3.2 Habitats near the Ashmore Reef anchorage and mooring area

The visit and sampling plan for the Cartier Island Marine Reserve could not be undertaken as poor weather conditions during the period of the marine survey prevented safe access. This section therefore describes the habitats most frequently visited at Ashmore Reef only. Russell and Hanley (1993: 41) have previously provided a description of Cartier Reef.

There are several types of hard and soft substrate in the large West Island lagoon area. Much of the substrate within the central area of the lagoon is fine silty sand, whereas near the edges coarse coralline sand predominates. Bare coral rock and a mix of coarse coralline sand and coral rubble are the predominant substrates on the reef flats that surround the lagoon. Beyond the wide flats and narrow reef crest which skirt the lagoon, the outer fringing reef typically slopes to a depth between 9 m and 12 m. Numerous coral bommies of varying size and depth are scattered throughout the lagoon, some of which are exposed during low tides while others in deeper areas remain permanently covered, some by several meters of water.

A number of wrecks, mooring blocks, mooring buoys and channel markers are present. The mooring blocks are 1.5 tonne and 3 tonne blocks of concrete with chains of varying sizes attached. The wrecks are Type I, II, or III Indonesian fishing vessels (perahus) that have sunk in various locations of the lagoon at different times. Some of these wrecks have been present for over 10 years with little original structure remaining. In some cases, they have disintegrated entirely.

A wide range of small vessels visit West Island and the West Island lagoon, the vast majority comprising traditional Indonesian fishing craft, suspected illegal entry vessels (SIEVs), cruising yachts, tourist/charter launches, research vessels, Australian Customs patrol vessels and Australian Defence force vessels (see Section 5 for details). The visit frequencies of the different vessel types vary considerably, with the least frequent comprising the tourist and research vessels and cruising yachts. The frequency of SIEV arrivals had increased in recent years, although none have accessed the Reserve since November 1991. Australian Customs Vessels have become the most frequent visitors, maintaining an almost continuous presence. All of these vessels have the potential to introduce marine NIS via hull fouling.

Entry into those parts of Ashmore Reef National Nature Reserve beyond the IUCN category II area (national park) is supposed to take place only under the conditions of a permit issued specifically for that entry (Section 2.3). Although SIEVs and/or their occupants have occasionally entered these areas, the lagoon is regularly patrolled by Customs with small boats and the incidence and numbers of unlicensed entrants has generally been very low.

It was therefore deemed likely that any vessel-mediated marine introductions to Ashmore Reef should be evident in the West Island and lagoon area, with any subsequent colonisation of the IUCN Ia areas occurring by natural dispersal mechanisms from the initial, pioneering population. A large part of the sampling effort for marine NIS at the Ashmore National Nature Reserve was therefore focussed on the West Island lagoon area, with reference sites established in the East Island lagoon and the shorelines of Middle and East Islands.

3.3 Field sampling methods

As noted above, the most likely vectors for marine introductions to the Ashmore Reserve include hull fouling plus organisms surviving on drifting fishing gear or other debris (see also Section 5). Habitats conducive to colonisation by fouling NIS include relatively bare intertidal and subtidal natural or artificial hard substrates that are not extensively covered by native fouling biota or recent antifouling coatings. Soft substrates providing favourable anchorages within the West Island lagoon were also deemed suitable for initial colonisation by burrowing NIS and these areas were also intensively sampled.

Sampling was conducted during a routine Australian Customs visit to the Reserves areas (27 May – 7 June 2002). Much of the work carried out involved SCUBA diving and snorkelling, including all underwater transect inspections and patterned searches. The survey time frame was limited, so sampling efficiency was maximised by using diver bottom time for the visual surveys and their surface intervals for sampling soft-bottom benthic biota using a van Veen grab.

It should be noted that CSIRO-CRIMP protocols for port surveys recommend the collection of soft bottom biota by diver hand coring and/or Smith-McIntyre grab (Hewitt and Martin 1996, 2001). A van Veen grab that collected a block of sediment approximately 25 cm x 25 cm wide and 13 cm deep was used in preference to a Smith-McIntyre grab as the former type is a scientifically valid substitute. In fact van Veen grabs have been reported to be more efficient in soft-sediments (eg. Eleftheriou and Holme 1984, Riddle 1989, Hayashi and Sugino 1993). Sediment coring is useful when there is a need to determine if cysts of certain cryptogenic protests that can be introduced by ballast water discharges are present in both modern (surficial) and historic (deep) sediment strata inside sheltered harbours etc. This objective was outside the scope and budget of the present survey, as was plankton sampling.

Photographs were taken prior to sampling and removal of taxa, including photographs of unremoved taxa. Samples of fouling organisms were scraped by divers from hard substrates directly into calico cloth bags. Where the amount of surface area on wrecks and mooring blocks permitted, replicate samples were scraped from randomly placed 0.1 m^2 quadrats, as per CRIMP guidelines (Hewitt and Martin 1996, 2001). Not all wrecks had sufficient surface area to undertake random quadrat scrapings, while many mooring blocks were substantially buried and/or heavily sedimented, with only a small portion of the hard surface exposed and colonised by fouling benthos. In these instances, representatives of all observed targeted taxa were taken instead.

3.4 Sampling sites

Sampling stations were established in locations containing artificial hard substrates, natural hard substrates, natural soft substrates, and shoreline habitats (Fig. 6 and Appendix 2).

