

**Ashmore Reef National Nature Reserve  
and  
Cartier Island Marine Reserve**

**Marine and Terrestrial Introduced Species  
Prevention and Management Strategy**

**Report for  
Department of Environment and Heritage**



**Natural Heritage Trust**

*Helping Communities Helping Australia*

An Australian Government Initiative

## ***Consultant Group***

**Museum and Art Gallery of the Northern Territory**

**CRC Reef Research Centre (Queensland) – Ports and Shipping Program**

**URS Australia Pty Ltd**



**Northern Territory Government**  
Department of Community Development, Sport and Cultural Affairs



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## ABBREVIATIONS

AC	Australian Customs
ACV	Australian Customs Vessel
ADF	Australian Defence Force
AFFA	Department of Agriculture, Fisheries and Forestry, Australia
AIMPAC	Australian Introduced Marine Pests Advisory Council (Formerly ABWMAC - Australian Ballast Water Management Advisory Council)
AMOG	AMOG Consulting
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
APEC MRCWG	Asia-Pacific Economic Cooperation organisation Marine Resource Conservation Group
AQIS	Australian Quarantine Inspection Service
AusAID	Australian Agency for International Development
CCIMPE	Consultative Committee on Introduced Marine Pest Emergencies
CRC	CRC Reef Research Centre, Townsville
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CRIMP	Centre for Research on Introduced Marine Pests
DBIRD	NT Department of Business Industry and Resource Development
DEH	Department of Environment and Heritage
DSS	Decision Support System
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations 2000 made under the EPBC Act
FSOP	Floating storage and offloading platform
GloBallast PCU	GloBallast Programme Coordination Unit, International Maritime Organisation
GPS	Global positioning system
IMO	International Maritime Organisation
IUCN	World Conservation Union (previously International Union for the Conservation of Nature and Natural Resources)
MAGNT	Museum and Art Gallery of Northern Territory
MOU	Memorandum of Understanding
NAQS	Northern Australia Quarantine Strategy
NIMPCG	National Introduced Marine Pests Coordination Group
NIMPIS	National Introduced Marine Pest Information System
NIS	Non-indigenous species

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NRSMPA	National Representative System of Marine Protected Areas
PLM	Perahu layar motor (Indonesian Type III vessel)
PoO	Port of Origin
QDPI	Queensland Department of Primary Industries
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RO-RO	Roll on – roll off ship
SCC/SCFA	Joint Standing Committee on Conservation / Standing Committee on Fisheries and Aquaculture (SCFA), National Taskforce on the Prevention and Management of Marine Pest Incursions
SCUBA	Self contained underwater breathing apparatus
SIEV	Suspected illegal-entry vessel
sp	species
spp	species (plural)
Tokyo MOU	Tokyo Regional Memorandum of Understanding of Port State Control
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Program
URS	URS Australia Pty Ltd
WAM	Western Australian Museum

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## EXECUTIVE SUMMARY

This report is an assessment of the current status and potential risks of introduction of non-indigenous terrestrial and marine species at Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve (the Reserves).

The project scope and objectives were to:

- identify and assess risks associated with the potential introduction of terrestrial and marine species into the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve;
- provide a range of recommendations for managing these risks including actions to prevent or minimise, monitor and respond to incursions;
- develop a marine and terrestrial introduced species prevention and management strategy, which could be implemented by the Department of Environment and Heritage's Marine Protected Areas Section.

The report includes:

- background information on the Reserves, relevant to the introduction of non-indigenous species (NIS), including location, climate and oceanography, history of human visits and uses, present day management, other activities, and marine and coastal habitats;
- the results of field surveys of the marine and terrestrial environments of the Reserves, and describes which NIS are currently present, their invasive characteristics and which habitats may be prone to future invasion;
- an appraisal of possible vectors for marine and terrestrial introduced species, including vector origin, frequency and capability;
- a risk assessment of species introductions;
- an introduced species prevention and management strategy, and provides recommendations for:
  - specific objectives, performance targets and review mechanism;
  - management of risk and introduced species prevention;
  - monitoring and data collection;
  - management of established terrestrial NIS.

The report also identifies further research and regional cooperation needs.

Recommendations of the introduced species prevention and management strategy are:

- continued management presence by ACV personnel at Ashmore Reef to enforce access restrictions;
- adoption of strict quarantine standards and procedures for all equipment and materials transported to and from the Reserves;
- avoidance of vessel ballast or trim water discharge and hull cleaning within the Reserves;
- risk assessment of all vessels for fouling organisms, with hull inspection of suspect vessels using recommended protocols developed for the Port of Darwin, and collection and reporting of suspect material;
- establishment of permanent moorings at Ashmore Reef outside of West Lagoon, and the interception and/or removal of 'high risk' vessels such as SIEVs from the lagoon to



these moorings to minimise the risk of inoculation of lagoon waters by eggs and larvae of non-indigenous marine species;

- improved data collection for all vessel arrivals;
- monitoring of marine debris, including removal and destruction of boat timbers and suspect driftwood, with collection and reporting of suspect material;
- regular monitoring for marine NIS, especially on artificial substrates such as mooring blocks and buoys, with review of the status of NIS and scientific re-survey every 3-5 years, or sooner if a NIS incursion is suspected;
- regular monitoring for potential invasive terrestrial NIS, with scientific re-survey of plant and terrestrial animals undertaken every 3-5 years on all three Ashmore islands and at Cartier Island, to monitor changes in populations and NIS impacts, and to detect the presence of new NIS;
- development of a long-term eradication program for 'high risk' weed species, with urgent eradication of buffel grass, *Cenchrus ciliaris*, and feather grass, *Pennisetum pedicellatum*;
- urgent survey of Ashmore islands to determine the extent and impacts of ginger ants, *Solenopsis geminata*, especially on bird and turtle nesting sites, with a view to the possible eradication of this species;
- research and monitoring of populations of the Asian house gecko, *Hemidactylus frenatus*, and assessment of its ecological impact on West Island;
- intensive annual trapping program to monitor for rodents on the Ashmore islands.

## 1. INTRODUCTION

### 1.1 Background

Introductions and spread of non-indigenous species (NIS) are posing significant threats to the biodiversity of native terrestrial and marine assemblages globally, with species invasions now recognised as a major element of global change (eg. Leppakoski *et al.* 2002, IUCN Global Invasive Species Program, <http://www.issg.org/database/welcome>). The accelerating transfer of aquatic species across natural oceanic barriers by modern shipping led Carlton and Geller (1993) to suggest that temperate bays, estuaries and harbours disturbed by human activities may be amongst the world's most threatened ecosystems with respect to harmful marine invasions, although Ruiz and Hewitt (2002) have warned that less disturbed open coastal systems in both high and low latitudes may not be as resistant to invasions as many scientists have supposed.

