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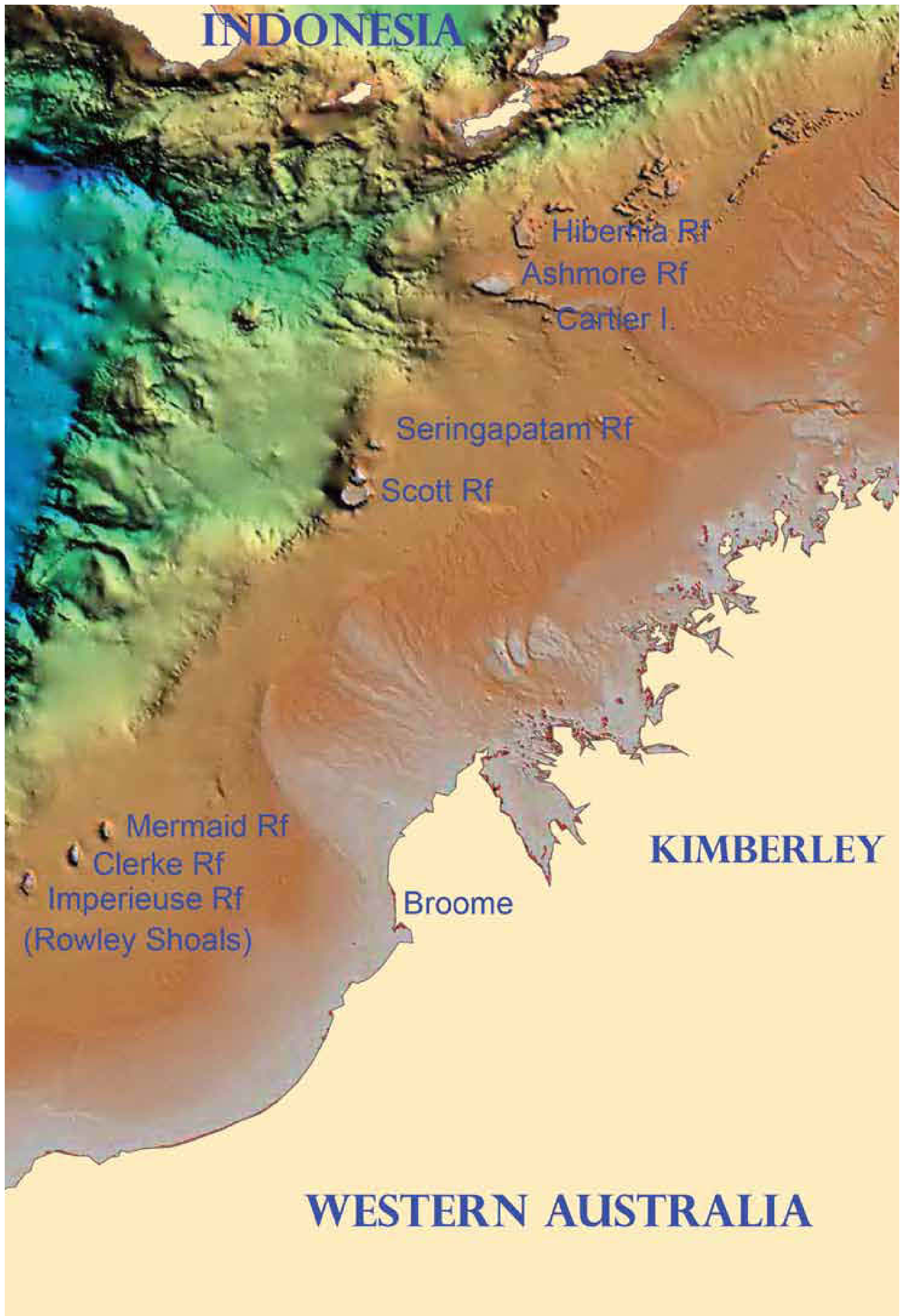
Marine Biodiversity Survey of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reef

Western Australia 2006

Edited by Clay Bryce

Records of the Western Australian Museum
Supplement No. 77


INDONESIA
Hibernia Rf
Ashmore Rf
Cartier I.
Seringapatam Rf
Scott Rf
Mermaid Rf
Clerke Rf
Imperieuse Rf
(Rowley Shoals)
Broome
KIMBERLEY
WESTERN AUSTRALIA

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Records
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The *Records of the Western Australian Museum* publishes the results of research into all branches of natural sciences and social and cultural history, primarily based on the collections of the Western Australian Museum and on research carried out by its staff members.

Collections and research at the Western Australian Museum are centred on Earth and Planetary Sciences, Zoology, Anthropology and History. In particular the following areas are covered: systematics, ecology, biogeography and evolution of living and fossil organisms; mineralogy; meteoritics; anthropology and archaeology; history; maritime archaeology; and conservation.

Western Australian Museum

Perth Cultural Centre, James Street, Perth, Western Australia, 6000

Mail: Locked Bag 49, Welshpool DC, Western Australia 6986

Telephone: (08) 9212 3700

Facsimile: (08) 9212 3882

Email: reception@museum.wa.gov.au

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Front cover: photo Sue Morrison; Back cover: photo (top) John Huisman, photo (bottom) Sue Morrison; Inside cover: photo Clay Bryce.

