend of *C. leucas* is unknown (Simpfendorfer & Burgess, 2005). There are trends to suggest that globally, bull shark populations are under threat by commercial fisheries. *C. leucas* is a commonly caught shark species in a large number of countries both as bycatch and a targeted species. The demand for shark products has increased in recent years, and thus *C. leucas* is threatened by an increase of fishing effort and a reduction of selectivity in the fishing process, as well as bycatch mortality in unrelated fisheries. Additionally, due to its proclivity for estuarine and riverine environments as nursery grounds frequently neighbouring human development, *C. leucas* is threatened by anthropogenic habitat modification and shark control programs (Dudley, 1997). Despite their tolerance of a wide variety of water conditions,

	O'Connell et al (2007) reported an effective extirpation of bull sharks due to habitat pollution in Louisiana, USA. Myers et al (2007) collate United States data regarding *C. leucas* population trends, indicating an estimated decline of 67% - 99% in some regions of the eastern coast.
19. *Explain the **relationship** between the Australian population and the global population, including:*	
a. *What **percentage** of the global population occurs **in Australia**;*	As there is no data defining populations of *C. leucas* either globally or Australia wide, it is not possible to define the percentage of the global population of the species is found in Australian waters.
b. *Is the Australian population **distinct**, geographically **separate** or does part or all of the population move in/out of Australia's jurisdiction (give an overview; details in Movements section);*	Preferring shallow waters*, C. leucas* is rarely observed in open ocean and thus Australian populations of the species are likely distinct from those that have been geographically isolated by deeper waters. However there is insufficient data to positively define the movements of *C. leucas* on an international scale and we are not aware of any studies underway to ascertain this data.
c. *Do **global threats** affect the Australian population*?	The Australian population is likely subject to the same threats nationally as it is worldwide, particularly those brought about by human impact occurring in costal and offshore areas. These threats particularly impact on *C. leucas* due to the location of their nursery areas in estuarine and freshwater systems, making them vulnerable to pollution and habitat modification (Simpfendorfer & Burgess, 2005). Whilst Illegal, Unregulated and Unreported (IUU) fishing levels have not been quantified, IUU fisheries in Australia, particularly in regions bordering south east Asia, may have a deleterious impact on Australian populations of *C. leucas.*

Surveys and Monitoring

20. *Has the species been **reasonably well surveyed**?* *Provide an overview of surveys to date and the likelihood of its current known distribution and/or population size being its actual distribution and/or population size.*	*C. leucas* has been inadequately surveyed quantitatively in Australian waters. Due to this dearth of required data, there is a great deal of uncertainty regarding actual numbers. Anecdotal evidence from recreational and commercial fishers is common, however cannot be reliably accounted for accuracy. There have been limited surveys undertaken - Thorburn et al (2004) is a survey of elasmobranches in the freshwater reaches of the Fitzroy River catchment in Western Australia which while useful in its insight, is limited in its geographical range. Werry et al (2009) examined the value of varied coastal habitats to the species in the Gold Coast/Nerang river region using acoustic tagging. The nominees are also aware of a NSW DPI program to tag and

	release bull sharks in Sydney harbour that has been underway since Summer 08/09. It is thought that only one shark was caught in 2009, and since then none have been caught.
21. *For species nominated as extinct or extinct in the wild, please provide details of the* ***most recent*** *known* ***collection****, or authenticated* ***sighting*** *of the species and whether additional populations are likely to exist.*	Not applicable
22. *Is there an ongoing* ***monitoring programme****? If so, please describe the extent and length of the programme.*	There are no ongoing monitoring programs of bull shark populations in Australia.