Over 250 marine NIS have been identified in Australian waters, most of which associated with unintentional introductions linked to commercial shipping, fishing vessels and aquaculture (eg. Hillman 1999, CRIMP <http://www.csiro.au/~spinks/crimp/index.html>). Other activities facilitating the spread of unwanted marine species include those related to the aquarium trade, movements of refugee vessels, cruising yachts and relocation of drilling rigs, floating docks and military vessels (eg. Coles and Eldredge 2002, Hutchings *et al.* 2002, Minchin and Gollasch 2002, Paulay *et al.* 2002).

Most research on marine species introductions comprises surveys and empirical studies in temperate regions, particularly in North America, Europe, and Australasia. Far fewer studies have been undertaken to detect and evaluate marine NIS in tropical areas, although several studies and surveys specifically focussing on introduced species in warm-water ports have now been completed, including Pearl Harbour (Coles *et al.* 1997, 1999a,b), Guam (Paulay *et al.* 2002) and ports in northern Australia (Hilliard *et al.* 1997, Hewitt *et al.* 1998, Hoedt *et al.* 2000, 2001a, Russell and Hewitt 2000, Ruiz and Hewitt 2002).

Only four studies have focussed on NIS on coral reef systems: at Kaho'olawe in the Hawaiian group (Coles *et al.* 1998), at Midway Atoll (DeFelice *et al.* 1998) at Johnstone Atoll (Coles *et al.* 2001) and Guam (Paulay *et al.* 2002). Results from these surveys indicate very low rates of species introduction to these areas (<1.5%), and have contributed to the developing paradigm of open tropical systems being less susceptible to marine pest invasions (Hilliard *et al.* 1997, Coles *et al.* 1999b, Hilliard 1999, Hutchings *et al.* 2002, Coles and Eldredge 2002). However, the identification of NIS in tropical regions remains constrained by taxonomic limitations for several important phyla (Hewitt 2002, Ruiz and Hewitt 2002).

It is also now recognised that artificial, disturbed and/or polluted habitats in tropical regions are susceptible to introductions (Paulay *et al.* 2002), including invasive species such as the black-striped mussel (*Mytilopsis salleri*) which is now present in many tropical harbours across Asia, including Mumbai, Vizakhapatnam, Singapore, Jakarta, Surabaya, Hong Kong and Manila (URS 2003) as well as its infamous colonisation of Darwin's marinas in 1998-1999 (Russell and Hewitt 2000, Willan *et al.* 2000). Anthropogenic stressors such as sedimentation, eutrophication, pollution, overfishing and destructive fishing methods can adversely affect corals just as much as tropical estuaries and other port environments, and coral reefs are increasingly suffering severe bleaching stresses due to global climate change. Local and globally induced impacts may therefore make coral reefs as prone to colonisation by NIS as other habitats (Hutchings *et al.* 2002, Coles and Eldredge 2002, Ruiz and Hewitt 2002).

### 1.2 Project scope and objectives

The Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve (the Reserves) are under the jurisdiction of the Commonwealth Government, and have national and international conservation significance due to their high biological diversity, unusual location, cultural values and geomorphological make up. Although remote from mainland Australia, the

location of the Reserves has caused them to receive a relatively high level of visitors from various groups including Indonesian traditional fishers, unauthorised 'boat-people' attempting to reach Australia via Asia, recreational visitors (mainly on cruising yachts), occasional commercial tourist visits, researchers, Australian Customs Service personnel, Fisheries officers, Navy officers and staff from Department of Environment and Heritage (DEH). The majority of these visitors arrive by sea, although Navy helicopters occasionally land on West Island at Ashmore Reef.

All visitors have the potential of introducing either a marine or a terrestrial species to the Reserves, with the risk highest in those areas receiving the highest level of vessel traffic and visitation. Recently DEH identified that the potential introduction of marine and terrestrial species due to the high level of visits represented a significant risk to the natural values and conservation objectives of the Reserves. This report addresses this concern and provides an introduced species prevention and management strategy for the Reserves. Specifically, the project scope and objectives were to:

- identify and assess risks associated with the potential introduction of terrestrial and marine species into the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve;
- provide a range of recommendations for managing these risks including actions to prevent or minimise, monitor and respond to incursions;
- develop a marine and terrestrial introduced species prevention and management strategy, which could be implemented by DEH's Marine Protected Areas Section.

### 1.3 Project approach and report contents

Development of any 'Introduced Species Prevention and Management Strategy' requires at least some understanding of what species pose an invasion risk as well as the status of NIS already in the region of interest. However assessing the invasion potential of marine and terrestrial biota is difficult because of the paucity of reliable taxonomic data and biological information for many species, while invasion risk assessment remains an infant, emerging science (eg. Gollasch 2002, Hayes and Hewitt 2002, Hilliard and Raaymakers 1997, 2003, URS 2002).

Nevertheless, it is worthwhile identifying as far as possible candidate risk biota, and attempting some quantifiable level of risk for these. To this end it is necessary to identify and evaluate the types of known or suspected NIS already present in the Ashmore and Cartier Reserves, as well as collating pertinent information on species deemed capable of invading these areas and the vectors which can transfer them.

Several previous studies have provided information on specific groups of marine and terrestrial taxa inhabiting the Reserves. Groups that were the prime focus of previous studies include the hard corals (Veron 1993), other cnidarians (Marsh 1993), molluscs (Wells 1993, Willan 1995), decapod crustaceans (Morgan and Berry 1983), echinoderms (Marsh *et al.* 1993), fishes (Hutchins 1988, Larson 1990, Allen 1993, 1995, Russell 1993), sea turtles and sea snakes (Guinea 1993, 1995), and birds and marine mammals (Guinea 1993). In addition, much unpublished information on the biodiversity of the Reserve areas is contained in reports by Russell and Vail (1988) and Russell and Hanley (1993).

A review of existing flora and fauna information for the Reserve areas (based on collections in the Museum and Art Gallery of the Northern Territory (MAGNT), the NT Herbarium and published data) has been undertaken to help identify what NIS are currently within the areas. This desktop analysis also facilitated the targeted sampling regimes adopted by the marine and terrestrial field surveys. The combined desktop and survey results provide a current knowledge base on present and potential future NIS in the two Reserves.

The structure of this report follows a logical sequence. A description of the Reserves is provided in Section 2, including a summary of their location and physiography, their history of human visits, uses and management, and their marine and island habitats. The methods and results of the marine and terrestrial field surveys are given in Sections 3 and 4 respectively. These

sections describe which NIS are currently present, their invasive characteristics and which habitats may be prone to future invasion.

Although the vectors and management factors associated with terrestrial and marine invasions are different, their survey results, risk assessment analyses and management strategies are presented in complimenting sub-sections of Section 5. This section assesses the possible vectors for introducing marine and terrestrial species into the Reserves, including vector origin, frequency and capability. The information in Sections 3-5 forms the basis for the risk assessment (Section 6) and proposed prevention and management strategy (Section 7, 8).

