THE RISK ASSESSMENT

2 Identification of the problem: information on the stressor and the environment

2.1 Ashmore Reef – brief overview of habitats, flora, fauna, historical and cultural values

Ashmore Reef National Nature Reserve was established by the Commonwealth on 16 August 1983 in order to protect its unique and vulnerable tropical marine ecosystems. The Reserve has international significance due to its high biological diversity and ecological values, geomorphological features and oceanic location, and historical and cultural values (Commonwealth of Australia 2002).

2.1.1 Geographical location and oceanographic conditions

Ashmore Reef Nature Reserve is located in the eastern Indian Ocean approximately 400 kms off the northwest Australian coast, almost half way between Australia and Timor in Indonesia. It includes two extensive lagoons, several channelled carbonate sand flats, shifting sand cays, an extensive reef flat, and three vegetated islands- East, Middle and West Island (Commonwealth of Australia 2002). Rising from a depth of 100 metres, Ashmore Reef is an example of a shelf-edge atoll. The reef platform, covers an area of 239 km^2, and lies at the western extremity of the Sahul shelf being one of the only three emergent reef systems (Figure 3). An ocean current known as the Indonesian Through-flow provides a steady stream of nutrients across the West Sahul Banks. This current transports biological material from the rich and diverse reef systems of the Phillipines and Indonesia. The West Sahul reef systems, which include Ashmore Islands, are the initial recipients of this transported material and play a primary role in the maintenance of biodiversity in the reef systems further to the south (Simpson 1991).

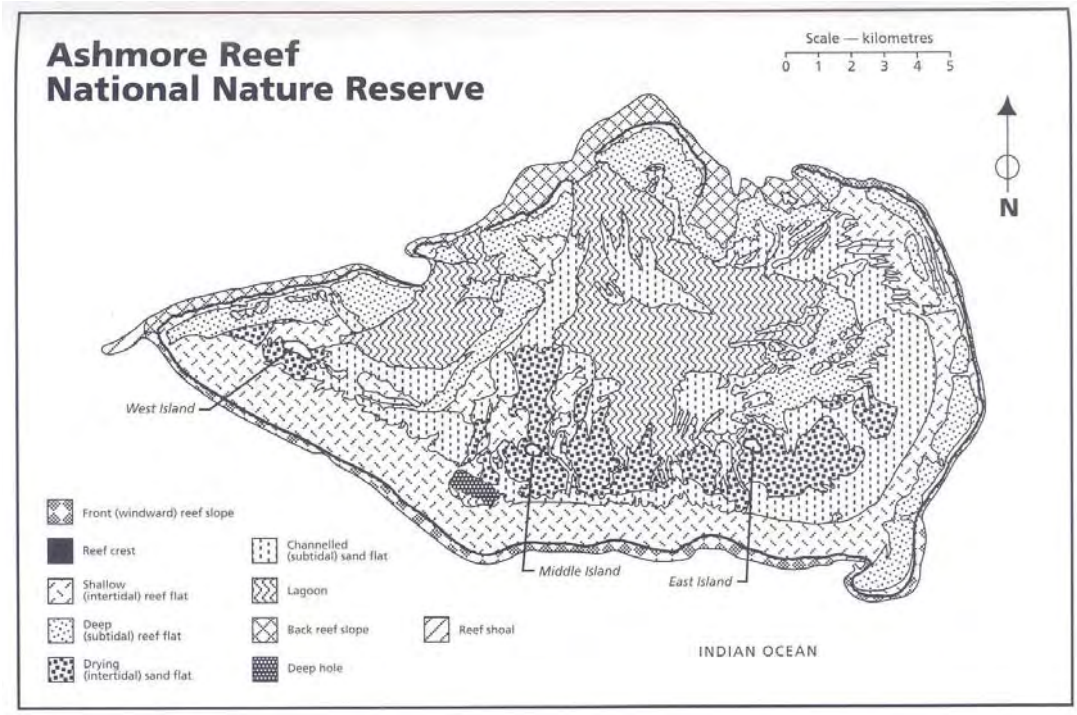

Figure 3 Physical feature of Ashmore reef (Pike & Leach 1997)

2.1.2 Historical and cultural values

Traditional Indonesian fishers have exploited the resources of Ashmore reef and adjacent islands for hundreds of years (Fox 1988, Clark 1998, 2000, Stacey 1999). In the past it was traditional practice for visiting fishermen to take turtles, seabirds and eggs for food and harvest sea cucumbers and trochus shells for commerce with Asian markets. Nowadays, an agreement between Australia and Indonesia (Memorandum of Understanding MOU) allows traditional Indonesian fishers to continue to regularly visit Ashmore Reef National Nature Reserve for fresh water, shelter and to visit grave sites but harvest of marine species is illegal. Fishing is only permitted for immediate consumption at West Island Lagoon of the Reserve (Commonwealth of Australia 2002).