Life Cycle and Population

23. *What is the species' total population size in terms of* ***number of mature individuals****? How were population estimates derived and are they reliable? Are there other useful measures of population size and what are they?* In the absence of figures, terms such as common, abundant, scarce can be of value.	There is insufficient data to reliably define the total population size of *C. leucas*. In international regions of similar environment and impact, local populations of *C. leucas* have fallen up to 99.9% due to overfishing and environmental degradation (O'Connell et al, 2007). Further, the average size of caught specimens has markedly reduced, indicating a lower proportion of mature individuals (Wintner et al, 2002).
24. *Does the species occur in a* ***number of smaller populations****? How many? For each population give the locality, numbers and trends in numbers and tenure of land (include extinct populations). Can these be considered to be subpopulations and why?* **Subpopulations** are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange.	There is insufficient data to indicate the presence of distinct subpopulations of *C. leucas* in Australian waters, however due to the extensive size of the species' natural range, it is likely that there is little genetic exchange between geographically distanced individuals. Further genetic studies of bull shark populations would assist in understanding these dynamics further.
25. *Provide details on ages of the following:*	
a. *sexual maturity;*	Sexual maturity for both sexes appears to vary throughout their range. Estimates for sexual maturity for both male and female *C. leucas* range from 6-14 years (Camhi et al, 2007), 9-10 years (Cruz-Martinez et al, 2004), and 20 years (Last and Stevens, 2009). Males mature at 157-226cm and females at 180-230 cm (Simpfendorfer & Burgess, 2005).
b. *life expectancy;*	Life expectancy data varies across their range. Last and Stevens (2009) report that the species has a life expectancy of up to 50 years in South Africa. Simpfendorfer and Burgess (2005)

	estimate that females live up to 16 years and males to 12 years from a study in Lake Nicaragua. The author is not aware of any life expectancy study that has been undertaken in Australia.
c. *natural mortality.*	Heupel and Simpfendorfer (2008) note that juvenile *C. leucas* appear to have a relatively low natural mortality rate according to capture/recapture records over their first 18 months. There is insufficient data to estimate natural mortality rates of adult age cohorts, however as an apex predator in most of its range, it is likely that natural mortality for adults is low. Simpfendorfer & Burgess (2005) reported that a research study estimated the natural mortality of *C. leucas* to be 0.166 $year^{-1}$ based on a maximum age of 27 years.
26. Reproduction	
For animals*: provide overview of breeding system and of breeding success, including: when does it breed; what conditions are needed for breeding; are there any breeding behaviours that may make it vulnerable to a threatening process?*	Scientific research reports a wide range of information on the reproduction of *C. leucas.* Depending on locality, bull sharks reach maturity at an age of between 6 – 15 years (the lower range for males), and a length of approximately 200cm for both sexes. *C. leucas* is a viviparous species that gives birth to 1 – 22 live young, dependent on locality (Cruz-Martinez et al, 2004). The gestation period for this species is between 10 – 11 months (Calliouet et al, 1964; Camhi et al, 2007). Breeding is temperature dependent – temperate areas have a late spring summer breeding period, while in tropical latitudes it is recorded that females can be caught at various stages of prenatal development throughout the year. Last and Stevens (2009) report that females normally give birth in estuaries and river mouths and the young remain in the river for up to 5 years; litter sizes range from 1-13 and the gestation period is 10-11 months. Simpfendorfer and Burgess (2005) report that reproduction is by placental viviparity, and most litters are between 6-8 pups. Birth normally occurs in late spring and summer, although in warmer areas (e.g. Nicaragua) breeding may occur year-round. Juveniles are independent from birth. Low rates of mortality among juvenile cohorts are been recorded by Simpfendorfer et al (2005). Bull sharks are highly dependent on estuarine environments as pupping and nursery grounds. Females move into these areas during parturition, however it is uncertain whether mating occurs there as well (Snelson, 1984). As these environments are also very important for human activities, there is potential that this breeding behaviour increases the potential for conflict. Beyond this, other factors of breeding success are poorly understood.