#### **1.4 Study team and acknowledgments**

The study team comprised Dr Barry Russell, MAGNT; Dr Kerry Neil, CRC; and Dr Robert Hilliard, URS; with contributions by Dr Graham Brown, Principal Entomologist, DBIRD (Terrestrial fauna report - Appendix 3); Paul Clark, MAGNT (Indonesian fishing activities); Ian Cowey, Botanist, NT Herbarium (Terrestrial flora report - Appendix 4); Dr Chris Glasby, MAGNT (Polychaetes - Section 3.6.3); Dr Di Jones (Cirripedes - Section 3.6.4); and Dr Richard Willan (Molluscs - Section 3.6.2). Dr Pat McLaughlin (Cirripedes) and Charlotte Watson (Polychaetes) also provided identifications. The terrestrial field surveys at Ashmore Reef and Cartier Island were undertaken by Ian Cowey (Appendix 3) and Dr Graham Brown (Appendix 4). Dr Andria Marshall contributed the section on Hull Inspection Protocols (Appendix 5). The marine field survey was undertaken by Dr Kerry Neil assisted by Dr Michael Rasheed and Ross Thomas.

We are grateful to Charlotte Watson and Janina Werner who undertook sorting of the marine samples, and Steven Gregg who processed the insect specimens. Tony Postle, Northern Australian Quarantine Strategy, Broome, made his insect survey records available. We also thank Dr Helen Larson (MAGNT) and Ray Chatto, (NT Parks and Wildlife Service) for comments on a damaged bird egg that was collected. Mr Steve Tester Australian Customs Service provided discussion on the visitation of Indonesian vessels to the Reserves and valuable information on the location of potential wrecks at Ashmore Reef. John Polglaze (URS) provided information on military vessel ballasting requirements and helicopter and equipment quarantine cleaning procedures. Dr Andria Marshall (NT Fisheries) and Dr Graham Brown (DBIRD) provided comments on the Report.

Finally, we thank Captain Mark Fitzsimmons and the crew of the ACV *Roebuck Bay* and Captain Brian Marien and the crew of the ACV *Holdfast Bay* who provided logistic support and hospitality during the marine and terrestrial field trips respectively, and useful discussions on Ashmore Reef and Cartier Island.

## 2. DESCRIPTION OF THE ASHMORE REEF AND CARTIER ISLAND RESERVES

### 2.1 Location

The Ashmore Reef National Nature Reserve is located near the outer edge of the Sahul Shelf in the Eastern Indian Ocean, about 400 nautical miles west of Darwin and 90 nautical miles south of the Indonesian island of Roti (Fig. 1). The Reserve includes 583 km<sup>2</sup> of seabed, three small islands (East, Middle and West Islands), a large reef shelf and surrounding waters. Rising from a depth of over 100 m, Ashmore Reef is an example of a shelf-edge atoll. The reef platform is beside the edge of the Sahul Shelf and covers an area of 239 km<sup>2</sup>.

The Cartier Island Marine Reserve lies 30 nautical miles to the south-east of Ashmore (Fig. 1). Cartier Island is an unvegetated sand cay surrounded by an extensive reef flat of about 8 km<sup>2</sup>. Of the various emergent reefs that have developed on the outer Sahul Shelf, only the Ashmore and Cartier Reefs possess relatively stable sand cays, with vegetation present on the islands at Ashmore Reef.

### 2.2 Climate and oceanography

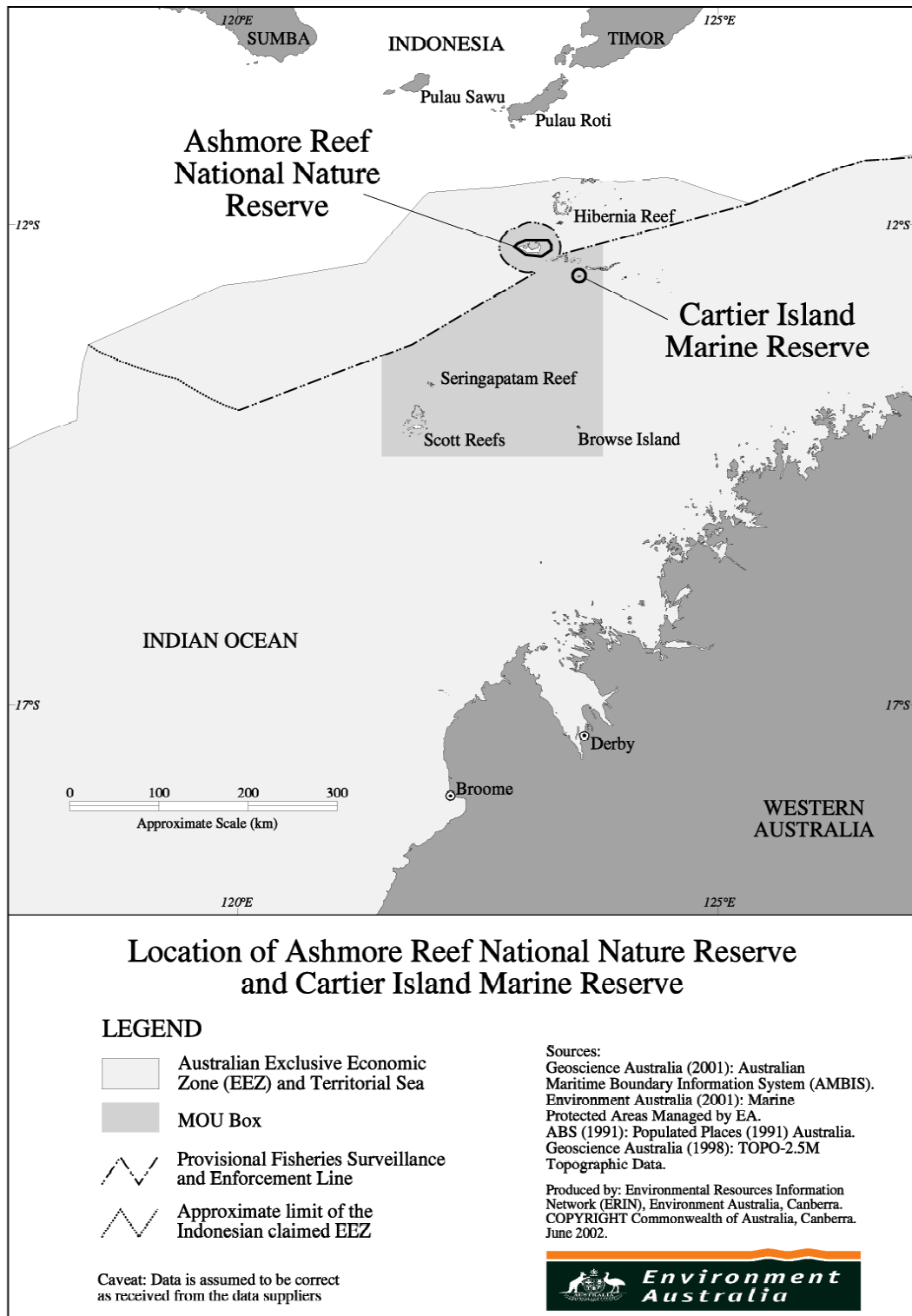
The climate of the region alternates between a dry season dominated by a SE monsoon (April–November) and a wet season dominated by a NW monsoon (December–March). From April to November, monsoon and trade winds augment each other. Variable winds occur during the rainy season from December–March. Squalls occur from October to April, rarely lasting longer than 3 hr, but develop winds of 50–160 km/hr (Van Andel and Veevers 1967). Tropical cyclones that usually pass by over relatively short intervals (12–24 hr), affect the area between November and April and occur at an average decadal incidence of about 8.5 (Lourensz 1981). Wind velocities typically reach 80–145 km/hr during these events.