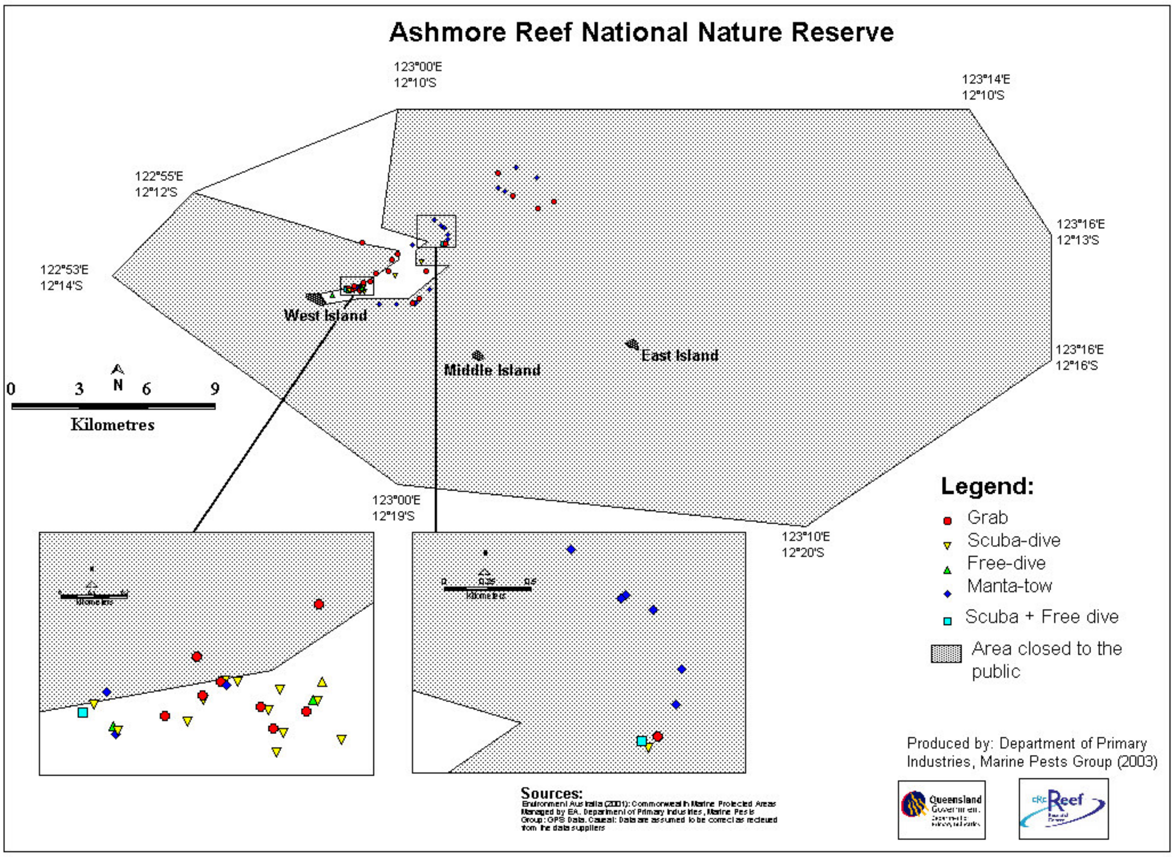


Figure 6: Ashmore Reef – location of marine field sampling sites

3.4.1 Artificial substrates

Wrecks

Areas in the West Island lagoon believed to contain one or more wrecks of Indonesian Fishing vessels (based on information from DEH) were inspected by manta-tow, free-diving and/or SCUBA diving. Located wrecks were then carefully examined for fouling biota by SCUBA divers, and representative samples of targeted taxa (polychaetes, barnacles, bivalves, bryozoans, sea squirts etc) were collected for laboratory identification. A number of wrecks could not be located. In these instances divers visually inspected the seafloor in the area of the reported wreck, and collected samples of the targeted taxa if found.

Mooring blocks

GPS locations for 11 concrete mooring blocks were provided to the survey team by DEH. It was noted that some blocks may have been moved and therefore may not be present at the given positions. One of these positions (at GPS 12°13.277'S, 123°00.587'E) was located in >20 m of water. This depth was considered unsafe for SCUBA diving at the isolated Ashmore Reef given its distance to emergency medical facilities, and this site was therefore not examined.

The other 10 mooring block GPS positions were searched for by SCUBA divers using a number of underwater search techniques. The fouling assemblage on located blocks and their adjacent marine habitats was examined for marine NIS. When blocks were not located, it was assumed that they had been moved and the search was abandoned. At these locations, divers examined the soft substrate and any natural hard substrates that were present within the area, for the targeted groups of taxa. Representatives of these taxa were collected for subsequent preservation and taxonomic analysis in the laboratory.

Mooring buoys

Australian Customs have two mooring buoys permanently located at Ashmore Reef that are utilised by the Australian Customs vessels that patrol the area. One mooring is located on the outer edge of the West Island lagoon, and the other is located near West Island within the lagoon (Fig. 2, 6). Free divers visually examined the fouling assemblages inhabiting the inner and outer mooring buoys, plus the chains fixing the buoys to their mooring blocks. When present representative taxa were collected for laboratory identification.

Marker buoys

A number of small buoys mark the channel used by the Customs vessels when navigating between the inner and outer moorings. These markers were situated on the crests of coral bommies that were scattered through the lagoon. A number of these bommies were examined by divers for the presence of target taxa, with representatives taken for laboratory identification wherever present.

3.4.2 Natural hard substrates

Dead coral and other rocky substrates inside the West Island lagoon and East Island lagoon were located and examined by manta-tow, free-diving or SCUBA diving respectively. The reef flats, reef crests, reef fronts and hard substrates in between the reef areas were also visited and examined for target taxa. The location of targeted taxa was recorded, with representatives collected for laboratory identification.

3.4.3 Natural soft substrates

Visual transects were made by manta-tow and various spot-dives across soft sediment areas. Benthic infauna was collected from soft sediment areas using the van Veen grab described in Section 3.3. Paired sediment samples were grabbed adjacent to the artificial hard substrates (eg. mooring blocks, wreck sites) as well as from sets of random locations in the West and East Island lagoons. Recovered sediment samples were immediately sieved through a 0.5 mm mesh and the various infauna were recovered for preservation and laboratory identification.

3.4.4 Shoreline habitats

Intertidal hard and soft substrates (including shoreline debris) were visually surveyed during low water periods around all three islands in the Ashmore Reserve. Searches focussed on evidence of NIS, including crab exuviae. Representatives of all intertidal taxa observed were collected for preservation and identification. Care was taken during the island visits to avoid any disturbance to native flora and fauna, particularly roosting birds.

3.5 Preservation and identification of taxa

All samples were labelled with site and collection information and immediately preserved in 80% ethanol. As in other parts of Australia's tropical seas, marine biodiversity on the Sahul Shelf is high, with most taxonomic phyla containing a substantial number of as yet unidentified native species. Thus, remote regions such as Ashmore Reef and Cartier Island contain a relatively high proportion of organisms not yet formally described. This is particularly the case for some difficult groups that require considerable taxonomic training and experience, including careful microscopical dissections, examinations and/or comparisons with voucher specimens.

After the preserved samples were sorted out in the laboratory, the more difficult of the targeted taxa were sent to specialists for identification. This included the polychaete specimens (to Charlotte Watson and Dr Chris Glasby), barnacles (to Dr Di Jones and Dr Pat McLaughlin) and bivalve molluscs (Dr Richard Willan). Representatives of all preserved specimens were vouchered for future reference at MAGNT.

3.6 Results

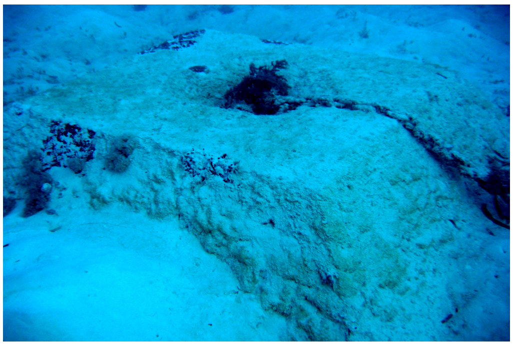
3.6.1 Status of Ashmore Reef habitats targeted by sampling regime

The various reefal habitats and their assemblages appeared in good health with no visually obvious evidence of recent coral bleaching, eutrophication or oil pollution (eg. tar balls or other bituminous deposits on beaches). Flotsam and jetsam are common on the shorelines of the islands at Ashmore Reef. The fruits and seeds from 83 different species, mostly of Indonesian origin were collected over four years (Pike and Leach 1997). Similarly, the most common shoreline jetsam and litter (timber, plastic bottles, rubber thongs and glass bottles) appears to be mainly of Asian origin. Marine debris (ropes and lines, buoys, discarded fishing nets) are found only infrequently compared with shorelines in northern Australia, and not at the high densities reported for beaches near Cape Arnhem (Keissling and Hamilton 2001).