Ashmore and Cartier islands were discovered by Europeans early in the nineteenth century (Russell & Vail 1988). A guano extraction industry was exploiting deposits on West Island between the 1840s and 1890s. There is evidence that prior to mining, West Island was the only Ashmore island with significant numbers of nesting sea birds. As a consequence of the mining activity and because of the introduction of rats, it would appear that most population of nesting birds were driven off West Island and established on Middle and East Islands, but the amount of guano material and the consequences of this activity have been poorly recorded and are largely unknown (Commonwealth of Australia 2002).

2.1.3 Ecological values – marine ecosystems

Because of its location and the oceanographic condition described in the previous paragraphs, the marine environments of Ashmore Reef Islands are notable for their high biological diversity. The Reserve supports the greatest number of reef building coral species of any reef area on the Western Australian coast (Veron 1993). The reef provides habitat for a great number of vertebrate and invertebrate marine species: fish, crustaceans, sponges, echinoderms and high populations of foraminifera (http://www.ea.gov.au/coasts/mpa/ashmore/index.html). Ashmore Reef has the highest known diversity and density of sea snakes in the world, three species of which are endemic to Australia's North West Shelf (Hanley & Russell 1993, Guinea 1993, Guinea & Pike 1994).

The reef flats of Ashmore Reef have also areas of sea grass, which provide critical feeding habitat for dugongs and turtles. Preliminary DNA studies have indicated that the small population of dugong (*Dugong dugong*) found within Ashmore Reef Reserve might be genetically distinct from any other Australian population (Whiting 1999).

The Reserve supports a significant population of approximately 10 000 nesting and immature feeding green turtle (*Chelonia myda*), small populations of nesting and feeding hawksbill turtle (*Eretmochelys imbricata*) and feeding individuals of the nationally endangered loggerhead turtle (*Caretta caretta*) (Guinea 1995).

2.1.4 Ecological values – terrestrial ecosystems

Flora

Ashmore Reef includes three small vegetated islands, about 15 ha each. The range of plant species recorded from Ashmore is limited, nevertheless an on-going dynamism in terrestrial species, in particular of grasses and small herbs, is continuosly occurring. The vegetation varies with seasonal conditions, new species are introduced by ocean currents and human activities, and the loss of species may result from natural events such as cyclones, high tides

spring events, long dry seasons, beach erosion and the effect of turtles and birds nesting (Pike & Leach 1997, Russell et al 2004).

West Island has a fringing shrubland community, comprising mainly octopus bushes (*Argusia argentea*), several coconut trees and isolated examples of fish plate shrub (*Guettarda speciosa*), Cardwell cabbage tree (*Scaevola sericea*) and sea trumpet (*Cordia subcordata*) (Figure 4).

Figure 4 Aerial view of West Island

This shrubland community provides suitable nesting habitat for the eastern reef egret (*Egretta sacra*) and the red-tailed tropicbird (*Phaeton rubricauda*). The interior of the island is dominated by herbs and grasses. The Asian beach spinifex (*Spinifex littoreus*) occurs on the northern beach of West Island, in a patch behind the dune area. This species, found from India through Sri Lanka and Malaysia to Indonesia, is the only record known for the Australian region (Pike & Leach 1997).

East island is predominantely grassland, with a species mix that includes *Digitaria marianensis, Lepturus repens, Boerhavia* sp and *Sporobolus virginicus*. The south west part of the island is occupied by several bushes of the introduced beach caltrop (*Tribulus cistioides*). This species is a pantropical weed, native to Central America and the Caribbean region, known to vigorously colonise new areas. Although an aggressive coloniser and invader in other areas of Australia, the species's distribution appears to be quite stable at Ashmore (Pike & Leach 1997). The habitat occupied by this species is used by the frigatebirds for roosting and by the eastern reef egrets for nesting.

Middle Island has the vestigial remnants of a fringing shrubland, comprising *Scaevola sericea, Argusia argentea* and *Suriana maritima* and the interior is dominated by herbfields and grasses similar to that found on East Island. The Middle Island shrubs provide the nesting habitat for the lesser frigatebird (*Fregata ariel*), the red footed booby (*Sula sula*), and the eastern reef egret (*Egretta sacra*). The brown booby (*Sula leucogaster*) and masked booby (*Sula dactylatra*) utilise these shrubs mainly for roosting, as they usually place their nest on the ground (Figure 5).