27. *What is the **population trend** for the entire species?*	
a. *What data are there to indicate **past decline** in size (if available, include data on rate of decline over past 10 years or 3 generations whichever is longer)?*	Numerous author report long term declines in *C. leucas.* O'Connell et al (2007) found high significant declines in populations in heavily fished and environmental degraded estuaries in Lousiana, United States – it was estimated that the species had declined by 98.6% to 99.9% since 1953. Wintner et al (2002) likewise reported an 85% decline in populations of *C. leucas* over a period between 1966 and 1977 in South Africa, with even further declines since. There is insufficient data to indicate similar trends in Australian waters, however it is likely that due to similar conditions and pressures, it could be assumed that similar declines are at least possible. The IUCN states that the population trend is unknown (Simpfendorfer & Burgess, 2005).
b. *What data are there to indicate **future changes** in size (if available, include data which will indicate the percentage of decline over 10 years or 3 generations whichever in longer (up to a maximum of 100 years in the future) where the time period is a continuous period that may include a component of the past)?*	There are no published data readily available that indicate future changes in the size of *C. leucas* populations. However, due to the proximity of human development with *C. leucas'* preferred habitat, it is likely that significant portions of *C. leucas'* habitats, particularly riverine and estuarine systems but also marine environments, have suffered a decline in quality (Cavanagh et al, 2003). In addition, *C. leucas* is frequently caught as bycatch in industrial fishing practices as well as being targeted as a sport fish and also exploited for its skin, liver oil and flesh, and prized for its fins in the shark-fin trade (Simpfendorfer & Burgess, 2005). These are therefore two of the main threats facing the bull shark which suggest that the population may decline in future unless these threats are addressed.
28. *Does the species undergo **extreme natural fluctuations** in population numbers, extent of occurrence or area of occupancy? To what extent and why?* **Extreme fluctuations** can be said to occur in a number of taxa when population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e. a tenfold increase or decrease).	Extreme fluctuations can be said to occur in a number of taxa when population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e. a tenfold increase or decrease). Though there is insufficient data to show that *C. leucas* undergoes extreme natural fluctuations in population numbers, this species is typified by slow growth rates, low mortality rates and a relatively low reproductive rate. Therefore it is highly unlikely that the species is characterized by extreme natural fluctuations.
29. *What is the **generation length** and how it is calculated?* **Generation length** is the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation	In this examination generation length is the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used. Utilising data from Smith et al (1998), in which *C. leucas* is

length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used.	conservatively given an age of maturity of 15 years and a maximum reproductive age of 27 years, it can be calculated as the average age of reproductive potential. Therefore if generation length is the average age of parents of the current cohort, this would be estimated at 21. (15+27)/2 = 21 years. However there is data to indicate that Australian populations become sexually mature at larger sizes (Frisk et al, 2000), and as size is usually correlated with age, it is possible that this generation length is conservative.
30. *Identify **important populations** necessary for the species' long-term survival and recovery? This may include: key breeding populations, those near the edge of the species' range or those needed to maintain genetic diversity.*	There are no data readily available that identifies populations of importance for this species.
31. *Describe any **cross-breeding** with other species in the wild, indicating how frequently and where this occurs.*	There is insufficient data regarding the occurrence of cross-breeding with other species in the wild. To date this behaviour has not been observed or recorded.
32. *Departmental Use only:*	

Populations In Reserve

33. *Which **populations** are **in reserve systems**? Which of these are actively managed for this species? Give details.*	No species-specific mechanisms are currently in place to manage particular populations of *C. leucas*, though sharks in general may be afforded some protection in reserve areas; however specific details regarding populations that *remain* within MPAs are not available. In Australian waters, *C. leucas* is likely found within Marine Protected Areas in the species range, occurring either permanently or occasionally. The map below shows the Commonwealth marine protected areas as of 2009 (source: DEWHA). *Image deleted due to copyright requirements*