Hard and soft corals and associated reef biota were present in many areas, including the fringing reef slope, reef crests and lagoon bommies. The reef crests contained typical spur and groove areas where the coral encrusted spurs (built principally by coralline red algae) are separated by sandy troughs, which are regularly scoured by water draining from the reef flats. The green calcareous algae (*Halimeda* spp.) were also visually predominant at many of the coral and soft sediment areas that were inspected and sampled. Numerous parts of the Eastern lagoon, which is exposed to the easterly trade winds and associated seas, were heavily scoured and contained more coral and rock rubble areas than the more sheltered Western lagoon, where scouring effects are restricted to the reef crest grooves.

Mooring blocks and chains were heavily sedimented and fouled with fine filamentous growth. Anemones, very small colonies of recently settled scleractinian corals (often less than five polyps) and macroalgae (eg. *Padina* sp.) were infrequent (Fig. 7a). Similarly, the ACV mooring buoys and chains were not heavily fouled, with most of the chain dominated by green filamentous algae and *Padina* sp. (Fig. 7b).

a



b

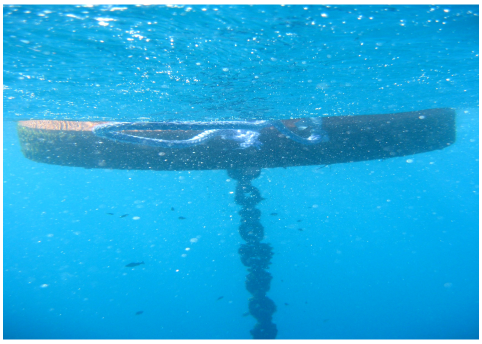


Figure 7: **a -** Typical mooring block, and **b -** inner ACV mooring buoy and chain

A total of 45 samples were collected from over 100 intertidal and subtidal sites that were inspected. Each sample was individually coded and their details are listed in Table 1. Sorting and taxonomic identifications were focussed on key benthic fauna groups known to include invasive species, and the results for each of these groups are provided in the following sub-sections.

Table 1: Station code, location and collection method of marine samples at Ashmore Reef

Station Code	Location	Structure	Method	Depth (m)
AR1	West Island	Shoreline	Visual search of beach debris	Intertidal
AR2	Outer mooring	Drift wood	Scrape	Surface
AR3	Inner Lagoon	Wreck site	SCUBA	10.1
AR4	Inner Lagoon	Inner Customs Mooring	SCUBA	13.0
AR5	West Island	Reef Flat	Free dive	0.7
AR6	Lagoon channel	Soft Sediment	Grab	15.0
AR7	Lagoon channel	Mooring block	SCUBA	15.0
AR8	Lagoon channel	Drift wood	Scrape	Surface
AR9	Lagoon channel	Soft Sediments	Grab	12.7
AR10a	Lagoon channel	Mooring block	SCUBA	15.0
AR10b	Lagoon channel	Wreck (Type III vessel)	SCUBA	15.0
AR11	Lagoon channel	Mooring block	SCUBA	15.5
AR12	Lagoon channel	Soft Sediments	Grab	15.5
AR13	Lagoon channel	Soft Sediments	Grab	18.0
AR14	Inner Lagoon	Soft Sediments	Grab	15.5
AR15	Inner Lagoon	Mooring block	SCUBA	15.4
AR16	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR17	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR18	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR19	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR20	Inner Lagoon	Soft Sediments	Grabs	16.0
AR21	West Island	Shoreline	Beach Wrack	Intertidal
AR22	West Island	Shoreline	Beach Wrack	Intertidal
AR23	Inner Lagoon	Inner Customs Mooring	Customs Vessel water strainer	Surface
AR24	Inner Lagoon	Inner Customs Mooring	Floating rubbish	Surface
AR25	Inner Lagoon	Inner Customs Mooring	Customs Vessel water strainer	Surface
AR26	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR27	West Island	Shoreline	Visual search of beach wrack	Intertidal

Table 1: continued

AR28	West Island	Shoreline	Visual search of beach wrack	Intertidal
AR29	Inner Lagoon	Fishing vessel hulls (Type II)	Snorkelling	1.50
AR31	Eastern Lagoon	Soft Sediments	Grab	15.0
AR32	Eastern Lagoon	Soft Sediments	Grab	2.0
AR33	Eastern Lagoon	Soft Sediments	Grab	7.0
AR34	Eastern Lagoon	Soft Sediments	Grab	2.4
AR35	Eastern Lagoon	Soft Sediments	Grab	7.0
AR36	Eastern Lagoon	Soft Sediments	Grab	2.5
AR37	Eastern Lagoon	Soft Sediments	Grab	2.0
AR38	Eastern Lagoon	Soft Sediments	Grab	5.0
AR39	Eastern Lagoon	Soft Sediments	Grab	5.0
AR40	Eastern Lagoon	Soft Sediments	Grab	15.0
AR41	Inner Lagoon	Soft Sediments	Grab	8.6
AR42	Inner Lagoon	Soft Sediments	Grab	6.0
AR43	Inner Lagoon	Soft Sediments	Grab	11.0
AR44	Inner Lagoon	Wreck (Type II vessel)	SCUBA	11.0

3.6.2 Molluscs (Dr R. Willan)

Some 84 mollusc samples containing over 1000 specimens were examined for NIS, with particular attention paid to mussels and oysters. Five mussel and five oyster species have been recorded by previous surveys of emergent reefs on the outer Sahul Shelf, and two of the mussel and three of the oyster species were found at Ashmore by the present marine survey (Table 2).

Table 2: Mussel and oyster species recorded by previous surveys on outer Sahul Shelf (from Willan 1993, Willan in press, and present survey)

Mussel and Oyster Taxa	Hibernia Reef	Cartier Island	Ashmore Reef	Ashmore Reef survey stations (2002)
FAMILY MYTILIDAE				
Crenella sp. 1	X	-	-	-
Lithophaga sp. 1	-	X	X	-
Modiolus auriculatus Krauss, 1848	-	X	X	-
Modiolus sp. 1	X	X	-	AR12*
Septifer bilocularis (Linnaeus, 1758)	X	X	X	AR9, AR32 - 34, AR38
FAMILY GRYPHAEIDAE				
Hyotissa hyotis (Linnaeus, 1758)	-	X	X	AR44
Parahyotissa imbricata (Lamarck, 1819)	-	X	-	-
FAMILY OSTREIDAE				
Lopha cristagalli (Linnaeus, 1758)	X	X	X	AR44
Ostrea sp. 1	X	-	X	-
Saccostrea cucullata (Born, 1778)	-	X	-	AR29 (sp.1), AR44 (sp.2)**

* *Modiolus* juvenile only, not identifiable to species; ** sp.1 circular, flat form, sp.2, elongate, corrugated form (see text)

Three of the species found by the targeted survey have previously been recorded for Ashmore Reef and/or Cartier Island, and are considered native to the region (*Modiolus* sp.1, *Septifer bilocularis, Lopha cristagalli*; Table 2). Of these, only the Shelf mussel (*S. bilocularis*) is known to attach to vessel hulls.