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Above: Tender transport was used extensively to reach station sites. (Photo: Clay Bryce)

From top: Station 37, North Scott Reef outer reef flat; Station 34, North Scott Reef; North end of Sandy Islet, South Scott Reef. Station 32, North Scott Reef. (Photos: John Huisman)

Above: Sandy Islet, South Scott Reef – looking south at low tide. (Photo: Clay Bryce)

Above: *Drupa ricinus (*Linnaeus, 1758). A common mollusc of the outer reef platforms of Mermaid Reef. (Photo: Clay Bryce)

Above: Station 39, North Scott Reef. Coral devastation surrounding live monolithic coral outcrops. (Photo: Clay Bryce)

Chief Executive Officer's Overview

The Western Australian Museum has been researching Western Australia's marine fauna since 1892. Collections from the Fremantle area and the Swan River were the first to grace the museum's collection areas. This modest start was to gather pace, albeit slowly, as the state blossomed. The sheer immensity of the state was a vexing issue. With a shoreline exceeding 12,500 km and extending across more degrees of latitude than any other geopolitical entity in the southern hemisphere the challenge to document the marine fauna was, and still is, formidable. The expanse of the state ensures a high diversity of habitats spanning both temperate and tropical zones. As such, Western Australia is home to a diverse and abundant array of marine life. Further out to sea, along our equally long continental edge, there is a relatively unknown deep water fauna surviving in habitats defined by depth, and therefore pressure, topographic gradation and soft sediments. The marine life in these dark depths is still relatively unknown. From about 17º 40'south latitude, near the southern edge of the Rowley Shoals, and extending northwards, the continental slope periodically and dramatically rises steeply to the surface forming a chain of atolls. These "oases of life" represent a unique habitat for Western Australia. In 1983 the WA Museum conducted a marine biodiversity survey of these continental-edge atolls (Rowley Shoals, Scott and Seringapatam Reefs) and the findings were published as a Supplement to the WA Museum Records in 1986 (Berry).

Twenty years later, in 2006, through generous support from Woodside Energy, the museum was able to revisit the area. As with the earlier 1983 survey, this new undertaking investigated the biodiversity of the reefs and the bio-geographic distributions of the various marine taxa inhabiting them. Woodside Energy has been a strong supporter of the WA Museum's marine research and development and our award winning partnership has stretched over 11 years. During this time the partnership has yielded an amazing wealth of published scientific data. These data have also been made available to the wider community in the form of displays, websites, public talks and documentary productions.

This current Supplement to the WA Museum Records titled *A Marine Biodiversity Survey of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia 2006*, represents a significant contribution to our knowledge of this remote oceanic region. This volume supersedes the results from an unpublished, preliminary report completed in November 2006 (WA Museum Survey Team, 2006). The results, now having undergone further analysis, document a substantial cross-section of the biodiversity of the atoll reefs with peer reviewed papers concerning the sponges, corals, molluscs, echinoderms, crustaceans and fish, as well as the algae and seagrasses. Habitat video analysis was also undertaken at many of the sites visited.

As with all museum surveys the findings in this volume are backed by carefully labelled voucher records. Without these specimen records to provide scientific evidence of what was observed the verification of new species and associated bio-geographic information used to determine distribution patterns of the various taxa would not be possible.

It is significant to note that 1,897 species were recorded during the survey. Of these, 262 species were new records — an indication of how little we know about the marine biodiversity of this huge state. A further example of this knowledge gap can be found by examining the sponge data. During the survey sponges were surveyed for the first time with 132 species recorded. Amazingly, the results show that 79 species, i.e. 60% of the species were unique to individual reefs, with only 14 species found at all three reefs.

The WA Museum/Woodside Energy partnership continues to provide a solid example of science and industry working together to increase our biological knowledge and raise public awareness of the marine biodiversity of this state. Current work by the WA Museum, with support from Woodside Energy, is concentrating inshore, around the Kimberley islands and coastline. With our work and from the efforts of other research agencies, a better understanding of our marine fauna, associated bio-geographic information and the habitats of our tropical north-west will be better understood.

Diana S. Jones
Chief Executive Officer (Acting)
Western Australian Museum

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Berry. P.F. (ed.), (1986). Faunal Surveys of the Rowley Shoals, Scott Reef, and Seringapatam Reef, North-western Australia. *Records of the Western Australian Museum,* Supplement **25***: 1–25.*

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Above: Intertidal fish collecting at Station 21, South Scott Reef. (Photo: Sue Morrison)

Left: Mermaid Reef. Research diver and *Acropora* forest; **Right:** Researchers with collected specimen vouchers. (Photos: Clay Bryce)

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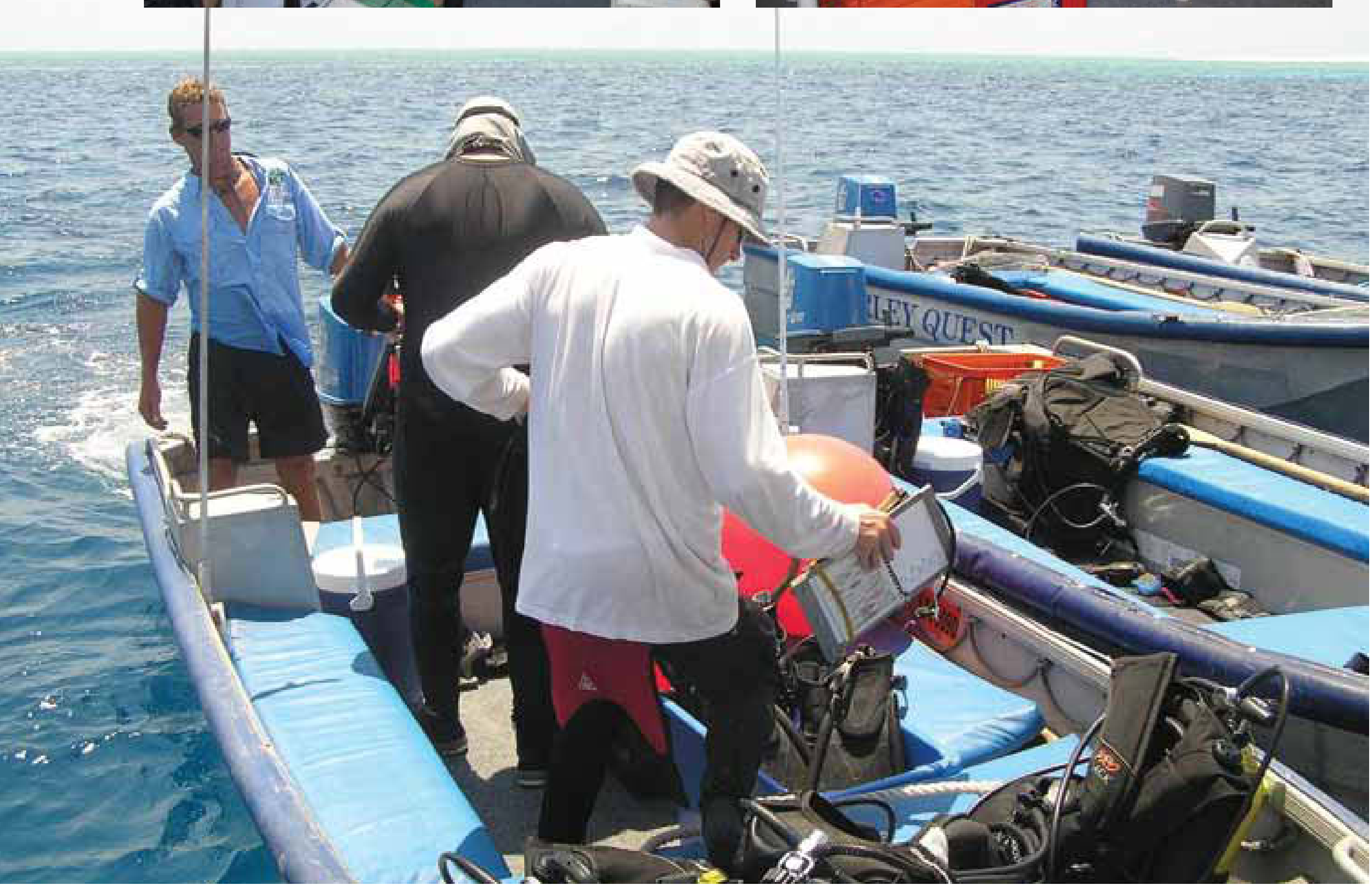
Clockwise From Top Left: Divers at safety stop; Replicated transects were used at most sites; Coral collecting. (Photos: Clay Bryce)