Figure 5 Red footed boobies and lesser frigatebirds nesting on vestigial remnants of *Argusia argentea,* November 2004

Birds

Despite the small size of the islands, the Reserve supports some of the most important seabirds rookeries of the North-west shelf. Past bird surveys at Ashmore recorded up to 50 000 seabirds of 26 species, of which 16 species have been recorded breeding, and up to 2000 shorebirds of 30 species. (ANPWS 1989, Milton 1999a&b, Swann 2001, Curran 2003). Large colonies of sooty tern (*Sterna fuscata*), crested tern (*Sterna bergii*), bridled tern (*Sterna anaethetus*) and common noddy (*Anous stolidus*) breed on East and Middle Islands (Milton 1999a). Ashmore Reef is the largest breeding colony of sooty terns in Western Australia, and the second largest colony of common noddy in Australia, after the Abrolhos Islands population (Higgins & Davies 1996, Milton 1999a&b, Dunlop & Goldberg 1999). The breeding colonies of other seabird species are also nationally significant. The estimates of 3000–4000 breeding pairs of bridled terns make Ashmore one of the five largest colonies recorded in Australia. The crested tern colony is similar in size to the third largest colony recorded elsewhere in Australia (Higgins & Davies 1996, Milton 1999).

During the field visit of this project, common noddy and sooty tern were recorded on Middle and East Island. The common noddy appeared to have just completed the breeding cycle, as the majority of individuals present on the islands were juveniles, whereas the sooty terns had just started to gather in thousands , and few started to lay eggs on Middle Island (Figure 6). Lesser frigatebirds (*Fregata ariel*), brown boobies (*Sula leucogaster*), masked boobies (S*ula dactylatra*), eastern reef egret (*Egretta sacra*) were recorded nesting on both islands, and red-footed boobies and crested terns (*Sterna bergii*) were found nesting on Middle Island.

Figure 6 Sooty terns on Midddle Island, November 2004

Ashmore Reef Reserve is also an important point for many migratory shorebirds. Thirty species of shorebirds have been recorded at least once on Ashmore Reef. This represents almost 70% of the species that regularly migrate to Australia (Watkins 1993). Two species, the grey-tailed tattler (*Heteroscelus brevipes*) and the ruddy turnstone (A*renaria interpres*), occur in numbers of international significance (more than 1% of the East Asian-Australasian Flyway population). Other species including the eastern curlew (*Numenius madagascariensis*), whimbrels (*Numenius phaeopus*), bar-tailed godwits (*Limosa lapponica*), common sandpipers (*Actitis hypoleucos*), and red-necked stint (*Calidris ruficollis*) occur in large flocks during October to November and March to April. Despite shorebirds using the outside perimeter of the three islands at high tide as roosting sites, they spend the majority of time feeding in habitats (intertidal areas) not suitable for the tropical fire ant, and as such will not be discussed in this report.

Turtles

There are seven species of marine turtles in the world and six occur in Australian waters. All six species have suffered population declines as a result of pollution, entanglement in fishing nets and egg predation by exotic species such as foxes and dogs. All turtles are protected in Australian waters (http://faunanet.gov.au/wos/factfile.cfm?Fact_ID=286). The three species of turtles occurring at Ashmore Reef (green turtle, hawksbill turtle and loggerhead turtle) are all listed on the 2000 IUCN Red List of Threatened Species, and under the *Convention on the International Trade of Endangered Species of Wild Animals* (CITES) and the *Convention on Migratory Species* (CMS). At a national level the green turtle (www.environment.gov.au/coasts/species/turtles/green.html) and the hawksbill (www.environment.gov.au/coasts/species/turtles/hawksbill.html) turtle are both listed as vulnerable, while the loggerhead turtle is listed as endangered, and in Western Australia as specially protected fauna (www.environment.gov.au/coasts/species/turtles/loggerhead.html).
Nesting at Ashmore Reef is predominantly by green turtles (Figure 7), although a small number of hawksbill turtles also utilise the site for this purpose. Both species have been

reported to nest on all the islands in the reserve (Serventy 1952, Guinea 1995). In addition a loggerhead sea turtle has been reported nesting on West Island (ANPWS 1989).