Similarly, the hyotid oyster (*Hyotissa hyotis*, which is the largest edible oyster in the tropical western Pacific Ocean) is also considered native to the Sahul Shelf region although its previous records had not included Ashmore Reef (Table 2). *H. hyotis* was found only on the submerged hull of a Type II wreck (station AR44 at 11 m depth), along with *Lopha cristagalli* and one of the two forms of *Saccostrea* oysters (sp. 2; Table 2). The other *Saccostrea* oyster (sp. 1) was scraped from the hull of a Type II Indonesian fishing vessel moored near the Australian Customs Vessel (station AR29; Tables 1,2).

Saccostrea oysters are widespread and relatively common throughout the tropical Indo-West Pacific region (eg. Thompson 1971, Wells 1986), although the taxonomy and origins of the species, including the corrugated form (*S. cucculata)* and smoother flat form (*S. commercalis*) are presently uncertain (genetic studies to determine the phylogeny of the genus have recently commenced; K. Lam, pers. comm.). Species of *Saccostrea* are generally confined to the rocky shores of continents and continental islands and are much less common on offshore coral cays. However no member of this widespread genus has displayed any 'invasive' credentials and a viable population is unlikely to establish on Ashmore Reef via transport of individuals attached to vessels from Indonesia or mainland Australia.

3.6.3 Polychaetes (Dr C. Glasby)

Of the 52 families of polychaete worms found in Australian waters, the taxonomy of only a dozen or so is sufficiently comprehensive to enable definitive recognition of an NIS. Of these, three families contain species that have been introduced to Australia and are on CRIMP's list of marine pests (Sabellidae, Serpulidae and Spionidae), while only the Nereididae and Terebellidae appear to have species with a well-developed capability to disperse and spread during their juvenile or adult stage (Wilson 1997). Members of these five families were therefore targeted for identification.

Despite several previous polychaete collections from Ashmore Reef (1984, 1986, 1987 and 1992), no taxonomic checklist has been published previously. The 1992 survey also collected polychaetes from the neighbouring Hibernia and Cartier Reefs, but much of this material remains identified to family only. Thus, of the 32 families that are known from Ashmore and Cartier (Table 3), identification to species level is possible for only nine families.

Polychaetes were present in samples from 29 of the 45 stations, and these yielded representatives of 24 families with 12 taxa further identified to either the genus or species level (Table 3). The identified genera are *Ceratonereis*, *Chone*, *Chrysopetalum*, *Eteone*, *Nereis*, *Pisione, Platynereis*, *Prionospio*, *Pseudobranchiomma*, *Simplisetia*, *Spiochaetopterus* and *Thelepus*. Because of the poor taxonomic knowledge base, only two taxa could be identified to the species level and this is tentative in both cases (ie. *Pseudobranchiomma* cf *orientalis* and *Chone* cf *australiensis*, both are members of the sabellid family; Table 3).

Pseudobranchiomma orientalis was originally described from Hong Kong but has since not been widely reported in the taxonomic literature and is absent from the Australian literature. A specimen closely resembling this sabellid worm was found on the mooring block at station AR15, where it was infesting a small unidentified sponge at 15 m depth (Table 1). The specimen may either be *P. orientalis* or a closely related species, since *P. orientalis* appears to have a widespread distribution across the Indo-Pacific and could well be native to the Sahul Shelf region.

The other tentative sabellid species identification was *Chone* cf. *australiensis*, a species that may be endemic to NW Australia. Although a positive identification was not possible, the Ashmore Reef specimens extracted from the soft sediment sample grabbed at site AR39 appear to represent this species.

The unidentified spionid worm from station AR35 (Table 3) is not a member of the polydorid group, which includes invasive species belonging to the genera *Boccardia*, *Polydora* and *Pseudopolydora*. While the targeted survey did not find any polychaete listed in the AIMPAC (Australian Introduced Marine Pests Advisory Council) or CSIRO CRIMP lists of invasive species, Hanley's 1993 report denotes the presence of *Hydroides elegans* at Cartier Island. This is a known fouling pest, which has a wide distribution in Indo-Pacific ports and harbours, including Sydney, Brisbane, Townsville and Darwin (Russell and Hewitt 2000, URS 2003). *Hydroides elegans* is an AIMPAC listed invasive species but there is some doubt as to its native range in and beyond Australia, and it is presently regarded as a cosmopolitan species with cryptogenic origins rather than an introduced species (Glasby in Russell and Hewitt 2000).

No specimen of any *Hydroides* tube worm was found by the 2002 survey, but it did yield worms representing three polychaete families not previously recorded for Ashmore Reef or Cartier Island (Pisionidae, Magelonidae, Paraonidae), plus a fourth family not previously recorded from Ashmore Reef (Orbiniidae; Table 3). None of these families has any species with demonstrated long distance dispersal characteristics but it is not surprising to find previously unrecorded species at remote sites in northern Australia, particularly for polychaetes. Eight families previously recorded for Ashmore Reef were not found in the 2002 samples (Aphroditidae, Euphrosinidae, Lumbrineridae, Oenonidae, Onuphidae, Pilargidae, Poecilochaetidae and Questidae; Table 3). This is also not surprising given the targeted approach of the survey.

Table 3: Polychaete taxa recorded at Ashmore Reef and Cartier Island (from MAGNT collections, 1984-1992, Hanley 1993, and the recent 2002 survey) X = Family present; - = Family not recorded.