The oceanography of the Timor Sea has been summarised by Wyrski (1961), Rochford (1962) and Van Anders and Tjia (1966). A weak (0.5–1.0 knot) south-westward surface current, the Timor current, prevails throughout the year. The axis of this current runs close to the coast of Timor, and transports westward between 1.0–1.5 × 10<sup>6</sup> m<sup>3</sup>/sec of water all year. Only during the time of full development of the SE monsoon is the Timor current supplied by water from the Arafura and Banda Seas.

Tides are semidiurnal, and mean spring and neap tidal ranges at Ashmore Reef are approximately 4.7 m and 2.8 m respectively (Berry 1993b). Observations on the tides at Cartier Island indicate that peak tidal heights may occur about 2 hours ahead of the predicted tide height for Ashmore Reef (Russell and Hanley 1993). Temperature and salinity in the region vary little throughout the year. Temperatures range between about 26–29°C and surface salinities average 34–35‰ (Russell 1972), although peak water temperatures within the lagoon can be expected to exceed 30°C whenever calm periods coincide with neap tides and high insolation in mid to late summer.

The Timor Sea is subject to discharge of sediments from drainage systems in Timor and north-western Australia, although the drainage area of the former (14,245 km<sup>2</sup>) is relatively insignificant compared with that of north-western Australia (647,500 km<sup>2</sup>). No records of discharges and sediment loads are available for the streams of Timor, and only incomplete records are available for those of north-western Australia. The rivers of both land masses, however, flow only intermittently because of the sharply defined wet and dry seasons (Van Andel and Veevers 1967).

There are no measurements of turbidity for the area of the Timor Sea that includes Ashmore and Cartier reefs, but surface sediments in this region are predominantly calcarenite calcirudites (Van Andel and Veevers 1967), which suggest that there is little or no terrigenous influence on the Reserves from either the coast of Timor or Australia. Our observations indicate that both Ashmore and Cartier reefs enjoy (relatively) clear oceanic water conditions, and that the main sources of turbidity affecting the reefs are fine suspended sediments discharged mainly from the reef flat (at Cartier Reef) or lagoon (at Ashmore Reef).



**Figure 1:** Location of the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve

As well as suspended sediments, transparency of the water at both reefs is also affected by the presence of zooplankton. At both reefs transient zooplankton masses, comprising mainly salps and ctenophores, sometimes in great densities, are carried in tidal streams along the reef edges. These plankters are fed upon by the many mid-water fish, and judging by the predominance of zooplankton-feeding fish at both Ashmore and Cartier reefs, zooplankton are

an important component of the oceanic waters in the area (Russell and Hanley 1993, and pers. obs).

## 2.3 History of human visits and uses

### 2.3.1 Indonesian activity

Indonesian fishers have traditionally fished the coasts and offshore reefs of northern and north-western Australia, probably for several centuries. The historical evidence points to regular use of Ashmore Reef by Indonesian fishers beginning sometime between 1725 and 1750 (Fox 1977). A brief account of the accidental discovery of Ashmore Reef by Rotinese seafarers in the early part of the 18<sup>th</sup> Century is provided by Fox (1977). At about this time it is also believed that Bajo and Makassan people from southern Sulawesi began exploring the southern islands of Indonesia, and it was these seafarers who were probably the first to exploit the marine resources of Ashmore and Cartier Reefs (Pike and Leach 1997). This notion is supported by Dutch records that confirm that Ashmore Reef was known to Indonesian fishers in the first half of the 18<sup>th</sup> Century (Macknight 1976: 95).

The earliest reported Australian contact with traditional fishers comes from the narrative of Flinders (1814: 228), who described an encounter with a fleet of about 60 perahus<sup>1</sup> near Cape Wilberforce, at the north-west corner of the Gulf of Carpentaria in February, 1803. The perahus were of about 25 tons and carried 20-25 men each, the total complement being about 1,000 men. The fleet, under the command of the chief Pobasso, belonged to the Rajah of Boni, and was engaged in fishing for trepang. Flinders enquired at Kupang about the trepang fishers and was informed that the natives of Macassar (Ujung Pandang) had long been accustomed to fish for trepang amongst islands near Java, and also upon a dry shoal lying to the south of "*Rottee*" (Roti), presumably Ashmore Reef.

Peron and Freycinet (1816: 245), naturalists on board the French vessels *Géographe* and *Naturaliste* under the command of Nicholas Baudin, also described meeting a fleet of 24 or 26 large Malay perahus fishing for trepang in the vicinity of Cassini Island and Holothuria Banks, off north-western Australia in April, 1803. These authors considered that the Malays discovered the northern coast of Australia and had been visiting it for centuries before the first Europeans.

Little is known of early Indonesian activities at what is now known as Ashmore Reef (Pulau Pasir) and Cartier Reef (Pulau Baru), and most information dates back only to the beginning of the 20<sup>th</sup> Century. Crawford (1969) provides extensive documentation of visits by vessels of many Indonesian islands in the period 1900-1940. The presence of archaeological sites and relics, including ceramic material, glass, abandoned wells, and graves are evidence of regular and frequent visits to the Ashmore Islands by Indonesian fishers, probably since the late 19<sup>th</sup> Century (Clark 2000).

During World War II, Indonesian fishers were not observed near Ashmore Reef by Australian service personnel who operated in the area (Witt 1951). However, during a CSIRO fisheries survey by *F.R.V. Warreen* in October 1949, Serventy (1952b) reported 23 perahus at anchor, most of which left quickly following the arrival of the survey vessel. In the general area the *Warreen* sited "*altogether 30 boats with an estimated personnel of 300*" (Serventy 1952b: 13). Serventy (1952b) reported that the islands of Ashmore Reef showed signs of well-established occupancy, with drying racks for clam meat and fish. HMAS *Cootamundra* visited Ashmore Reef in August 1958 and observed the presence of Indonesian perahus from Timor (Commonwealth of Australia 1989). Crawford (1969) records a number of vessels from the Indonesian island of Madura at Ashmore Reef in 1967-68. In July 1974, HMAS *Diamantina* found Indonesian fishers using the cays at Ashmore Reef for cooking and drying seabirds (Commonwealth of Australia 1989). These observations all demonstrate the historical practice of Indonesian fishers utilising the Reserves for traditional fishing.

<sup>1</sup> Perahu's are wooden hulled vessels, classed as Type 1, 2 or 3, based on DEH records. Refer section 5.6 for a further description of these vessels.