Figure 7 Green turtle tracks at West Island

2.2 Tropical fire ant overview of natural history: reproductive strategy, growth development and survival of all life stages (eggs, larvae, adults)

All ants are in the family *Formicidae*. The genus *Solenopsis* consists of a line of 'fire ants' and 'thief ants'. Fire ants are widely know around the world as a pest species. The name fire ant comes from the fiery pain caused by their painful sting which can produce itchy sores and sometimes an allergic reaction. Numerous ants may attack a person when the colony is disturbed. Thief ants are smaller and less known due to their minimal impact on humans. Instead, they tend to rob the food from the nests of other ant species.

Solenopsis geminata, (commonly known as the tropical fire ant or the tropical fire ant), is an aggressive and competitive ant and has successfully spread throughout most of the tropics, mostly by human commerce since the beginning of last century. *S. geminata* is native to the tropics and warmer parts of the temperate New World. Thought to have originated between Central America and southern Northern America, it has invaded and established in most parts of Africa, South East Asia, the Pacific region and northern Australia. *S. geminata* is regarded as an environmental and economic pest throughout these regions having major impacts on ecological balances, agricultural industries and human well-being.

Many ants from the genus *Solenopsis* are tramp ant species, or species that are spread by human commerce and exhibit characteristics such as nest polygyny and colony reproduction by budding (McGlynn 2000). These ants tend to spread great distances through human activities such as movement of soils (eg. pot plants) or shipping containers. Only a fertile queen and a small army of workers are required for successful relocation to a new environment.

2.2.1 Description

S. geminata are browny-orange in colour and are 2–5 mm long. Some of the features that help to identify this species are that they have a ten segmented antenna including a two segmented antennal club; their head is almost square, they have a two segmented petiole; they are polymorphic (come in a range of sizes); they have major and minor workers and form a relatively messy nest in the ground, often with many craters or entrances around tufts of grass (Andersen 2000, Yates 2005).

2.2.2 Food

Solenopsis geminata feed on grass seeds that are gathered and stored in granaries of their large centralised nest systems. They also tend honeydew producing hemiptera, especially mealybugs and aphids. This increases populations of hemipteran pests and the incidence of disease vectored by hemiptera. *S. geminata* feed on arthropods, sugars, meats and fats, preferring food with high protein content, but will feed on almost anything, plant or animal. (Hölldobler & Wilson 1990, Yates 2005, Taber 2000, Way et al 2002)

2.2.3 Reproduction and colonies

S. geminata have the ability to start new colonies across short distances via reproductive flights. The colonies are individually established by newly mated queens following a mating flight. Colonies, often initiated by a solitary, fertile queen, may eventually consist of a few queens, many winged males, winged virgin females, a gradation in size of soldiers and workers (major and minor workers), and all stages of immature forms (Yates 1994). *S. geminata* are polygynous, ie have multiple queens per colony. *S. geminata* usually have their reproductive flights during the warmer months of the year in Hawaii and the United States (Yates 1994, Taber 2000). Reproductive flights have not been recorded from Ashmore Reef, but collections of *S. geminata* at Ashmore Reef made during the wet season in March 2004 could be linked. An upturned log on East Island disturbed a heaving colony of *S. geminata* that contained a large number of winged males and females.

Mating takes place 90 to 240 metres in the air. Newly mated queens seek moist areas, normally within one mile of the mother colony. If the female lands on a suitable site, she sheds her wings and burrows into the ground, usually under a leaf, rock, or small crevice. She excavates a small chamber at the end of the burrow, seals it, and begins egg production (10 to 15 eggs). During the next 8–10 days a further 75 to 125 eggs are laid. She then stops laying eggs until the first brood is mature (Taber 2000, Yates 2005). It can take one to two years for *S. geminata* colonies to mature (Taber 2000). Nests of this species can consist of up to 100 000 individuals (Taber 2000).

S. geminata may also start new colonies by budding off or dividing into a sub colony from an existing colony (Yates 2005). In this last case, a queen or queens leave the nest with a cohort of workers, larvae, etc. and starts a new colony. Budding assists with expanding the foraging range and contact with the original colony is often maintained (Hölldobler & Wilson 1990).

2.2.4 Life cycle stages

Eggs and larvae

Eggs take approximately two weeks to develop and hatch. Larvae emerge from the eggs as soft, legless grubs. Larvae take approximately six weeks to develop (Taber 2000). Trophallaxis (the regurgitation of liquids) occurs between larvae and queens and workers,

while the caring of the larvae and pupae is left to the workers. The queen feeds the young larvae with regurgitated oils. The last larvae stage, in addition to receiving liquid food, is also fed solid foods. The larvae have enzymes which digest the food, which is regurgitated to adult ants who are not able to digest protein themselves. These digested proteins are also fed to the queen to stimulate egg production (Hölldobler & Wilson 1990, Yates 1994).