Habitat

34. *Describe the **species' habitat** (e.g. aspect, topography, substrate, climate, forest type, associated species, sympatric species). If the species uses different habitats for different activities (e.g. breeding, feeding, roosting, dispersing, basking), then describe each habitat.*	*C. leucas* inhabits a broad range of aquatic environments. These range from shallow marine environments of depths of 1m to depths of 150m, and due to the specie's euryhaline physiology it also has the capacity to survive indefinitely in estuarine and completely freshwater river and lake environments. It is found within waters of both very high and low turbidity. The species is known to be migratory in its habits, with pregnant females migrating to estuarine areas to give birth. The juveniles remain in these areas until temperatures drop below optimal levels when they migrate to warmer offshore waters. (Simpfendorfer & Burgess, 2005). Simpfendorfer and Burgess (2005) also reported on a study in the US which demonstrated the migratory behaviour of *C. leucas* along the east coast, moving northwards during summer as temperatures rise and southwards as temperatures in the north cooled. The behaviour of adult bull sharks appears to vary across their range. Most authors report observations that adults have a relatively sedentary lifestyle – although there is an ontogenic partition and movement between environments relating to age categories, adults rarely move far from the surrounding waters of the estuaries they developed in (Wintner et al, 2002). In general, adults use estuarine environments with mid-range salinity values as nursery grounds (McCord and Lamberth, 2009; O'Connell et al, 2007), including man-made canal systems (Green et al, 2009; Heupel and Simpfendorfer, 2008). Juvenile *C. leucas* usually remain within low salinity estuarine environments, surmised to be advantageous due to lower risk of predation.

35. *Does the species use **refuge habitat**, e.g. in times of fire, drought or flood? Describe this habitat.*	As an active swimmer, *C. leucas* is likely capable of retreating to zones of lesser impacted coastal water in times of flood or storm.
36. *Is the **extent or quality** of the species' habitat **in decline**? If the species uses different habitats, specify which of these are in decline.*	Due to the proximity of human development with *C. leucas'* preferred habitat, it is likely that significant portions of *C. leucas'* habitats, particularly riverine and estuarine systems but also marine environments, have suffered a decline in quality (Cavanagh et al, 2003). This decline is primarily due to anthropogenic habitat modification and pollution through agriculture and industry.
37. *Is the species part of, or does it rely on, a **listed threatened ecological community**? Is it associated with any other **listed threatened species**?*	*C. leucas* is not solely part of, and does not rely solely on, a listed threatened ecological community. However as an opportunistic predator *C. leucas* likely interacts with listed threatened species as part of a balanced ecosystem. The nominees are not aware of specific examples have that have been published.

Feeding

38. *Summarize the species' **food** items or sources and timing/seasonality.*	*C. leucas* is an opportunistic eurytrophic predator (Thorburn, 2006). Although preferring bony fish and other elasmobranches as prey, *C. leucas* is omnivorous and has been known to consume turtles, birds, terrestrial and aquatic mammals including dolphins, crustaceans, molluscs and echinoderms, as well as carrion (Last and Stevens, 2009). Snelson et al (1984) observed that analysis of stomach contents of *C. leucas* showed selectivity for the most common food items present, usually bony fish species. A greater dependence on elasmobranch prey has been correlated with increased size (Cliff and Dudly, 1991). There is no data available on seasonality of dietary preference.
39. *Briefly describe the species' **feeding behaviours**, including those that may make the species vulnerable to a threatening process.*	*C. leucas* is an aggressive and inquisitive feeder that relies on visual, electrochemical and olfactory cues to locate prey. The species' willingness to undertake exploratory feeding behaviour on a wide variety of organisms, including rare instances of humans, leads to this species being particularly maligned, and hence targeted by retaliatory fishing effort. It's easily accessed habitat and low selectivity of food items makes this species vulnerable to such concerted hunting efforts.

Movement Patterns (fauna species only)

40. *Describe any relevant **daily and seasonal pattern of movement** for the species, or other irregular patterns of movement, including relevant arrival/departure dates if migratory.*	Data from international research shows that female bull sharks in temperate waters show seasonal movement patterns related to breeding requirements. In temperate and subtropical waters, pregnant females move into estuaries and river mouths during late spring early summer to give birth, and often move upstream after birth to take advantage of low competition for prey items