In 1974, a Memorandum of Understanding (MOU) was signed by the governments of Australia and Indonesia, which allowed continuation of certain traditional Indonesian fishing at Ashmore Reef and Cartier Island and adjacent offshore reefs (Anonymous 1975). In April 1989 the MOU was revised to include an enlarged 'box area' where traditional fishing was permitted (Fig. 1).

Following the development of the MOU there were continuous and numerous reports of regular visits to Ashmore Reef by Indonesian fishing vessels (ANPWS unpublished folios, NP77/129), with evidence of heavy exploitation of marine resources (empty clam shells, dried sharks' fins and meat, dried fish, turtles, and sea birds remains). In an attempt to control some of the excesses of these activities, and in order to implement Australia's obligations under international treaty agreements on the protection of migratory seabirds and endangered wildlife, the then Australian National Parks and Wildlife Service moved to declare Ashmore Reef as a National Nature Reserve in 1983 under the *National Parks and Wildlife Conservation Act 1975*. Proclamation of the Reserve was published in the *Commonwealth of Australia Gazette* No. G 32 on 16 August 1983.

In 1985, to control depredation by Indonesian fishers on turtles and seabirds, the Department of Territories established a seasonal surveillance program at Ashmore Reef. This program, which involved the presence of a contract surveillance officer from March-November during the fishing season, was improved during 1987-88 with some considerable success at reducing the illicit taking of turtles and birds. Nonetheless, some illicit activities continued and in July 1988 the Australian Government introduced new regulations that banned all traditional fishing activities within the boundaries of the Ashmore Reef National Nature Reserve, although access by Indonesian fishers to the lagoon near West Island for shelter and to the island itself for water continued to be permitted.

Cartier Island appears to have been much less visited by Indonesian fishers than Ashmore Reef, probably because it lacks a sheltered lagoon and a supply of freshwater. However, there is material evidence of regular visits by fishers (Jeffery *et al.* 1993), and at least one Indonesian fisher was buried on Cartier Island during 2000 (Commonwealth of Australia 2002). Indonesian fishers currently visit Cartier Island on a regular basis, but under the new Management Plan, from July 2003 all access to Cartier Island will be restricted.

### 2.3.2 European discovery and activities

Europeans discovered the two reef systems in the early 19<sup>th</sup> Century. Cartier Island was found first (by Captain Nash in the ship *Cartier* in 1800), and its position verified soon after in 1801 by Captain Heywood of HMS *Vulcan* (King 1827: 389). Captain Samuel Ashmore of the brig *Hibernia* discovered "*Ashmore's Shoal*" (= Ashmore Reef) in 1811, and he also discovered and named Hibernia Reef, which is located 16 miles NNW of Ashmore Reef (King 1827: 389, 390).

During the late 1800's Ashmore Reef was heavily exploited by phosphate miners, and from 1876 onwards a regular export trade (to the United States) of guano from all the islands between Ashmore Reef and the Abrolhos Islands was carried out (Woodward 1917, Fairbridge 1948). As a result of this trade, there was some friction between the British Colonial Office and the United States State Department, which finally resulted in Britain annexing Ashmore Reef in 1878, and Cartier Island in 1909 (Langdon 1966). Export of phosphate was prohibited in 1904 (Woodward 1917), but by 1891 all the guano appears to have been removed from Ashmore Reef, and Louis Knoop, a traveller who visited the reef, reported that the only things that remained were the "*traces of old rails, tanks, etc.*" (Langdon 1966). A few years later Indonesians were reported to have resumed their visits to Ashmore Reef and attempted to plant coconuts on the islands (Langdon 1966). In 1920 an Australian syndicate attempted again to mine for guano, but their efforts were unrewarding and were abandoned (Langdon 1966).

In 1923, the Western Australian State Government complained to the Commonwealth Government that Indonesian fishers were illicitly fishing at Ashmore Reef. Since the Commonwealth had no authority of the islands, it referred the matter to the British Government. In 1931, Britain placed the islands under the authority of the Commonwealth of Australia. However, legislation accepting the Ashmore and Cartier Islands as an Australian Territory, the *Ashmore and Cartier Islands Acceptance Act (No. 60, 1933)* was not finally enacted until 1934 (Langdon 1966). Control of the islands was vested in the Administrator of



the Northern Territory in 1938 (Langdon 1966) by amendment of the *Ashmore and Cartier Islands Acceptance Act (No. 11, 1938)*, but with self-government of the Northern Territory in 1978, control over the Ashmore and Cartier Islands Territory was retained by the Commonwealth Government through amendment of the *Ashmore and Cartier Islands Acceptance Act (No. 59, 1978)*.

There is no recorded use of Ashmore Reef during World War II, although HMAS *Tiger Snake* and HMAS *River Snake* visited the reef in 1945 (Commonwealth of Australia 1989). An automatic weather station was erected on West Island in 1962, but by 1970, all equipment had been stolen and the inner walls removed. The station was refurbished in 1971, but pilfering and vandalism again resulted in the destruction of the station, and it was abandoned in 1973 (Commonwealth of Australia 1989).

In the case of Cartier Island, evidence of European and more recent activity on the surrounding reef include the remains of an iron hulled barque, the *Ann Millicent*, wrecked on the southern edge of the reef on 5 January 1888; the remains of a Second World War RAAF Beaufighter aircraft which crash landed on the island on 6 April 1944; and remnants of exploded munitions (Jeffery *et al.* 1993).

Cartier Island and its surrounding area within a 10 km radius is gazetted as a Defence Practice Area for the purposes of military exercises. It has been principally used as an air weapons range, with its first use for this purpose appearing to date back to World War II (Commonwealth of Australia 2002). It has not been used for this or other military exercises for some time and is unlikely to be in the future. In 1986, a clearance operation to locate and remove obvious unexploded ordnance was conducted on Cartier Island and its adjacent reef flat. It still remains a gazetted Defence Practice Area but is essentially closed.