Pupae

The pupal stage takes approximately two weeks to develop (Taber 2000). In the nest the pupae are tended by workers.

Adults

Newly emerged adults spend several days to weeks taking care of eggs, larvae, pupae, and the queen. These small workers, called 'miners', open the burrow to locate food, feed the queen and the new larvae, and begin construction of the mound. As they age, they become reserves, who groom the larvae, defend the colony, build and maintain the mound, and bring back food found by the foragers, the oldest ants. When a food source is found foragers lay a chemical trail for the reserves to follow and the food supply is taken to the nest (Yates 2005). *S. geminata* can also forage below the soil surface, an activity that is thought to allow foraging at higher temperatures during the heat of the day (Taber 2000). *S. geminata* have a large tolerance for temperature variation. A critical maximum temperature of 45°C has been observed to cause 50% mortality after 30 minutes with 25°C to 33°C optimal and a lower threshold of 2°C (Taber 2000).

2.3 History of tropical fire ant invasion at Ashmore Reef

The earliest comprehensive records of insect fauna surveys at Ashmore Reef were conducted by Pike in May 1992. During this visit, Pike collected specimens of *S. geminata* from Middle and West Islands (Brown 1999); these have been incorporated into the collections made by Brown. Thus it is likely that *S. geminata* had been present at Ashmore Reef prior to 1992.

There are two potential routes of entry of *S. geminata* to the islands at Ashmore Reef and both are from accidental introduction through human activity. One pathway is via traditional Indonesian fishermen and the other is via the movement of people from Darwin. It is known that *S. geminata* was established in Indonesia and Darwin during times of human traffic to Ashmore Reef.

Unrestricted access to the islands was still permitted until 1988, when in recognition of the significant bird colonies and marine animals at Ashmore Reef, the first restrictions were established. Landings on Middle and East Islands were prohibited to the public. Mooring and fishing were only permitted in the western lagoon and visits to West Island were allowed only for collecting water, sheltering from storms and visiting the grave site. In 1989, during the revision of the Memorandum of Understanding (MOU) between the Indonesian and Australian governments, the same restrictions were applied to the traditional fishermen (Australia National Parks and Wildlife Service (ANPWS) 1989).

Stitz first reported *S. geminata* in Indonesia in 1912 (as cited by ISSG 2003). Traditional Indonesian Fishermen have been visiting Ashmore Reef for hundreds of years and are reported to have regularly landed on the islands to collect fresh fish, birds and eggs. They would have used either their canoes or simply beached their fishing boats on the shore to gain access to these islands. *S. geminata* is known to hitch rides on these boats and could have easily been introduced to any of the islands during these landings. Australian Quarantine and Inspection Service (AQIS) inspectors have observed and collected *S. geminata* on Indonesian

fishing vessels and suspected illegal entry vessels during routine inspections that are conducted on detained boats in Broome and Darwin (Brockway & Brown, pers comm).

Although a specimen of *S. geminata* was collected from Darwin in 1939 (Hoffman & O'Connor 2004), it is thought to have been established in Darwin since at least the mid 1970s where it has remained somewhat contained. Infestations have also been reported on the Tiwi Islands, at Katherine and Kakadu. However, an eradication program at Kakadu has shown no re-infestations 12 months after several colonies were killed (Hoffman & O'Connor 2004). S. *geminata* has also been detected in south-eastern Queensland and in the East Kimberley region in Western Australia, but it is not known to be established at these locations (Shattuck & Barnett 2001, Postle pers comm).

Darwin is used as the major port for Australian boat expeditions and transportation of equipment to Ashmore Reef. In 1962, an automatic weather station was erected on West Island. Over the years the equipment was stolen, so the weather station was restored in 1971. The weather station was abandoned in 1973 after it had been ruined for the second time (ANPWS 1989). Off-shore Navigation Australia, a petroleum exploration company, had a base camp-site on West Island during the late 1970s and 1980s. There were also regular visits by ANPWS and the Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) during the mid to late 1980s (ANPWS 1989).

Equipment transported from Darwin could have carried *S. geminata* colonies and accidentally transported them to Ashmore Reef. However, the frequency of visitation by Indonesian fishing vessels and sightings of *S. geminata* on these boats suggests that the Indonesian fishermen introduced it accidentally.