	(Pillans et al, 2004; Schmidt and Murru, 1994). Unfortunately there is little data on the daily movements of adult bull sharks, however Snelson et al (1984) and Thorburton (2006) observe a marked increase of activity during night hours in marine, estuarine and freshwater conditions. Depending on its locale, the species is known to be either highly migratory or relatively sedentary. In Nicaragua, *C. leucas* has been observed moving up and down freshwater rapids towards the Nicaragua Lake system, travelling 190km from oceanic conditions to freshwater lacustrine conditions over the period of 7 – 11 days (Thorston, 1971). Conversely, elsewhere *C. leucas* is considered a relatively sedentary species (Winter et al, 2005). With conflicting evidence from international sources, and insufficient data regarding the movement of *C. leucas* in Australian waters, it is infeasible to apply the same assumptions to local populations of bull sharks without further research.
41. *Give details of the species' **home ranges/territories**.*	There is insufficient data regarding adult bull shark home range or territory, although the species is considered solitary and aggressively competitive (Bres, 1993).

Survey Guidelines

42. *Give details of the **distinctiveness and detectability** of the species.*	*C. leucas* is a considered a large, aggressive and inquisitive shark (Thorburn, 2007). As it is one of a very limited number of shark species to spend time in low salinity environments, it often has distinctiveness due to its locality alone. However, in environments where other species of genus *Carcharhinus* are found, accurate identification is often challenging, and it is surmised that many observations of *C. leucas* in open marine environments are actually misidentified (Thorburn et al, 2004). Adults have indistinct fin markings making them challenging to identify from distance (Last and Stevens, 2009). Juveniles of *C. leucas* are difficult to identify without tooth count examination. The detectability of *C. leucas* is reliant on water conditions, however it willingly takes bait and is regarded as a relatively easy species to detect if searched for (Heupfel and Simpfendorfer, 2008).
43. *Describe **methods for detecting species** including when to conduct surveys (e.g. season, time of day, weather conditions); length, intensity and pattern of search effort; and limitations and expert acceptance; recommended methods; survey-effort guide.*	*C. leucas* studies have primarily used direct capture as a method of detecting the species in an environment. Due to their preference for coastal waters, capture primarily involves longline fishing (Simpfendorfer et al, 2005; Thorburn, 2004), seine netting and gill netting (O'Connell et al, 2007), depending on the importance on the survival of the shark. Surveys have also been conducted using examination of commercial bycatch records (O'Connell et al, 2007), and beach meshing records (Dudley, 1997; Krogh and Reid, 1996).

Section 2 - Threats and Threat Abatement

Threats

44. *Identify **past, current and future threats**, to the species indicating whether they are actual or potential. For <u>each</u> threat, describe:*	Primary threats to *C.leucas* can be identified into 3 broad categories: 1) environmental degradation and 2) fishing and 3) meshing practices.
a. ***how and where** it impacts on this species;*	*1)* As this species is highly dependent on estuarine environments for parturition and juvenile development, the environmental degradation caused by human induced habitat modification and pollution are likely to have more of an impact on this species in comparison to more pelagic species of shark. Canal developments in Florida (USA) and the Gold Coast (QLD, Australia) which have substantially altered the environment have been prolific in areas where *C. leucas* is found. (Simpfendorfer & Burgess, 2005). This is widely regarded as an *actual* threat. 2) *C. leucas* is frequently caught as bycatch in industrial fishing practices as well as being targeted as a sport fish and also exploited for its skin, liver oil and flesh, and prized for its fins in the shark-fin trade (Simpfendorfer & Burgess, 2005). This is a global impact, but in Australia is most likely to occur in subtropical and temperate coastal environments where humans and bull sharks most likely interact. Much of this fishing is largely unmonitored despite best efforts. The impacts of overfishing practices on *C. leucas* populations overseas are well documented, and thus are considered an *actual* threat. 3) The preferred environment of bull sharks overlaps with human recreational activities. *C. leucas* is frequently recorded in shark meshing programs in Australia and South Africa (Cliff And Dudley, 1991; Green et al, 2009). Simpfendorfer and Burgess (2005) note that due to species identification issues in Queensland program until the early 1990s the impacts of the Queensland shark control program is unknown. Shark nets have arguably contributed to the decline of large shark species and disruption of breeding behaviour, and thus this practice is a *potential* threat to the species, especially in combination with the previous factors. The species is also exploited by large aquariums as they adapt well to life in a tank. The increasing number of aquaria worldwide is increasing this demand, and it is not known what impact this will have on the wild bull shark population. (Simpfendorfer & Burgess, 2005).
b. *what its **effect** has been **so far** (indicate whether it is known or*	1) There is a paucity of data regarding the specific impact of environmental degradation on bull sharks in Australia. However it