Family	**ASHMORE REEF** Genus/Species	**CARTIER ISLAND** Genus/Species	**ASHMORE REEF 2002** Fam/Subfam/Genus/Species /Station
Amphinomidae	X	*Chloeia* sp. *Eurythoe pacifica*	Amphinomidae: AR8, 39
Aphroditidae	*Palmyra aurifera*	-	-
Capitellidae	-	X	Capitellidae : AR6,13,18,42
Chaetopteridae	X	-	Chaetopteridae: AR6 *Spiochaetopterus* sp: AR9, 13, AR14,42,43
Chrysopetalidae	*Arichlidion sp.* *Chrysopetalum latusceritrum* *Chrysopetalum remanei* *Chrysopetalum* sp. 7 *Chrysopetalum* sp. B1	- *Chrysopetalum latusceritrum* - - -	- *Chrysopetalum*: AR18 - - -
Cirratulidae	X	X	Cirratulidae: AR42
Dorvilleidae	X	-	Dorvilleidae: AR38, 42
Eunicidae	- - *Lysidice* sp. - -	*Eunice torresiensis* *Eunice* sp. *Lysidice collaris* *Nematoneris unicornis* *Palola siciliensis*	Eunicidae: AR7, 10, 15, 18, AR20, 44
Euphrosinidae	X	-	-
Glyceridae	X	X	Glyceridae: AR37, AR45
Hesionidae	X	*Hesione genetta* *Hesione intertexta* *Leocrates chinensis* *Leocrates* sp. *Leocratides* sp.	Hesionidae: AR15
Lumbrineridae	X	X	-
Magelonidae	-	-	Magelonidae: AR42
Maldanidae	X	-	Maldanidae: AR18, 35
Nereididae	- - *Nereis* sp. - *Platynereis* sp. cf. *Simplisetia* sp. *Websterinereis* sp.	*Ceratonereis mirabilis* *Ceratonereis* sp. *Nereis* sp. *Nicon* sp. - - -	Nereididae: AR38, 39 *Ceratonereis* sp: AR7 *Nereis* sp: AR18 - *Platynereis* sp: AR44 *Simplestia* sp: AR18 -
Oenonidae	X	-	-
Onuphidae	X	-	-
Opheliidae	X	X	Opheliidae: AR6, 7, 10, 13, AR18, 20
Orbiniidae		X	Orbinidae: AR13
Paraonidae	-	-	Paraonidae: AR41, 42

Table 3: continued

Phyllodocidae	- - *Eumida* sp. *Phyllodoce* sp. *? Protomystides* sp.	*Anaitides* sp. - - - *? Protomystides* sp.	- *Eteone* sp: AR32, 42 - Phyllodocidae: 3, 8,43,44,45 -
Pilargidae	X	-	-
Pisionidae	-	-	*Pisione* sp: AR38
Poecilochaetidae	X	-	-
Polynoidae	*Adyte sp.* - - - *Gastrolepidia* sp. *Harmothoe* sp. *Hermenia* sp. *Hololepidella* sp. - *Iphione* sp. *Lepidonotus* sp. - - *Paralepidonotus* sp. - - - *Verrucapelma* sp. - -	- *Australaugeneria* sp. *Australaugeneria pottsi* *Australaureneria michaelseni* *Gastrolepidia clavigera* *Harmothoe vesicudenta* *Hermenia acantholepis* *Hololepidella* sp. *Hololepidella nigropunctata* *Iphione muricata* *Lepidonotus carinulatus* *Paradyte crinoidicola* *Paradyte tentaculata* *Paralepidonotus indicus* *Subadyte papillifera* *Subadyte* sp. *Thormora jukesii* *Verrucapelma* sp. *Verrucapelma nigricans* *Verucapelma retusa*	Polynoidae: AR18
Questidae	X	-	-
Sabellidae	X	-	Sabellidae: AR3 *Chone* cf. *australiensis:* AR39 *Pseudobranchiomma cf orientalis:* AR15
Serpulidae	- *Pomatostegus stellatus* - - -	***Hydroides elegans**** - *Serpula vermicularis* *Spirobranchus giganteus* *Spirobranchus tetraceros*	- - Serpulinae: AR6, 36, 39, 40 Spirorbinae: AR6, 13,23,38, AR43, 45
Sigalionidae	X	-	AR6, 30, 31, 36, 40, 43
Spionidae	X	X	Spionidae: AR35 *Prionospio* sp: AR35, 41,42, AR44
Syllidae	*Ehlersia* sp. *? Pseudoexogone* sp. *Syllis* sp. 2 *Syllis* sp. 3	- - - -	Syllidae: AR3,7,8,11,14,18, AR20, 32, 33, 34, AR36, 37, 44, 45
Terebellidae	X	*Eupolymnia koorangia* *Pista* sp. -	Terebellidae: AR39 - *Thelepus* sp: AR18

3.6.4 Barnacles (Cirripedia) (Dr D. Jones)

During the field survey two main types of barnacles were found: pedunculate cirripedes (= stalked or 'goose' barnacles) and sessile cirripedes (= acorn barnacles). Both are fouling taxa but the stalked barnacles have never achieved a fouling pest status due to their pelagic existence.

The stalked barnacle specimens represented two species (*Lepas (Anatifa) anserifera* and *Lepas (Anatifa) pectinata*) that were collected from 10 stations (Table 4). Both species are common in tropical northern Australian waters and are typical members of the open ocean fouling community of tropical and temperate seas (Jones 1992). Apart from adult specimens sampled from driftwood at station AR8, many recently settled juveniles were also found (Table 4).

Table 4: Identification of barnacles collected from Ashmore Reef in 2002

Station	Suborder/Family	Genus / Species	Number of Specimens
AR 7	Lepadomorpha/Lepadidae	*Lepas anserifera*	4 juveniles
AR 8	Lepadomorpha/Lepadidae Lepadomorpha/Lepadidae	*Lepas anserifera* *Lepas* sp.	Many adults and juveniles on floating drift wood 3 juveniles
AR 16	Lepadomorpha/Lepadidae	*Lepas ?pectinata*	2 juveniles
AR 21	Lepadomorpha/Lepadidae	*Lepas ?anserifera*	1 juvenile
AR 22	Lepadomorpha/Lepadidae	*Lepas pectinata*	8 juveniles
AR 23	Lepadomorpha/Lepadidae	*Lepas ?pectinata*	1 juvenile attached to algal air-bladder
AR 24	Lepadomorpha/Lepadidae	*Lepas anserifera*	1 juveniles
AR 26	Lepadomorpha/Lepadidae	*Lepas ?anserifera*	1 juvenile
AR 27	Lepadomorpha/Lepadidae Balanomorpha/Balanidae	*Lepas anserifera* *Austromegabalanus ?krakatauensis*	Many juveniles 3 dried tests
AR 28	Lepadomorpha/Lepadidae	*Lepas anserifera*	Many juveniles
AR 29	Balanomorpha/Balanidae	*Austromegabalanus krakatauensis*	5 specimens: 3 ovigerous adults, 1 sub-adult, 1 dried test

Sessile barnacles representing *Austromegabalanus,* a genus of large barnacles in the subfamily Megabalaninae, were collected from two stations; namely a dried specimen at AR27 (on beached flotsam and jetsam) and three live individuals and one empty test at station AR29 (hulls of the Type II Indonesian fishing vessels). Both the dried and living specimens were identified as *Austromegabalanus krakatauensis* (Table 4).

This species is previously known only from its type locality (Krakatau, Sunda Strait, Malay Archipelago), and several megabalanids are regarded as nuisance foulers (URS 2002, 2003). This first record of the presence of *Austromegabalanus krakatauensis* in Australian waters is therefore of interest and some concern, since three of the four live specimens taken from the Indonesian fishing vessel hulls contained eggs (ie. they were ovigerous). If released, these might produce an introduced population if fertilisation and settlement onto local substrates were to be successful.