Above: Coral rubble provides a cryptic habitat for reef platform marine life. (Photo: Clay Bryce)

Above: Researchers wading to ashore to the next intertidal station. (Photo: Clay Bryce)



Above: Deck and tender activity, from dive preparation to specimen identification was constant. (Photos: Sue Morrison & Clay Bryce)

Participants and Authors

WA MUSEUM STAFF MEMBERS

Field Participants:

Clay Bryce (Project leader and dive supervisor)	Molluscs
Jane Fromont	Porifera
Melissa Titelius	Crustacea
Christine Hass	Crustacea
Sue Morrison	Fishes
Corey Whisson	Molluscs

Non-field participants:

Diana Jones	Crustacea
Loisette Marsh	Echinoderms
Alison Sampey	Crustacea

NON WA MUSEUM STAFF MEMBERS

Field Participants:

John Huisman Murdoch University and Department of Environment and Conservation	Marine flora
David McKinney Australian Institute of Marine Science	Scleractinian corals
Glenn Moore Murdoch University	Fishes
Peter Morrison Sinclair Knight Merz Pty. Ltd.	Video transects
Anna Kernohan (Private)	Paramedic

Non-field participants:

Mathew A. Vanderklift Commonwealth Scientific and Industrial Research Organisation	Sponge analysis
Frederik Leliaert Ghent University, Belgium	Algae
Heroen Verbruggen Ghent University, Belgium	Algae
Roberta A. Cowan Murdoch University, Australia	Algae

Above: Station 28. Surge channel at South Scott Reef indicates a high energy, subtidal zone. (Photo: Glenn Moore)

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Station and Transect Data for Mermaid (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia.

Clay Bryce

Department of Aquatic Zoology, Western Australian Museum, Locked Bag 49 , Welshpool, D.C. 6986.
Email: clay.bryce@museum.wa.gov.au

The biodiversity survey of Mermaid (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia, undertaken in September 2006, recorded six faunal taxa (Porifera, Scleracterinia corals, Crustacea, Molluscs, Echinodermata and Pisces (fish) as well as the marine flora (algae and seagrasses).

Stations were sited to represent as many habitats as possible. Where practical, stations were overlayed or placed close to established Australian Institute of Marine Science (AIMS) monitoring sites (A. Heyward, pers. comm.) and Western Australian Museum (WA Museum) collecting sites as cited in Berry (1986) (Table 1). Five stations were also located in areas proposed for industrial activity (stations 25 and 28 from South Scott Reef; stations 31, 32 and 35 from North Scott Reef).

STATION SITES AND TRANSECT DATA:
(Figures 1, 2 and 3; Table 2, 3, 4)

Location of station sites and transect data for Mermaid (Rowley Shoals), Scott and Seringapatam Reefs can be found in Figure 1 and Table 2; Figure 2 and Table 3 and; Figure 3 and Table 4 respectively.

Tables 2, 3 and 4 provide station numbers, coordinates, survey dates, transect data (T- depth, T-length, T-width, T-area in m^2 and hectares) and a brief habitat descriptor for the surveyed reefs. A total of 45 stations were surveyed (Mermaid 17 stations; South Scott Reef 14; North Scott Reef 10 and Seringapatam 5) over 16 sampling days. The station identification data (date, habitat descriptor, station number, coordinates in UTM, depth and decimal latitude and longitude) are in bold type for easy recognition.

The coordinates for stations and transects were recorded in the Universal Transverse Mercator geographic coordinate system (UTM), which uses "northings" and "eastings". These coordinates were converted to latitude and longitude (degrees and decimal minutes) for the convenience of reader use. The identification waypoint for stations was determined at the deepest point of each station. Within each subtidal station two sets of bisecting transect were established. This approach helped to alleviate site crowding with 10 divers in the water at any one time. It also allowed for predetermined sampling methodologies for each taxa to be accommodated within the one hour dive time. Intertidal stations were sampled qualitatively for all taxa, except for Porifera.

The set of transects dedicated to Algae (A), Mollusca (M), Echinodermata (E) and Fish (F) ran from the deepest point (station waypoint) to the shallowest part of each station. The fish transects (F1) ran in a general upslope or cross-station direction and had no recorded end waypoint but concluded at the reef edge. This set of transects crossed (i.e. ran perpendicular to) the second set, which were recording Scleracterinia (S), Porifera (P) and Crustacea (C). These latter transects were depth restricted at approximately 5 m and 12 m (relative to mean sea level). When they were sited at a significant distance from the station waypoint a decimal latitude and longitude conversion was also provided in Tables 2, 3 and 4. The area encompassed by these transects was recorded on video and analysed for percentage cover (Morrison, P., this volume).