suspected; present supporting information/research; does it only affect certain populations);	is widely believed that bull sharks, just like other estuarine species, are susceptible to habitat modification and environmental degradation due to human activities. Camhi et al (2007) and McCord and Lamberth (2009) indicate that habitat degradation impacts many species of sharks to the point of local population extirpation, and as bull sharks are more dependent on these environments than many other shark species, it is likely that this risk is exacerbated for this species. Hazin et al (2008) argues that habitat degradation may also lead to the displacement of shark populations into areas preferred by humans, leading to an increase in interactions. 2) Overfishing pressure is considered the most significant of threats regarding the conservation of *C. leucas*. The species is both a targeted and bycatch species in many fisheries in Australia and overseas (Camhi et al, 2007; Zhou and Griffith, 2008). Studies overseas have found that bull shark constitutes a significant proportion of sharks caught in both of these fisheries (O'Connell et al, 2007). However, the majority of shark capture is unrecorded or lacking in specificity, therefore the exact impact of fisheries is difficult to quantitatively ascertain. O'Connell (2007) suggests that direct fishing mortality, either through overharvesting or bycatch, is higher for apex predators in easily accessible near-shore habitats compared to more remote offshore areas. 3) Due to the relatively small movement range of bull sharks and a preference for shallow coastal and estuarine habitats, bull sharks are caught in shark meshing programs (Krogh and Reid, 1996).
c. *what is its **expected effect in the future** (is there supporting research/information; is the threat only suspected; does it only affect certain populations);*	1) In general, bull sharks will be impacted by habitat modification and degradation more than pelagic shark species due to proximity. Unfortunately there is insufficient data regarding the long term impact of habitat degradation on bull sharks, and due to their wide range this threat will be of higher significance in areas of human environmental interaction. It is expected that as human distribution increases further developments will result in increased interaction with *C. leucas.* 2) There is a considerable amount of data that suggests that most shark species that are impacted by fisheries will continue to be negatively impacted due to their low capacity for population rebound after consistent population decline (Camhi et al, 2007; Cavanagh et al, 2003). This holds true for bull sharks, which as previously mentioned, are more susceptible to all forms of fishing due to their preference for shallow estuarine habitats. This impact will likely spread over a wide area, impacting more populations of sharks, as demand for fisheries increases over time. 3) Shark meshing programs likely exacerbate the previous