No megabalanid species has reached sufficiently high numbers in natural, undisturbed habitats to cause biodiversity reduction or deleterious ecological change, and those members of the group considered nuisance foulers have gained this reputation only with respect to hulls, jetties, mariculture gear and other artificial substrates (eg. *Megabalanus tintinnabulam* in E. Australian and Indian ports and *Megabalanus coccopoma* in some Brazilian ports; URS 2003). Thus, transfers of *Austromegabalanus krakatauensis* from Indonesia to Ashmore Reef via fishing vessel hulls or driftwood are considered unlikely to pose a risk to its biodiversity or ecological processes. In fact such transfers have probably occurred many times during the long history of fishing vessel visits from Indonesia (Section 2.3). Even if a population was to establish a toehold at Ashmore Reef, this would not represent a significant increased threat to ports such as Broome or Darwin owing to the present level of vessels arriving from the Indo-Malay archipelago.

3.6.5 Other targeted taxa

Logistical and cost constraints limited both the spatial and taxonomic scope of the marine survey and led to the adoption of its targeted approach, with particular attention paid to visually detecting non-indigenous fouling species and other benthic macrobiota placed in current Australian lists of known or potential marine 'pest' species (Table 5). These lists are being used by AFFA, the AQIS Seaports Program and CSIRO-CRIMP to help identify, avoid and/or eradicate incursions of unwanted species. Members of the field team are familiar with most of these taxa (particularly the tropical and subtropical species) and none were observed during the course of the inspection and sampling work.

The taxonomic analyses have subsequently confirmed the absence of established populations of unwanted fouling tube worm, bivalve and barnacle species (the *Austromegabalanus krakatauensis* barnacles were restricted to fishing vessel hulls and driftwood). With respect to non-indigenous macroalgae, the species targeted by the Australian lists comprise temperate and subtropical forms that so far have not established on tropical Indo-Pacific reefs (Table 5).

Table 5: Invasive marine species on the current AIMPAC, NIMPCG and CSIRO-NIMPIS 'target' and 'trigger' lists of unwanted taxa

Species*	Common name	Ability to establish at Ashmore Reef/Cartier
BACTERIA		
Vibrio cholerae	Cholera bacterium	Very low (due to water clarity, insolation and flushing)
DINOFLAGELLATES		
Alexandrium catenella	Toxic dinoflagellate	Very low (prefers temperate/subtropical coastal bays)
Alexandrium minutum	Toxic dinoflagellate	As above
Alexandrium tamarense	Toxic dinoflagellate	As above
Dinophysis norvegica	Toxic dinoflagellate	As above
Gymnodinium catenatum	Toxic dinoflagellate	Low (due to open location and no eutrophic processes)
Pfiesteria shumwayae	Toxic dinoflagellate	Very low (prefers eutrophic coastal lagoons and bays)
Pyrodinium bahamense	Toxic dinoflagellate	Low-Moderate, widespread tropical strain, already in north Australia
DIATOMS		
Chaetoceros concavicornis	Biddulphid diatom	Low (due to open location and no eutrophic processes)
Chaetoceros convolutes	Biddulphid diatom	As above
Pseudonitzschia seriata	Pennate diatom	Low (prefers temperate/subtropical coasts)
Womersleyella setacea	Diatom	Low (prefers temperate/subtropical coasts)
MACROALGAE		
Caulerpa taxifolia (aquarium strain)	Monaco sea grapes	Low (selectively bred for temperate waters)
Codium fragile tomentosoides	Broccoli weed	Low (prefers temperate-subtropical coasts)
Sargassum muticum	Asian strangle weed	Low (prefers temperate-subtropical rocky coasts)
Undaria pinnatifida	Wakame kelp	Very low (prefers temperate rocky coasts)
CTENOPHORES		
Mnemiopsis leidyi	Comb jelly	Very low (prefers temperate coastal waters)
CNIDARIA		
Aurelia aurita	Moon jellyfish	Low (prefers subtropical coastal embayments)
HYROIDS		
Blackfordia virginica	Hydroid	Very low (prefers temperate coastal waters)
POLYCHAETES		
Hydroides sanctaecrucis	Fouling tube worm	Low-Moderate (prefers rocky and artificial substrates)
Hydroides dianthus	Fouling tube worm	
Hydroides dirampha	Fouling tube worm	Low (lower temperature preference)
Sabella spallanzanii	Giant fan worm	Low (lower temperature preference)
		Low (prefers temperate-subtropical coastal waters)

Table 5: continued

CRUSTACEANS		
Pseudodiaptomus marinus	Copepod	Low (prefers subtropical estuarine waters)
Balanus eburneus	Ivory barnacle	Low (prefers lower temp, disturbed or artificial substrata)
Callinectes sapidus	Swimming crab	Low (prefers lower salinity subtropical areas)
Carcinus maenas	European shore crab	Very low (prefers temperate-subtropical coasts)
Charybdis japonica	Asian paddle crab	
Eriochir sinensis	Chinese mitten crab	Low-Moderate (prefers subtropical coasts and
Hemigrapsus penicillatus	Asian grapsid crab	estuaries)
Rhithropanopeus harrisii	Burrowing xanthid	Very low (prefers temperate, brackish waters)
		Low (prefers temperate-subtropical rocky coasts)
		Low (prefers lower salinity coastal muddy areas)
MOLLUSCS		
Corbula gibba	Basket clam	Very low (prefers lower temp and salinity areas)
Crassostrea gigas	Pacific oyster	Very low (prefers rocky subtropical and temperate coasts)
Crepidula fornicata	Slipper limpet	Very low due to low temperature, salinity preference
Dreissena bugensis	Quagga mussel	Very low (prefers temperate coastal waters)
Maoricolpus roseus	New Zealand screw shell	Very low (prefers cool to temperate continental waters)
Mya arenaria	Soft-shell clam	Very low (prefers temperate coastal embayments)
Mytilus galloprovincialis	Mediterranean blue mussel	Low (prefers temperate/subtropical rocky coasts)
Mytilopsis sallei	Black-striped mussel	Very low (prefers brackish coastal areas and disturbed harbours)
Musculista senhousia	Asian date mussel	Low (prefers subtropical, disturbed coastal areas)
Limnoperna fortunei	Asian golden mussel	Very low (prefers brackish to freshwater areas)
Perna perna	Brown mussel	Low (prefers temperate to subtropical rocky shores)
Perna viridis	Asian green mussel	Low-Moderate (prefers coastal, harbour and estuary areas)
Potamocorbula amurensis	Chinese clam	Very low (prefers temperate coastal waters)
Philine auriformis	New Zealand sea slug	Very low (prefers temperate coastal waters)
Rapana venosa (thomasina)	Predatory snail	Very low (prefers temperate brackish waters)
ECHINODERMS		
Asterias amurensis	North Pacific sea star	Very low (prefers temperate embayments)
FISHES		
Liza ramada	Thin-lipped mullet	Very low (prefers temperate brackish waters)
Neogobius melanostomus	Black-mouth goby	Very low (prefers temperate brackish waters)
Pagrus major	Red sea bream	Low (prefers temperate to subtropical rocky shores)
Siganus rivulatus	Marbled spinefoot	Low-Moderate (a Red Sea species that has spread to the Mediterranean, prefers coastal, harbour and estuary areas)

* species in **bold** considered to have a Low-Moderate chance of establishing a viable population at Ashmore Reef

3.6.6 Conclusions

Of the various benthic-fouling groups targeted by the survey, only one taxon, the barnacle *Austromegabalanus krakatauensis*, appears to be introduced to, but possibly not yet established, at Ashmore Reef. Live specimens of this taxa were collected from the hull of the Indonesian fishing vessels (Type II) which were anchored in the western lagoon. The inspections showed the hulls were generally free of fouling, apart from a light film of filamentous algae and the barnacles and oysters that were collected (see Section 5.6).