Distances defining transect lengths were determined from measuring tape and way point coordinates. For the A, M and E transects, where a slope distance was required, a simple straight line estimate was calculated. The slope calculation used is expressed as:

$\sqrt{a^2 + b^2 + c^2}$ Where:

- a = "easting" coordinate (UTM) distance between deepest buoy and shallowest buoy
- b = "northing" coordinate (UTM) distance between deepest buoy and shallowest buoy
- c = difference in the depths at the two buoys.
- Detailed methodologies for each taxon are contained within the following papers of this volume.

To read the tables:

Example 1: Station 17, Scott Reef.

On the 18 September 2006 at Scott Reef dive

Above: Station 2, Mermaid Reef. (Photo: Sue Morrison)

Table 1 Stations with matching coordinates for the 2006 WA Museum survey, AIMS monitoring stations and WA Museum stations (Berry, 1986).

WA Museum Stations (This survey - 2006)	WA Museum Stations (Berry, 1986)	AIMS Monitoring Stations
11		RL1-1(old) (Mermaid)
18 and 24	2 and 4 (Scott)	
22	23 (Scott)	
26	20 (Scott)	
27	19 (Scott)	
26		SL2-1 (Scott)
30		SS1-1 (Scott)
34		SL4-1 (Scott)
41	13 (Seringapatam)	
44 and 45		SS3 (Seringapatam)

Station 17 (located at UTM Zone 50S, easting 369212 : northing 8429152 or 14°12.360'S : 121°47.273'E) a 1 m wide transect for Algae (AI, A2), Mollusca (M1, M2), Echinodermata (E1, E2) and Fish (F1) began in 20 msw running for 72 m and ended in 3.5 msw at coordinates 14°12.325'E : 121°47.289'E. The survey area covered was 72 m² or 0.007 ha. Note that the Fish transect (F1) end coordinate was approximate and not recorded.

The start points for the transects of Porifera (P1 at 10.5 m and P2 at 3.5 m), Scleracterinia corals (S1 at 10.5 m and S2 at 3.5 m) and Crustacea (C1 at 10.5 m and C2 at 3.5 m) are recorded in UTMs ("northings' and "eastings"). The location of this set of replicated transects was also converted to decimal latitude and longitude (14°12.343'S: 121°47.281'E to 14°12.325'S: 121°47.289'E) for convenience as they were considered to be at a significant distance from the identifying station marker located at 14°12.360'S: 121°47.273'E.

Example 2: Station 21, Scott Reef.

On the 20 September 2006 at Scott Reef intertidal Station 21 (located at UTM Zone 50S easting 364563 : northing 8443446 or 14°04.593'S : 121°44.732'E) a 1 m wide transect for Porifera (P1) began in 0 msw running for a measured 15 m. The survey area covered was 15 m² or 0.002 ha. All other marine groups were surveyed qualitatively.

REFERENCE:

Berry, P.F. and Marsh, L.M. (1986). Part 1. History of investigation and description of physical environment. In Berry. P.F. (ed.), Faunal Surveys of the Rowley Shoals, Scott Reef, and Seringapatam Reef, North-western Australia. Records of the Western Australian Museum, Supplement **25**: 1–25.

Above: Station 34, North Scott Reef. Numerous sea fans indicate a periodical, strong current flow. (Photo: John Huisman)

From top: Station 36, North Scott Reef. Pocked reef-crest with encrusting coralline algae; A well scoured habitat at Station; North Scott Reef; Station 45, Seringapatam Reef; Station 42, Seringapatam Reef. The reef at this site was inundated by sand. (Photos: John Huisman)