	threats due to displacement due to habitat modification; however the threat of netting is likely to remain constant over time. Naturally, if more mesh programs are approved, their impact will increase.
*d. what is the **relative importance or magnitude** of the threat to the species.*	1) Habitat degradation is likely to be of high concern to *C. leucas*, as its natural range and need for low salinity nursery grounds makes it more susceptible to human impact through pollution and environmental modification than other more pelagic species. 2) Due to a lack of protection and little capacity of regulatory enforcement in global and local shark fisheries, fishing pressure is likely to be of very high importance. There is little indication that restrictions on shark fisheries have been effective given a rapid increase in demand for shark products. 3) Shark meshing programs are relatively localised impacts that while overall do not have a high level of impact magnitude, may lead to an exacerbation of the previous impacts.
45. *If not included above, identify **catastrophic threats**, i.e. threats with a low predictability that are likely to severely affect the species. Identify the threat, explain its likely impact and indicate the likelihood of it occurring (e.g. a drought/cyclone in the area every 100 years).*	Due to its broad distribution and habitat tolerance, *C. leucas* is unlikely to be directly impacted across its total population by a catastrophic effect as defined in this question. However, the possibility of food chain collapse due to any manner of events may have a deleterious effect on *C. leucas* populations. It could be argued that enhanced fishing pressure could emulate the effects of a catastrophic event (Hoenig and Gruber, 1990).
46. *Identify and explain any **additional biological characteristics** particular to the species that are threatening to its survival (e.g. low genetic diversity)?*	There is limited to no data on further biological characteristics of the bull shark that threaten its survival. Like most shark species, the bull shark maintains a relatively low fecundity and extended gestation period. There is arguably an osmoregulatory-related physiological need for juvenile bull sharks to remain in estuarine waters for extended periods of time (Heupel and Simpfendorfer, 2008; Whitehead, 2002) which increases the chances of individuals to be impacted by either degraded habitat conditions or fishing-related mortality. Fishbase (www.fishbase.org) assigns very high vulnerability and very low resilience to *C. leucas*.
47. *Identify and explain any **quantitative measures or models** that address the probability of the species' extinction in the wild over a particular timeframe.*	The nominees are not aware of a model such as this specifically outlined for *C.leucas*, however articles such as Myers and Worm (2005) highlight that in general, a reduction of mortality of 40%-80% is required for the recovery of elasmobranch populations in general. Field et al. (2009) have assessed the susceptibility of sharks to extinction.
48. *Is there **other information***	The lack of research in Australia, continued high level tropical

that relates to the survival of this species that you would like to address?	and temperate shark fisheries with no stock assessments, and the fact that species recording has been very poor result in there being little idea whether impacts on each species are also threats for the survival of *C. leucas*.

Threat Abatement and Recovery

49. *Give an overview of how broad-scale **threats** are **being abated**/could be abated and **other recovery actions** underway/ proposed. Identify who is undertaking these activities and how successful the activities have been to date.*	Due to the generally poor reputation of bull sharks (due to their aggressive nature) and their requirement for aquatic environments preferred for human activity, there has been historically little social incentive to undertake mitigation measures or approaches. There is an increase in ecological and biological studies of the species that will increase knowledge of bull shark behaviour such as Werry and Otway (2009).
50. *For species nominated as extinct in the wild, provide details of the locations in which the **species** occurs **in captivity** and the level of human intervention required to sustain the species.*	Not applicable

Mitigation Approach

51. *Describe any **mitigation measures or approaches** that have been developed specifically for the species at identified locations. Identify who is undertaking these activities and how successful the activities have been to date.*	Although various management plans have been launched for shark fisheries in Australia, in which fisheries are required to develop management tools such as quotas, licensing, equipment restriction and bycatch monitoring, these plans are applied as a general strategy for shark fisheries which target multiple species, as opposed to a species-specific approach (Camhi et al, 2007). Consequently there is little data to specifically reflect the success of such activities in regards to *C. leucas* in particular, with no stock assessments for bull sharks in particular or for large sharks in general.

52. *Departmental use only:*	

Major Studies

53. *Identify major studies on the species that might relate to its taxonomy or management.*	There are few major studies that focus *specifically* on bull shark taxonomy or management. However, bull sharks are prominent in a number of Australian studies that examine the interaction of elasmobranchs with shark meshing programs (Dudley, 1997; Green et al, 2009) Krogh and Reid, 1996) and fisheries practices (Zhou and Griffiths, 2008). Similar studies from international sources build on the general knowledge of elasmobranch management plans (Cavanagh et al, 2003).

Management Documentation

54. *Identify **key management documentation** available for the species, e.g. recovery plans, conservation plans, threat abatement plans.*	There is little evidence to suggest that *C. leucas* is the specific focus of recovery plans. However, documentation that examines management of sharks stocks in general are likely to be relevant.
55. *Departmental use only:*	

Section 3 – References and Reviewers

Notes:

- The opinion of appropriate scientific experts may be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and full contact details must also be provided in the reference list below.
- Please provide copies of key documentation/references used in the nomination

56. *Reference list*

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Figure 1 - *Carcharinus leucas* - Bull Shark

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Figure 2 – Global Distribution of *Carcharinus leucas* - Bull Shark

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