Austromegabalanus krakatauensis has not previously been recorded from Australian waters, with its type location based in the Indo-Malay Archipelago. Although three of the six live individuals collected were ovigerous, the risk that their larvae could establish a permanent and ecologically disruptive local population is considered low for several reasons (Section 3.6.4). However, it would be worth checking both the mooring buoys and rocky shoreline of West Island as soon as possible for evidence of any recent recruitment.

None of benthic animals and plants currently listed by AIMPAC, NIMPCG and CSIRO-CRIMP (Table 5) were observed or collected at Ashmore Reef. In fact, very few of the listed taxa could be considered capable of tolerating the tropical conditions of the outer Sahul Shelf, as most are temperate and/or subtropical forms associated with coastal embayments, estuaries and/or brackish waters (Table 5). Of the various candidates in Table 5, only the tropical toxic dinoflagellate *Pyrodinium bahamense* (var. *compressum*), the tube worm *Hydroides sanctaecrucis*, the paddle crab *Charybdis japonica*, the bivalve *Perna viridis,* and the marbled spinefoot *Siganus rivulatus,* would appear to have a Low-Moderate capacity to establish a persistent population.

The tropical toxic dinoflagellate *Pyrodinium bahamense* has been reported to be present in northern Australian waters (McMinn 1990, Russell and Hewitt 2000), although the risk of transfer to Ashmore lagoon and its establishment there is considered to be low. *Perna viridis* has been found on the hulls of Indonesian vessels visiting Darwin on several occasions, although it does not appear to have established. A small number recently found breeding in Trinity Inlet (Cairns) (mostly on hulks, pylons and other artificial substrates) are believed to have originated from mature *P. viridis* fouling the hulls of vessels arriving from Indo-West Pacific ports. This species is not native to Australian waters and has the potential to pose a threat to the biodiversity of Ashmore Reef if introduced to the region, since it can outcompete native species for space and food (Sommerfield *et al*. 2000), although there have been no reported instances of *P. viridis* establishing on undisturbed reefs and we believe that it is unlikely that this species could readily establish at Ashmore or Cartier Reef. The tube worm *Hydroides sanctaecrucis*, the paddle crab *Charybdis japonica*, and the marbled spinefoot *Siganus rivulatus,* all prefer coastal and/or disturbed environments and while listed as Low-Moderate risk species, the establishment of viable populations at Ashmore or Cartier Reefs is probably at the lower end of the risk spectrum. To reduce the risk of unwanted introductions of hull foulers such as *P. viridis* and megabalanid barnacles, it would be worth educating visitors to the Reserves regarding the need to maintain clean hulls and not to undertake any careening and hull cleaning operations whilst inside the Reserve boundaries.

With respect to the other harmful microalgae and invasive zooplankton in Table 5, it is worth noting that their principal vector does not occur very close to Ashmore Reef (ballast tank discharges; see Section 5.1). The benthic cysts of toxic dinoflagellates and other protists are most likely to accumulate in areas where fine-grained anoxic muds are rarely disturbed (G. Hallegraeff pers. comm.). However, even if the finest sediments at Ashmore Reef (the silty fine sands in the 15-20 m deep areas of the lagoons) remain unmobilised during cyclonic events and so allow cysts to accumulate, the amount of tidal and wave-induced flushing in the main lagoons, together with the oligotrophic waters and lack of significant nutrient inputs, must reduce the risk of eutrophic conditions that stimulate toxic blooms. In this context, no red tides have been recorded at Ashmore Reef, even during hot, still conditions after coral spawning in late summer (a time when lagoons of oceanic atolls such as the Cocos (Keeling) Islands and in the Federated States of Micronesia and French Polynesia have been impacted by local 'red tide' events).

The pathogenic (Type II) strains of *Vibrio cholerae* are most common in turbid fresh, brackish and inshore coastal waters near dense population areas of developing countries in the wet tropics, although their numbers are typically very low (ie. well below an infectious dose) except where a cholera outbreak is occurring. These strains are rapidly killed in transparent offshore waters by natural UV radiation and salinity effects, and their half-life in the generally clear, very saline, highly insolated and regularly flushed waters at Ashmore Reef would be short compared to that in harbours and estuaries of the wet tropics.

Even with a worst-possible scenario (eg. release of a high level of untreated faecal waste from a boat load of cholera-infected fishers or suspected illegal entrants stranded at the Western lagoon for several days), it is therefore unlikely that the lagoon waters would remain contaminated for any lengthy period following their departure. However, if the people concerned had landed and camped on the island, the lens of fresh to brackish groundwater on West Island could become contaminated, so water quality testing would be required, particularly at any well or bore sites.

4 TERRESTRIAL FIELD SURVEY

4.1 Methods and survey areas

Details of the survey methodologies and survey areas at Ashmore and Cartier Islands for terrestrial plants and fauna are contained in Appendices 3 and 4 respectively, and the results are summarised below.

4.2 Terrestrial plants

Thirty species of terrestrial vascular plants were recorded during this current survey, with 39 species recorded over a number of years during this and previous surveys. The parasitic vine *Cuscuta australis* was the only species recorded during this survey that had not previously been recorded from the Islands. The tar vine *Boerhavia glabrata* previously recorded, was not found during this survey, although this species was reported subsequently during the NAQS survey in 2003 (Mitchell in Curran 2003). However, this species may have been confused with other *Boerhavia* species.

Forty four species have been recorded as drift seeds on the Islands' beaches.

Eight non-indigenous plant species are presently known from the Islands. At present, none of these NIS can be regarded as a major problem on the islands. Of the taxa seen, all except two species of native plant and all of the NIS recorded on the islands are found on the Australian mainland. There is no indication that either of these native species would become serious weeds if introduced to Australia. Of the non-indigenous taxa recorded, two species are well established, *Tribulus cistoides* and *Cenchrus brownii*. Two other species, *Cenchrus ciliaris* and *Pennisetum pedicellatum* , were found in small populations and should be eliminated from West Island before they become well established and spread to adjacent islands.

4.3 Terrestrial fauna

Studies of the terrestrial fauna of Ashmore Reef have been sporadic and apart from various bird surveys, no comprehensive field surveys have been undertaken until now.

4.3.1 Insects

Two previous surveys of the insect fauna of Ashmore Reef were undertaken by Pike (1992) and Brown (1999). In reporting on the latter survey Brown (1999) incorporated the material collected by Pike (1992) and listed 127 species of insects in 67 families as well as seven families of spiders, and one each of pseudoscorpions, centipedes and millipedes.