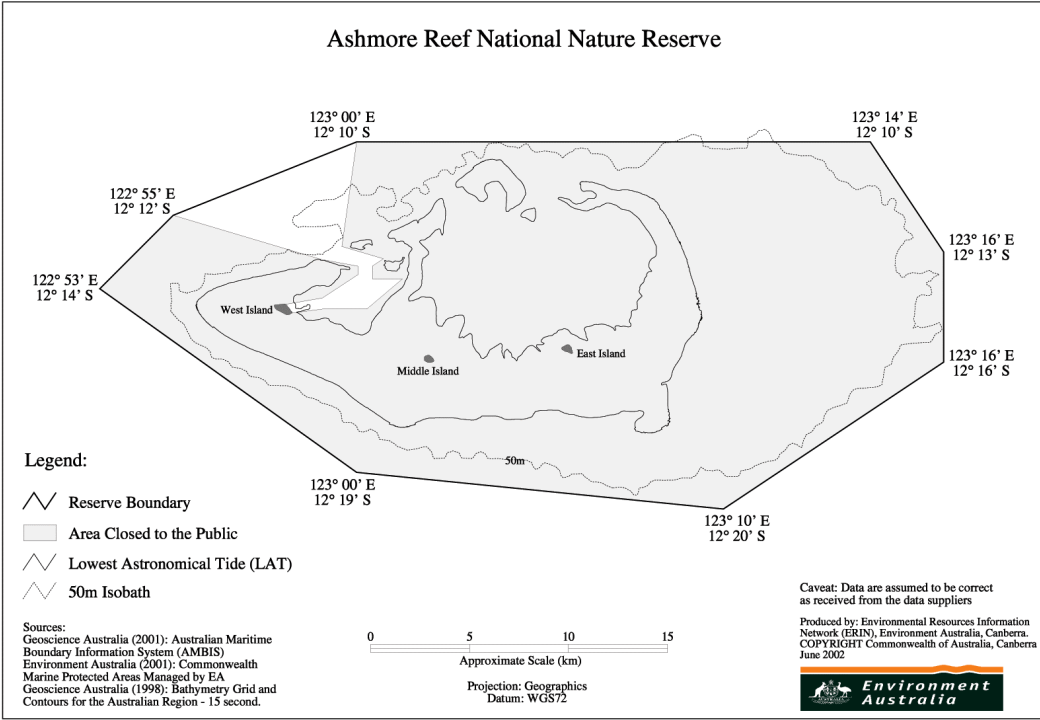
## 2.4 Present day management

The Ashmore Reef was declared a National Nature Reserve in 1983 (Fig. 2). Cartier Island Marine Reserve was established on 21 June 2000, enclosing a circular area 4 nautical miles in radius from the centre of Cartier Island (Fig. 3).

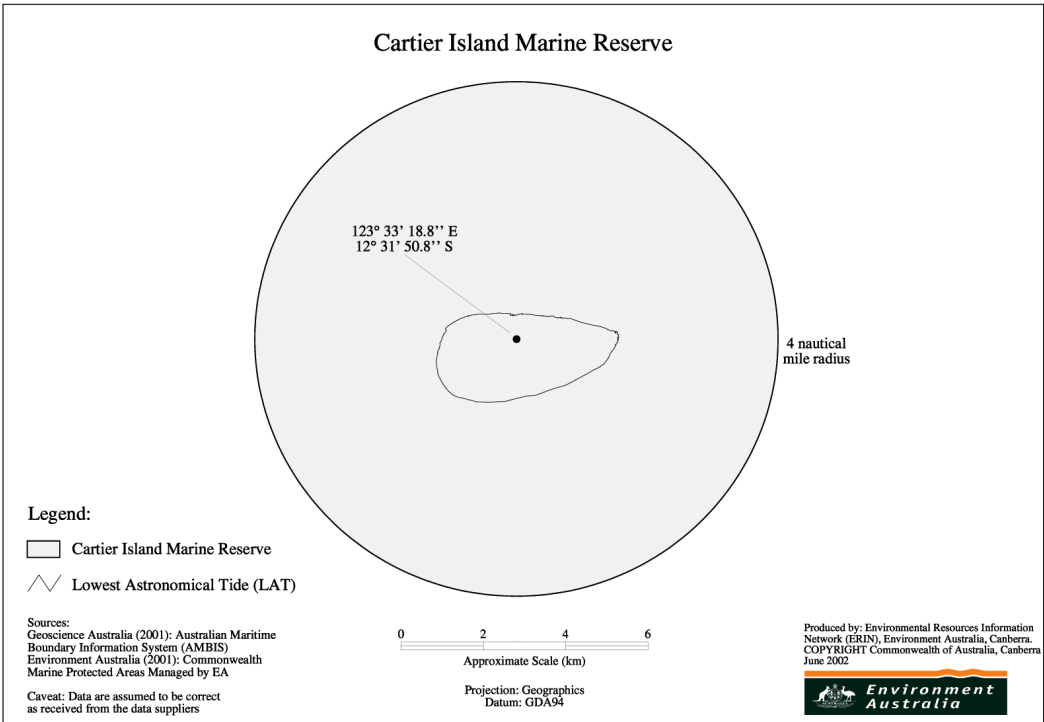
General visitor access to Ashmore Reef was restricted in 1988 to protect the biodiversity of the Reserve. The majority of Ashmore Reef is currently closed to the public by an Instrument of Prohibition that was issued in 1997 (Commonwealth of Australia 2002). Public access is restricted to West Island Lagoon and a small portion of West Island (Fig. 4). The area has been assigned to IUCN category II (national park). The remainder of Ashmore Reef is closed to public access, and has been assigned to IUCN category Ia (strict nature reserve).

Cartier Island Marine Reserve has been closed to the public for some decades as a Defence Practice Area. A prohibition notice closing the Reserve under the EPBC Act was issued in May 2003.

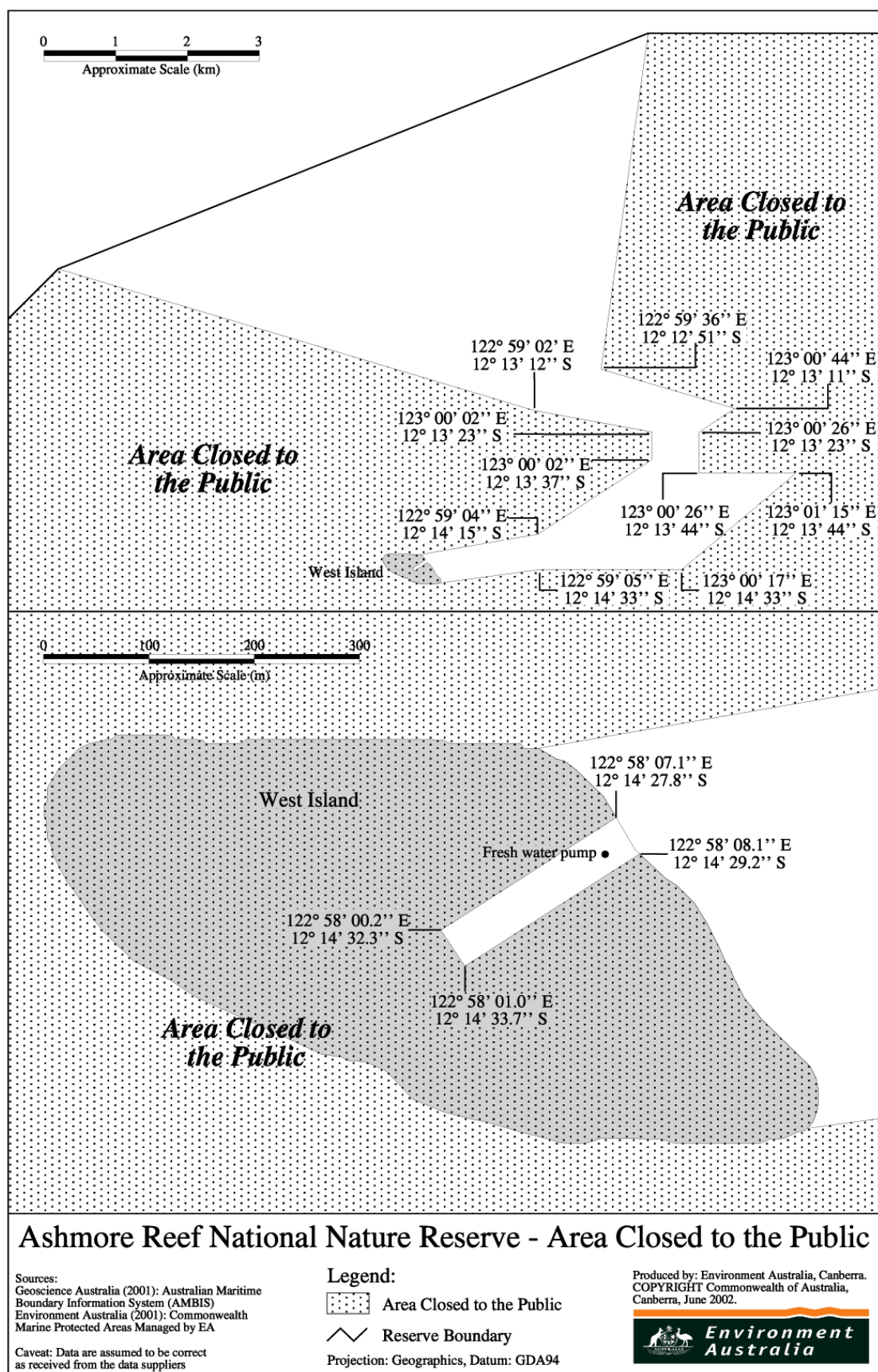
Both Reserves are managed by DEH under the *Environment Protection and Biodiversity Conservation Act 1999*. The second management plan for Ashmore Reef National Nature Reserve and first management plan for Cartier Island Marine Reserve came into effect in 2002. Under the current Management Plan that covers both Reserves, access continues to be limited; commercial fishing activities are prohibited; commercial tourism activities are highly restricted and subject to permit; and non-commercial recreation activities at Ashmore Reef are permitted only in those areas which are open to the public (Commonwealth of Australia 2002). On-site management of the Reserves is carried out by the Australian Customs Service, on behalf of DEH.