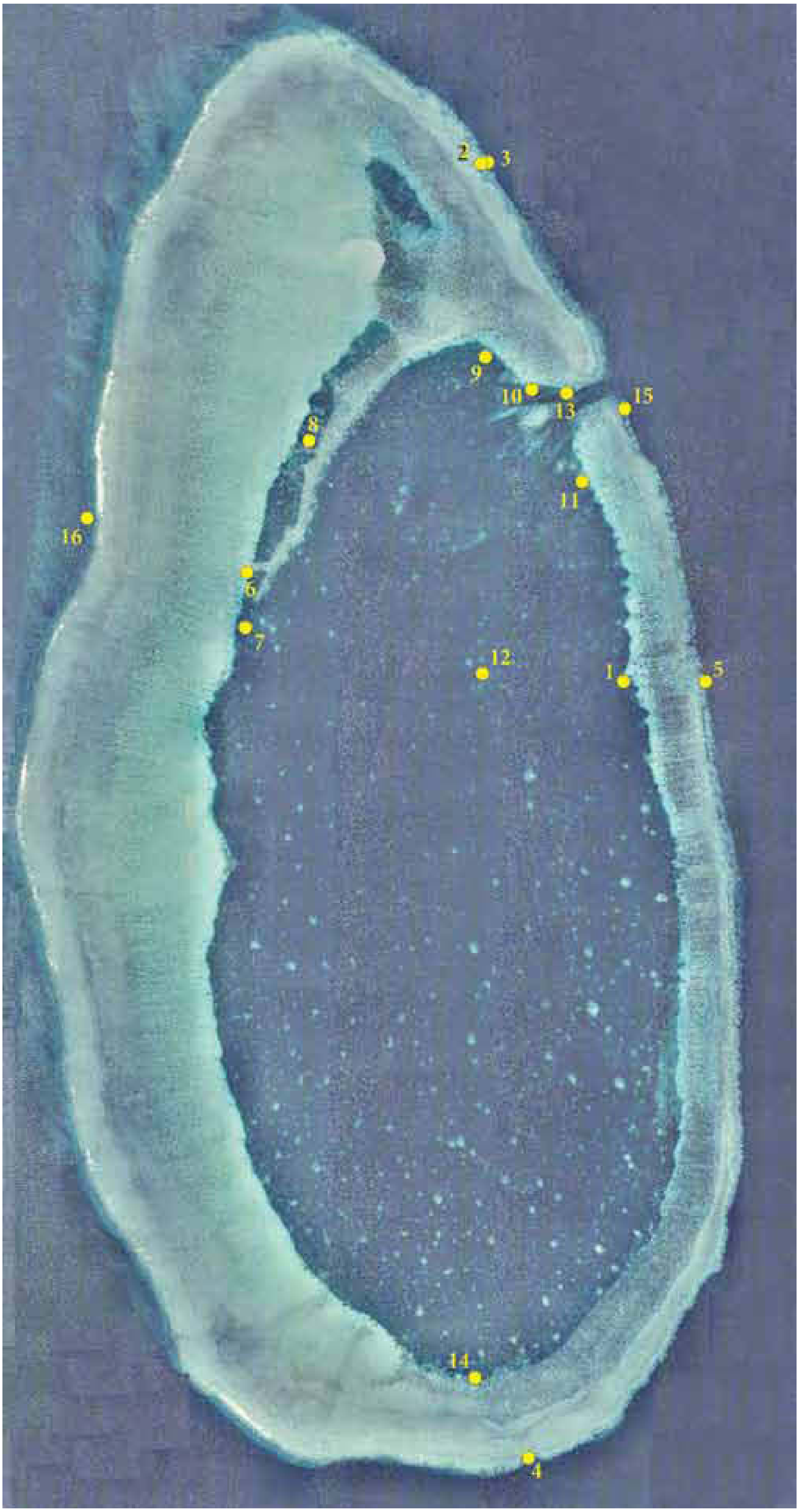

Figure 1 Mermaid Reef (Rowley Shoals) with surveyed station sites (2006)

Table 2 Station and transect data for Mermaid Reef (Rowley Shoals) (2006)

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	MERMAID REEF (ROWLEY SHOALS)		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
12-Sep-06	**Dive: Inner lagoon - east side**	**1**	**781932**	**8108620**	**10.5**	**0**	**0**	**0**	**0.000**	**S 17°05.374′**	**E119°38.948′**
	Coralline sands and coral rubble bottom shallowing to a coral ourcrop. Outcrop with extensive coral growth across top and sides. Adjacent is a sand zone, which extends to inner reef platform edge. South of AIMS RL1-3 lagoon site.		782046	8108631	3.5	115	1	115	0.011	S 17°05.368′	E119°39.012′
		Algae (A1)	781932	8108620	10.5	0	0	0	0.000		
		Algae (A2)	782046	8108631	3.5	115	1	115	0.011		
		Porifera (P1)	781943	8108615	10.5	15	1	15	0.002		
		Porifera (P2)	781988	8108634	3.5	15	1	15	0.002		
		Scleracterinia (S1)	781944	8108615	10.5	15	1	15	0.002		
		Scleracterinia (S2)	781088	8108634	3.5	15	1	15	0.002		
		Crustacea (C1)	781944	8108615	10.5	5	1	5	0.001		
		Crustacea (C2)	781088	8108634	3.5	5	1	5	0.001		
		Mollusca (M1)	781932	8108620	10.5	0	0	0	0.000		
		Mollusca (M2)	782046	8108631	3.5	115	1	115	0.011		
		Echinodermata (E1)	781932	8108620	10.5	0	0	0	0.000		
		Echinodermata (E2)	782046	8108631	3.5	115	1	115	0.011		
	Coordinates for Fish are approximate	Fish (F1)	781932	8108620	10.5	0	0	0	0.000		
	Dive: Outer slope - NE corner	**2**	**780510**	**8114050**	**20**	**0**	**0**	**0**	**0.000**	**S 17°02.442′**	**E119°38.106′**
	Vertical outer reef wall with wide spurs and deep, narrow grooves. Walls with good coral cover. Soft corals evident beneath underhangs. Reef crest subject to high energy wave action and deeply scored.		780501	8114050	3	19	1	19	0.002	S 17°02.443′	E119°38.101′
		Algae (A1)	780510	8114050	20	0	0	0	0.000		
		Algae (A2)	780501	8114050	3	19	1	19	0.002		
		Porifera (P1)	780510	8114050	20	15	1	15	0.002		
		Porifera (P2)	780501	8114050	3	15	1	15	0.002		
		Scleracterinia (S1)	780510	8114050	20	15	1	15	0.002		
		Scleracterinia (S2)	780501	8114050	3	15	1	15	0.002		
		Crustacea (C1)	780510	8114050	20	5	1	5	0.001		
		Crustacea (C2)	780501	8114050	3	5	1	5	0.001		
		Mollusca (M1)	780510	8114050	20	0	0	0	0.000		
		Mollusca (M2)	780501	8114050	3	19	1	19	0.002		
		Echinodermata (E1)	780510	8114050	20	0	0	0	0.000		
		Echinodermata (E2)	780501	8114050	3	19	1	19	0.002		
	Coordinates for Fish are approximate	Fish (F1)	780510	8114050	20	0	0	0	0.000		