The higher taxa of insects found during the present survey, together with those collected by Pike in March, April and May 1992, Brown in May 1995 (Brown 1999) and Postle in February 2000 (Tony Postle, pers. com.) are summarised in Table 6.

A total of 149 species in 103 families of insects have been recorded from Ashmore Reef at various times between 1992 and 2002 by Pike (1992), Brown (1999), and Postle (pers. com.). However, as some species were not recollected during subsequent surveys, they may not have become permanently established.

On West Island during the present survey, the only common species were the moths *Utethesia* sp(p). (family Arctiidae), *Anisodes ?obrinaria* (Guenée) (family Geometridae) and the unknown pterophorid (family Pterophoridae), the grasshoppers *?Aiolopus* sp. and *Pycnostictus seriatus* Saussure (family Acrididae) and an unknown blattellid cockroach (family Blattellidae). The *Utethesia* moths were associated with octopus bush, *Argusia argentea argentea.* The larvae of these had caused minor damage to most leaves, but only one live larva was found. One moth in good condition was also found on *Argusia argentea* on East Island, but there was no larval damage observed on any of the leaves. No evidence of *Utethesia* was found on Middle Island.

The geometrid and pterophorid moths are probably associated with creepers, *Ipomoea* spp., and Tar Vines, *Boerhavia* spp., respectively, and the blattellid cockroaches with *Argusia argentea*. The moths and cockroach were only found on West Island; whereas the grasshoppers were common on all three islands, although their distribution appeared to be patchier on East and Middle Islands. The latter were associated with grasses including *Digitaria mariannensis*.

Table 6: Numbers of families and insects collected during past and present surveys

	Pike (Mar-May 1992)		Brown (May 1995)		Postle (Feb 2000)		Brown (June 2002)	
Taxa	**Family**	**Species**	**Family**	**Species**	**Family**	**Species**	**Family**	**Species**
Non-insects								
Isopoda					1	1	1	1
Diplopoda	1	1					1	1
Scolopendrida	1	1					1	1
Pseudoscorpionida	1	1						
Acarina					2	2		
Araneida	6	7	5+	5+	1+	1+	2+	3+
Collembola					1	1		
Insects								
Thysanura					1	1	1	1
Odonata	2	2	3	5				
Blattodea	1	2	1	3	1	1	1	1
Mantodea	1	1						
Orthoptera	3	6	3	6	3	6	3	6
Embioptera	1	1	1	1	1	1	1	1
Psocoptera					1	1	1	1
Phthiraptera					1	3		
Hemiptera	4	6	6	11	7	9	4	4
Thysanoptera							1	1
Neuroptera	1	1	1	1	1	1	2	2
Coleoptera	9	10	7	7	3	3	5	6
Diptera	11	13	10	14	14	14	7	8
Lepidoptera	10	31	11	28	3	3	5+	5+
Hymenoptera	5	5	9	11	2	4	8	9
Total insects	49	78	51	87	39	48	40+	46+
Total all species	57	88	57+	92+	44+	53+	45+	46+
New insect records	49	78	36	49	16	20	2	2

Apart from grasshoppers, bushflies *Musca vetustissima* (Walker) (family Muscidae) and small black flies, *Siphunculina striolata* (Wiedemann) (family Chloropidae) were also common on both East and Middle Islands.

Searches for specific non-indigenous insect species found no evidence of boring beetles or termites in living or dead trees, or in driftwood.

The insect fauna found in the public access area, the most likely first point of contact for any potential invasive species, did not differ from the fauna found elsewhere within the Reserve area (although the ginger ant was abundant at one site as mentioned below). This included an inspection of the water well associated with the pump on West Island, and the wells on West and Middle Island. These wells are closed and inaccessible to both humans and insects, and it is presumed that no insects are breeding in any of them (a pipe inserted through the cover of the well is used to access the water for testing).

On Cartier Island, insects and mites were generally rare and difficult to find (Appendix 3: Table 4). Only two species of insect were observed: a redlegged ham beetle, *Necrobia rufipes* (De Geer) (family Cleridae) on the carapace of a dead turtle, and a small midge (family Chironomidae) running ant-like on the sand. Several mites were also observed under a dead and dehydrated tern.

4.3.2 Spiders

Two species of jumping spider (family Salticidae) were relatively common on West Island, and present on all three islands. The blue salticid was only found on shrubs, while a brown species occurred on both shrubs and on the ground. The latter could be confused with a juvenile wolf spider (family Lycosidae) as they are similarly coloured.

4.3.3 Ants

The ginger ant, *Solenopsis geminata* (Fabricius) (family Formicidae), was present and widespread on all three islands including the beaches. It was found under most dead birds, but usually in relatively small numbers. However, much larger numbers were observed near the pump on West Island and under the coconut trees on Middle Island, where, it is possible, more water was available to this species. The Ginger ant is now widespread on all three islands at Ashmore Reef, and appears to be surviving on dead birds. It may be more abundant in the wet season and could be having an effect on nesting birds and turtles, but neither of these issues could be determined during this visit.

Paratrechina longicornis was the only other ant found during this survey. It was seen to be occurring on and under larger shrubs and trees. This species is widespread throughout the tropics including Australia and during this survey was found only on the *Argusia argentea* (Octopus bush) and the fish plate shrub, *Guettarda speciosa*. However, Postle (pers. com.) also tentatively recorded two other species of ants, *Tetramorium* sp. and a second species of *Solenopsis*. That these taxa were not seen during this survey may be a reflection of the different timing of the surveys or that these taxa have not persisted at the Reserves.

4.3.4 Molluscs

No terrestrial snails or slugs were found.

4.3.5 Crustaceans

Amphipods were common under wetter driftwood on the beach at West Island, and there were very few hermit crabs compared to a previous visit to Ashmore Reef in May 1995. Hermit crabs were, however, common in and around dead turtles and in a hollow log at Cartier Island.

4.3.6 Reptiles

The Asian house gecko, *Hemidactylus frenatus* , was common on West Island. It was found on all larger pieces of wood above the high water mark with several often being seen on each log. It was also heard calling in the coconut trees. It was not observed in any of the *Argusia argentea* bushes, although it is expected to occur there. It was not found on East or Middle Islands, even though similar conditions occurred there.

The Asian house gecko was rare in May 1995. It was neither seen nor heard at that time, and its presence was only detected in a Malaise trap on West Island. It is now widespread and abundant on West Island, but not detected on either East or Middle Islands.

No other terrestrial reptiles were found.

4.3.7 Rodents

There was no evidence of mice or rats on West Island, although an egg found on East Island showed possible damage from an unknown vertebrate predator.

4.3.8 Other organisms

The presence of raptors may be reducing the size of the grasshopper populations on West Island. If so, this could result in rapid and long-term changes in the abundance and biomass of some plants such as grasses on West Island. However, this is probably a naturally occurring cycle at Ashmore Reef.