**Figure 2:** Ashmore National Nature Reserve boundaries



**Figure 3:** Cartier Island Marine Reserve boundaries

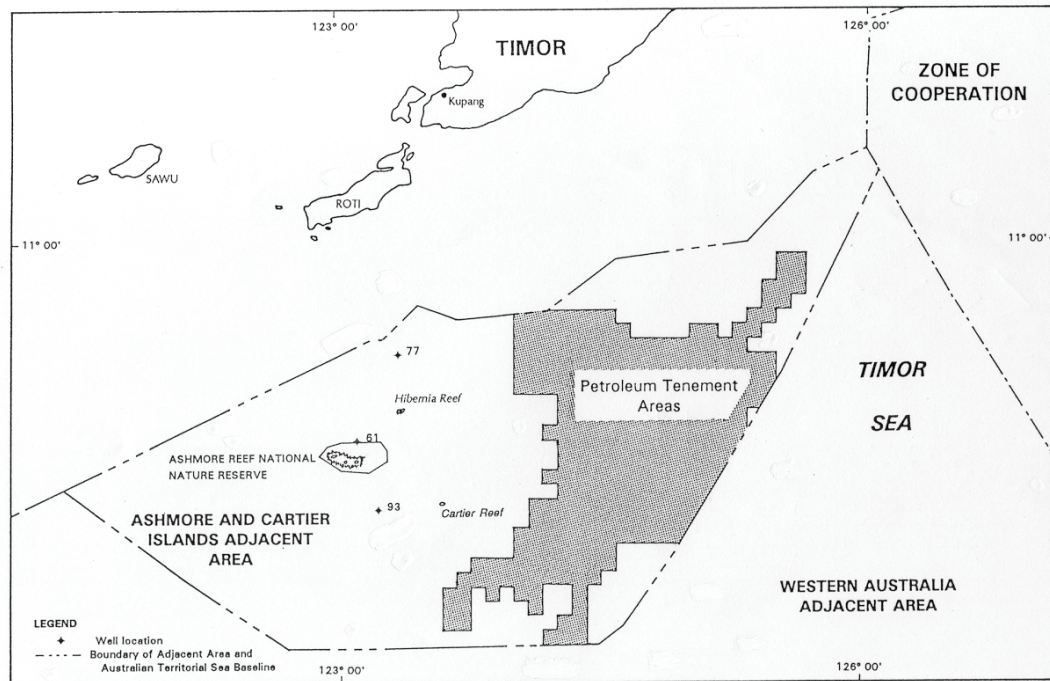


**Figure 4:** Ashmore Reef National Nature Reserve – area closed to the public

## 2.5 Other activities

### 2.5.1 Oil and gas exploration

The Ashmore and Cartier Reserves are located about 50-80 km west of the main offshore Petroleum Tenement areas in the Timor Sea (Fig. 5). The nearest exploration wells drilled to date are located about 36 km west of Cartier Reef (No. 93, Mt. Ashmore No. 1B, completed 26/10/1980), and also at Ashmore Reef (No. 61, Ashmore Reef No. 1, completed 27/3/1968). The area is not currently subject to any oil exploration permits or production licenses (Department of Mines and Energy 1992).



**Figure 5:** Petroleum exploration and production tenements near Ashmore Reef and Cartier Island (after Department of Mines and Energy 1992)

### 2.5.2 Scientific research

The first scientific report of Ashmore Reef is that of Smith (1926) who reported on a collection of sea snakes deposited in the Natural History Museum, London, Museum of Comparative Zoology, Harvard, and United States National Museum, Washington. Voris (1974) subsequently examined the stomach content items of these specimens and reported a number of fish species.

Serventy (1952a) made brief observations of bird-life seen around reefs and islands on the Sahul Shelf, including Hibernia Reef and Cartier Island, during a fishery survey on board the *F.R.V. Wareen* in October 1949.

During 1972-73, the Scripps Institute of Oceanography *Alpha Helix* Expedition carried out research on sea snakes and fishes at Ashmore, Cartier and Hibernia Reefs (Dunson 1975, McCosker 1975, Minton and Heatwole 1975).

In October 1978, the USSR *R.V. Professor Bogorov* expedition visited Ashmore Reef with scientists from the Western Australian Museum (WAM) on board. Collections of corals, molluscs and echinoderms were made (Marsh 1986) and the presence of four species of Alcyonacea were recorded (Anonymous 1979).

The CSIRO research vessel *F.V. Courageous* undertook trawl surveys close to Ashmore, Cartier and Hibernia reefs in June 1979 and July 1980, but the results of this work are unpublished.

In March-April 1970, the Taiwanese *R.V. Hai Kung*, made a number of trawls in the Timor Sea to the east of Hibernia and Cartier Reefs, and Dr C.C. Lu, Museum of Victoria, collected cephalopods and fishes.