13-Sep-06	**Reef walk: NE Corner of reef**	**3**	**780438**	**8114039**	**0**	**100**	**1**	**100**	**0.010**	**S 17°02.449′**	**E119°38.065′**
	Reef flat with isolated coral outcrops, algal turf and soft coral (*Lobophyton*). Little coral rubble and no tidal pools of significance.	Porifera (P1)	780438	8114039	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
	Dive: Outside slope south end of reef	**4**	**780937**	**8100490**	**20**	**0**	**0**	**0**	**0.000**	**S 17°09.786′**	**E119°38.450′**
	Coral rubble slope rising to cemented rubble and coral ridge. Deep gutters dissecting reef with a floor of broken rubble. Reef wall steep with plate and branching coral. Outer reef platform at 3 m heavily eroded and honeycombed.		780989	8100447	3.5	69	1	69	0.007	S 17°09.809′	E119°38.479′
		Algae (A1)	780937	8100490	20	0	0	0	0.000		
		Algae (A2)	780989	8100447	3.5	69	1	69	0.007		
		Porifera (P1)	780937	8100490	12.2	15	1	15	0.002		
		Porifera (P2)	780989	8100447	5.2	15	1	15	0.002		
		Scleracterinia (S1)	780937	8100490	12.2	15	1	15	0.002		
		Scleracterinia (S2)	780989	8100447	5.2	15	1	15	0.002		
		Crustacea (C1)	780937	8100490	12.2	5	1	5	0.001		
		Crustacea (C2)	780989	8100447	5.2	5	1	5	0.001		
		Mollusca (M1)	780937	8100490	20	0	0	0	0.000		
		Mollusca (M2)	780989	8100447	3.5	69	1	69	0.007		
		Echinodermata (E1)	780937	8100490	20	0	0	0	0.000		
		Echinodermata (E2)	780989	8100447	3.5	69	1	69	0.007		
	Coordinates for Fish are approximate	Fish (F1)	780937	8100490	20	0	0	0	0.000		
	Dive: Outside slope middle east side	**5**	**782790**	**8108620**	**20**	**0**	**0**	**0**	**0.000**	**S 17°05.368′**	**E119°39.431′**
	Vertical wall with hard and soft corals, some underhangs forming small caves. Area of wall sampled was bordered by deep channels with many plate corals, *Tridacna* clams and soft corals on sidewalls. Reef crest heavily weathered and honeycombed.		782777	8108618	3.5	21	1	21	0.002	S 17°05.369′	E119°39.424′
		Algae (A1)	782790	8108620	20	0	0	0	0.000		
		Algae (A2)	782777	8108618	3.5	21	1	21	0.002		
		Porifera (P1)	782790	8108620	12.7	15	1	15	0.002		
		Porifera (P2)	782777	8108618	5.7	15	1	15	0.002		
		Scleracterinia (S1)	782790	8108620	12.7	15	1	15	0.002		
		Scleracterinia (S2)	782777	8108618	5.7	15	1	15	0.002		
		Crustacea (C1)	Not done								
		Crustacea (C2)	Not done								
		Mollusca (M1)	782790	8108620	20	0	0	0	0.000		
		Mollusca (M2)	782777	8108618	3.5	21	1	21	0.002		
		Echinodermata (E1)	782790	8108620	20	0	0	0	0.000		
		Echinodermata (E2)	782777	8108618	3.5	21	1	21	0.002		
	Coordinates for Fish are approximate	Fish (F1)	782790	8108620	20	0	0	0	0.000		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	MERMAID REEF (ROWLEY SHOALS)		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
14-Sep-06	**Snorkel: Inner platform - west side**	**6**	**777987**	**8109760**	**1.8**	**0**	**0**	**0**	**0.000**	**S 17°04.785′**	**E119°36.717′**
	Coral reef and sand interface at west side of lagoon. Station at southern end of southward extending spur. Coral outcrop surrounded by infill sand that extends to reef platform. Isolated coral outcrops scattered about. Whole area has been subject to extensive damage from either cyclonic activity and/or coral bleaching activity. High diversity of *Tridacna* clams and holothurians.		778016	8109724	1.8	46	1	46	0.005	S 17°04.805′	E119°36.734′
		Algae (A1)	777987	8109760	1.8	0	0	0	0.000		
		Algae (A2)	778016	8109724	1.8	46	1	46	0.005		
		Porifera (P1)	777987	8109760	1.8	15	1	15	0.002		
		Porifera (P2)	778016	8109724	1.8	15	1	15	0.002		
		Scleracterinia (S1)	777987	8109760	1.8	15	1	15	0.002		
		Scleracterinia (S2)	778016	8109724	1.8	15	1	15	0.002		
		Crustacea (C1)	777987	8109760	1.8	5	1	5	0.001		
		Crustacea (C2)	778016	8109724	1.8	5	1	5	0.001		
		Mollusca (M1)	777987	8109760	1.8	0	0	0	0.000		
		Mollusca (M2)	778016	8109724	1.8	46	1	46	0.005		
		Echinodermata (E1)	777987	8109760	1.8	0	0	0	0.000		
		Echinodermata (E2)	778016	8109724	1.8	46	1	46	0.005		
	Coordinates for Fish are approximate	Fish (F1)	777987	8109760	1.8	0	0	0	0.000		
	Dive: Inner lagoon outcrop - west side	**7**	**777968**	**8109179**	**11.3**	**0**	**0**	**0**	**0.000**	**S 17°05.100′**	**E119°36.711′**
	Isolated coral outcrop sloping down to sand and coral rubble with areas of staghorn forest. Outcrop slope littered with coral rubble - possible evidence of either / or cyclonic destruction or coral bleaching. Some giant clams (*Tridacna derasa*) were seen in reasonable numbers.		777997	8109193	4.3	33	1	33	0.003	S 17°05.092′	E119°36.727′
		Algae (A1)	777968	8109179	11.3	0	0	0	0.000		
		Algae (A2)	777997	8109193	4.3	33	1	33	0.003		
		Porifera (P1)	777968	8109179	11.3	15	1	15	0.002		
		Porifera (P2)	777997	8109193	4.3	15	1	15	0.002		
		Scleracterinia (S1)	777968	8109179	11.3	15	1	15	0.002		
		Scleracterinia (S2)	777997	8109193	4.3	15	1	15	0.002		
		Crustacea (C1)	777968	8109179	11.3	5	1	5	0.001		
		Crustacea (C2)	777997	8109193	4.3	5	1	5	0.001		
		Mollusca (M1)	777968	8109179	11.3	0	0	0	0.000		
		Mollusca (M2)	777997	8109193	4.3	33	1	33	0.003		
		Echinodermata (E1)	777968	8109179	11.3	0	0	0	0.000		
		Echinodermata (E2)	777997	8109193	4.3	33	1	33	0.003		
	Coordinates for Fish are approximate	Fish (F1)	777968	8109179	11.3	0	0	0	0.000		