Scientists from the Museum and Art Gallery of the Northern Territory (MAGNT) and the Western Australian Museum (WAM) have made extensive collections of marine animals at Ashmore and Cartier Reefs since 1984 and for many groups the marine fauna is now reasonably well known (Russell and Vail 1988, Vail and Russell 1989, Berry 1993a, Russell and Hanley 1993, Allen 1993, 1996, Hutchins 1998).

AQIS, through its Northern Australia Quarantine Strategy (NAQS), has also undertaken surveys in 2000 and 2003 at Ashmore Reef for plant and animal species of quarantine interest (Curran 2003).

Other research carried out at Ashmore and Cartier Reefs in recent years has included work on sea snakes, dugong, turtles, sea birds and migratory birds, geomorphology and monitoring of Indonesian target species. Much of the current research in the Ashmore region is summarised in the proceedings of a symposium held in Darwin in April 2001, *Understanding the Cultural and Natural Heritage Values and management Challenges of the Ashmore Region* (Russell *et al.* in prep).

## 2.6 Marine and coastal habitats

The marine environments of the North-west Shelf and specifically the West Sahul region, are high in biological diversity and support some of the most complex biological systems on Earth. The Ashmore Reef and Cartier Island areas present a variety of marine habitats including extensive seagrass meadows, sandflats, reef flats and lagoons. Consequently, these areas are able to support the greatest number of species of any area of North-western Australia. Recent surveys, such as those undertaken by the WAM, MAGNT and others noted above, within the region have discovered a high diversity of taxa (Berry 1993a, Russell and Hanley 1993) including sponges, reef building corals, echinoderms, polychaetes, molluscs, crustaceans, fishes and foramaniferans. In addition, the region is known to support the highest diversity and density of sea snakes in the world, with several species being endemic to the area (Guinea 1995). These areas also provide important breeding and feeding habitats for threatened species including dugongs, green turtles, loggerhead turtles and hawksbill turtles.

Ashmore Reef has three small islands that have a combined area of 112 hectares. The vegetation varies with seasonal conditions and consists mainly of grassland, woody shrubs and herb fields. Luxuriant growth occurs during the wet season, however, during the dry season the vegetation dies back leaving a layer of dead plant material over much of the islands. Phosphate (guano) mining and other anthropogenic activities have impacted on the islands, with the deliberate or inadvertent introduction of several new plant species, including weeds, the effects of which have yet to be fully determined. It is believed that the phosphate mining era was responsible for the introduction of the Black rat to West Island (Pike and Leach 1997). Rats dominated West Island until the mid 1980's, after which time an eradication program, commenced in the early 1980's, was eventually successful (Pike and Leach 1997). However, fluctuating populations of the House mouse, also thought to have been introduced as a result of human activity, persist on East and Middle Islands (Pike and Leach 1997). The common Asian house gecko also is common on West Island, but apparently absent from East and Middle Islands.

Cartier Island is a small sand cay that is nearly submerged during spring high tides and is swept during storm conditions. Consequently, few terrestrial taxa persist in the area.

Despite the small size of the islands, Ashmore Reef supports some of the most important seabird rookeries on the North-west Shelf and is important as a staging point for migratory wetland birds, especially waders.

### 3. MARINE FIELD SURVEY

#### 3.1 Survey approach and sampling strategy

Hull fouling and ships' ballast water are important vectors for introductions of marine NIS, with the aquaculture industry and aquarium trade also providing significant vectors (eg. Carlton 1985, 1999, Gollasch 2002, Lavoie *et al.* 1999, Reise *et al.* 1998, Ruiz *et al.* 2000, Wonham *et al.* 2000, Paulay *et al.* 2002). Drifting rubbish, plastic litter and discarded fishing nets are also a concern, particularly in remote oceanic regions (Barnes 2002, Keissling and Hamilton 2001).

Marine NIS can be transferred across natural barriers to new habitats as readily by small vessels as by merchant ships, barges, drilling rigs or floating docks (Hutchings *et al.* 2002, Minchin and Gollasch 2002). In the case of small fishing craft, cruising yachts, tourist/charter launches or refugee boats, NIS can survive a voyage in their bilge water, anchor lockers, moist sediments, wet stores, or on the anchors, anchor chains, ropes, fishing lines and nets. Many fouling species can also survive in cooling water intakes as well as on the external hull, including sea chests and other nooks or crannies. Exotic marine protists, bacteria and viruses can reside in chilled or frozen fish bait. With the exception of frozen fish product and bait carried as cargo for the aquaculture industry, all the above locations are commonly considered part of the 'hull fouling' vector (eg. Rainer 1995, Hilliard *et al.* 1997, Hutchings *et al.* 2002, C. Hewitt, pers. comm.).

Because ships are encouraged to exchange their ballast water whilst en-route between ports, the ballast water, hull fouling and floating debris vectors all warrant consideration in the risk assessment of marine introductions at the Ashmore and Cartier Reserves. During planning of the marine survey, the most hazardous representatives of the three vectors were deemed to be illegal entry vessels in poor condition, fishing vessels from Indonesia and lost/discarded fishing gear. Thus sampling for NIS associated with discharges of ballast water and ballast tank sediments (ie. zooplankton, phytoplankton and benthic cyst stages) was not undertaken (Section 3.3).

An introduction via hull fouling or drift debris requires that a NIS not only survives a voyage and subsequently escapes the vessel and/or releases its gametes, but that these also yield a sufficient number of recruits that survive and grow to establish a viable, self-reproducing population (Section 6.1). Whether or not this new population goes on to spread rapidly and demonstrate a harmful, noxious or other nuisance trait that confers its status as an 'invasive' or 'pest' species is another question (Appendix 1). Theoretically a single release of less than a handful of individuals or zygotes has the capacity to establish a new population, although the chance is much higher if larger numbers are released over multiple intervals of time.

Hull fouling escapees and/or their gametes obviously have the best chance to survive, grow and reproduce after a vessel has arrived in shallow waters, rather than en route over deep water. Anchorage and mooring areas are therefore important places to look for NIS, particularly if these offer a variety of nearby habitats including hard substrates with disturbed or 'vacant' areas (eg. artificial surfaces such as buoys, pylons or piles) and sand or mud substrates suitable for burrowing species. The sampling regime was also focussed on detecting typical fouling NIS, including polychaete worms, bivalve molluscs, barnacles and bryozoans, since any attempt to collect and identify all classes of marine taxa in the Reserves was beyond the scope and budget of this project.

The marine survey therefore adopted a targeted sampling regime that was designed to provide a rapid assessment of habitats most likely to host NIS introductions via small vessel hull fouling and drift debris. For this reason the regime did not fully adhere to the CSIRO-CRIMP sampling protocols for port baseline NIS surveys (these typically cost between A\$75,000 - A\$150,000 each depending on the size and complexity of the port). However, sampling methods were based on those described in Hewitt and Martin (2001) and Hoedt *et al.* (2001b), and used by CRC Reef/QDPI in previous NIS surveys of tropical ports.