	Dive: South end lagoon back reef	**8**	**778639**	**8111137**	**12.8**	**0**	**0**	**0**	**0.000**	**S 17°04.034′**	**E119°37.074′**
	Large pool with *Acropora* forest extending to coral rubble slope. Extensive damage evident - possible evidence of either cyclonic destruction and/or coral bleaching. Rim of pool consists of coral rubble with occasional coral outcrops. Sediment consists of fine coral sands.		778646	8111083	5.8	55	1	55	0.005	S 17°04.064′	E119°37.078′
		Algae (A1)	778639	8111137	12.8	0	0	0	0.000		
		Algae (A2)	778646	8111083	5.8	55	1	55	0.005		
		Porifera (P1)	778639	8111137	12.8	15	1	15	0.002		
		Porifera (P2)	778646	8111083	5.8	15	1	15	0.002		
		Scleracterinia (S1)	778639	8111137	12.8	15	1	15	0.002		
		Scleracterinia (S2)	778646	8111083	5.8	15	1	15	0.002		
		Crustacea (C1)	778639	8111137	12.8	5	1	5	0.001		
		Crustacea (C2)	778646	8111083	5.8	5	1	5	0.001		
		Mollusca (M1)	778639	8111137	12.8	0	0	0	0.000		
		Mollusca (M2)	778646	8111083	5.8	55	1	55	0.005		
		Echinodermata (E1)	778639	8111137	12.8	0	0	0	0.000		
		Echinodermata (E2)	778646	8111083	5.8	55	1	55	0.005		
	Coordinates for Fish are approximate	Fish (F1)	778639	8111137	12.8	0	0	0	0.000		
15-Sep-06	**Dive: North end of lagoon**	**9**	**780482**	**8112012**	**11.1**	**0**	**0**	**0**	**0.000**	**S 17°03.547′**	**E119°38.105′**
	Reef outcrop at edge of low tide sand flat. Corals at top and sides have sustained considerable damage. Deeper areas are well forested with branching *Acropora*. Reasonable meadow of *Thalassia* between ourcrop and intertidal sand flat.		780503	8112032	4.1	30	1	30	0.003	S 17°03.536′	E119°38.117′
		Algae (A1)	780482	8112012	11.1	0	0	0	0.000		
		Algae (A2)	780503	8112032	4.1	30	1	30	0.003		
		Porifera (P1)	780482	8112012	11.1	15	1	15	0.002		
		Porifera (P2)	780503	8112032	4.1	15	1	15	0.002		
		Scleracterinia (S1)	780482	8112012	11.1	15	1	15	0.002		
		Scleracterinia (S2)	780503	8112032	4.1	15	1	15	0.002		
		Crustacea (C1)	780482	8112012	11.1	5	1	5	0.001		
		Crustacea (C2)	780503	8112032	4.1	5	1	5	0.001		
		Mollusca (M1)	780482	8112012	11.1	0	0	0	0.000		
		Mollusca (M2)	780503	8112032	4.1	30	1	30	0.003		
		Echinodermata (E1)	780482	8112012	11.1	0	0	0	0.000		
		Echinodermata (E2)	780503	8112032	4.1	30	1	30	0.003		
	Coordinates for Fish are approximate	Fish (F1)	780482	8112012	11.1	0	0	0	0.000		
	Drift dive: Lagoon entrance channel	**10**	**780973**	**8111676**	**0**	**0**	**0**	**0**	**0.000**	**S 17°03.726′**	**E119°38.385′**
	High current tidal channel that drains and fills the lagoon. Depth to 18 m. Steep sided with branching off shoots. Base well scoured and sides covered		781764	8111779	18	820	10	8200	0.820	S 17°03.664′	E119°38.829′

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	MERMAID REEF (ROWLEY SHOALS)		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Drift dive: Lagoon entrance channel (continued) with both hard and soft corals- *Dendronephthya* and *Melithaea*. Coarse coralline sands in deposition pockets. Co-ordinates and T-widths are indicative only and represent approximate area sampled for all phyla.	Qualitative - biodiversity sampling (except Porifera)									
	AIMS dive site: Lagoon sth of channel	**11**	**781500**	**8110711**	**12.4**	**0**	**0**	**0**	**0.000**	**S 17°04.244′**	**E119°38.689′**
	Series of low and scattered rocky outcrops on fine coralline sands. Outcrops with fine coating of silt with damage to the branching *Acropora*, which has formed coral rubble scree slopes. Good populations of several species of holothurians.		781509	8110763	5.4	53	1	53	0.005	S 17°04.216′	E119°38.694′
		Algae (A1)	781500	8110711	12.4	0	0	0	0.000		
		Algae (A2)	781509	8110763	5.4	53	1	53	0.005		
		Porifera (P1)	781500	8110711	12.4	15	1	15	0.002		
		Porifera (P2)	781509	8110763	5.4	15	1	15	0.002		
		Scleracterinia (S1)	781500	8110711	12.4	15	1	15	0.002		
		Scleracterinia (S2)	781509	8110763	5.4	15	1	15	0.002		
		Crustacea (C1)	781500	8110711	12.4	5	1	5	0.001		
		Crustacea (C2)	781509	8110763	5.4	5	1	5	0.001		
		Mollusca (M1)	781500	8110711	12.4	0	0	0	0.000		
		Mollusca (M2)	781509	8110763	5.4	53	1	53	0.005		
		Echinodermata (E1)	781500	8110711	12.4	0	0	0	0.000		
		Echinodermata (E2)	781509	8110763	5.4	53	1	53	0.005		
	Coordinates for Fish are approximate	Fish (F1)	781500	8110711	12.4	0	0	0	0.000		
16-Sep-06	**Dive: Reef system - central lagoon**	**12**	**780456**	**8108703**	**12.1**	**0**	**0**	**0**	**0.000**	**S 17°05.340′**	**E119°38.116′**
	Subtidal reef system 2 km south of anchorage. Damaged *Acropora* forest in deeper water leading to a rubble scree slope at base of reef outcrops. Crown of reef with larger coral outcrops including plate and massive corals. Good diversity of giant clams and holothurians. Generally a picturesque site.		780475	8108695	5.1	22	1	22	0.002	S 17°05.344′	E119°38.127′
		Algae (A1)	780456	8108703	12.1	0	0	0	0.000		
		Algae (A2)	780475	8108695	5.1	22	1	22	0.002		
		Porifera (P1)	780456	8108703	12.1	15	1	15	0.002		
		Porifera (P2)	780475	8108695	5.1	15	1	15	0.002		
		Scleracterinia (S1)	780456	8108703	12.1	15	1	15	0.002		
		Scleracterinia (S2)	780475	8108695	5.1	15	1	15	0.002		
		Crustacea (C1)	780456	8108703	12.1	5	1	5	0.001		

		Crustacea (C2)	780475	8108695	5.1	5	1	5	0.001		
		Mollusca (M1)	780456	8108703	12.1	0	0	0	0.000		
		Mollusca (M2)	780475	8108695	5.1	22	1	22	0.002		
		Echinodermata (E1)	780456	8108703	12.1	0	0	0	0.000		
		Echinodermata (E2)	780475	8108695	5.1	22	1	22	0.002		
	Coordinates for Fish are approximate	Fish (F1)	780456	8108703	12.1	0	0	0	0.000		
	Drift dive: Lagoon entrance channel	**13**	**781335**	**8111637**	**0**	**0**	**0**	**0**	**0.000**	**S 17°03.744′**	**E119°38.589′**
	Site revisit at slack tide (neaps) to investigate different micro-habitats within confines of channel. Coordinates and T-widths are indicative only and represent approximate area sampled for all phyla.		781813	8111869	18	579	10	5790	0.579	S 17°03.615′	E119°38.857′
		Qualitative - biodiversity sampling (except Porifera)									
	Dive: South end of inner lagoon	**14**	**780375**	**8101327**	**11.9**	**0**	**0**	**0**	**0.000**	**S 17°09.337′**	**E119°38.127′**
	Branching *Acropora* covered outcrops with scattered smaller monolithic coral heads. Sediment consists of fine coral sands and rubble with good coverage of *Thalassia* and *Halophila*.		780303	8101320	4.9	72	1	72	0.007	S 17°09.341′	E119°38.086′
		Algae (A1)	780375	8101327	11.9	0	0	0	0.000		
		Algae (A2)	780303	8101320	4.9	72	1	72	0.007		
		Porifera (P1)	780375	8101327	11.9	15	1	15	0.002		
		Porifera (P2)	780303	8101320	4.9	15	1	15	0.002		
		Scleracterinia (S1)	780375	8101327	11.9	15	1	15	0.002		
		Scleracterinia (S2)	780303	8101320	4.9	15	1	15	0.002		
		Crustacea (C1)	780375	8101327	11.9	5	1	5	0.001		
		Crustacea (C2)	780303	8101320	4.9	5	1	5	0.001		
		Mollusca (M1)	780375	8101327	11.9	0	0	0	0.000		
		Mollusca (M2)	780303	8101320	4.9	72	1	72	0.007		
		Echinodermata (E1)	780375	8101327	11.9	0	0	0	0.000		
		Echinodermata (E2)	780303	8101320	4.9	72	1	72	0.007		
	Coordinates for Fish are approximate	Fish (F1)	780375	8101327	11.9	0	0	0	0.000		
17-Sep-06	**Dive: "Cod Hole" outer slope east side**	**15**	**781944**	**8111473**	**12.1**	**0**	**0**	**0**	**0.000**	**S 17°03.828′**	**E119°38.933′**
	Spur and groove outer slope that has broken off to form a deep reef pool (Cod Hole). Seaward slope reasonably steep to a "false reef crest" then drops vertically into a wide, deep hole to rise again to reef crest proper. Base of slope and hole consists of coral rubble.		781921	8111428	5.1	51	1	51	0.005	S 17°03.853′	E119°38.920′
		Algae (A1)	781944	8111473	12.1	0	0	0	0.000		
		Algae (A2)	781921	8111428	5.1	51	1	51	0.005		
		Porifera (P1)	781944	8111473	12.1	15	1	15	0.002		
		Porifera (P2)	781921	8111428	5.1	15	1	15	0.002		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	MERMAID REEF (ROWLEY SHOALS)		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Dive: "Cod Hole" outer slope east side (continued)	Scleracterinia (S1)	781944	8111473	12.1	15	1	15	0.002		
	Slope with good coral coverage. Crest essentially bare and honeycombed.	Scleracterinia (S2)	781921	8111428	5.1	15	1	15	0.002		
		Crustacea (C1)	781944	8111473	12.1	5	1	5	0.001		
		Crustacea (C2)	781921	8111428	5.1	5	1	5	0.001		
		Mollusca (M1)	781944	8111473	12.1	0	0	0	0.000		
		Mollusca (M2)	781921	8111428	5.1	51	1	51	0.005		
		Echinodermata (E1)	781944	8111473	12.1	0	0	0	0.000		
		Echinodermata (E2)	781921	8111428	5.1	51	1	51	0.005		
	Coordinates for Fish are approximate	Fish (F1)	781944	8111473	12.1	0	0	0	0.000		
	Dive: West side outer slope	**16**	**776311**	**8110327**	**11.8**	**0**	**0**	**0**	**0.000**	**S 17°04.490′**	**E119°35.769′**
	High energy zone. Long even slope with well developed spur and grooves. Some coral outcrops at deeper levels forming caves and sandy pockets. Patchy frequent clusters of *Halimeda* at various levels. Crest well scoured and honeycombed.		776331	8110323	4.8	22	1	22	0.002	S 17°04.492′	E119°35.780′
		Algae (A1)	776311	8110327	11.8	0	0	0	0.000		
		Algae (A2)	776331	8110323	4.8	22	1	22	0.002		
		Porifera (P1)	776311	8110327	11.8	15	1	15	0.002		
		Porifera (P2)	776331	8110323	4.8	15	1	15	0.002		
		Scleracterinia (S1)	776311	8110327	11.8	15	1	15	0.002		
		Scleracterinia (S2)	776331	8110323	4.8	15	1	15	0.002		
		Crustacea (C1)	776311	8110327	11.8	5	1	5	0.001		
		Crustacea (C2)	776331	8110323	4.8	5	1	5	0.001		
		Mollusca (M1)	776311	8110327	11.8	0	0	0	0.000		
		Mollusca (M2)	776331	8110323	4.8	22	1	22	0.002		
		Echinodermata (E1)	776311	8110327	11.8	0	0	0	0.000		
		Echinodermata (E2)	776331	8110323	4.8	22	1	22	0.002		
	Coordinates for Fish are approximate	Fish (F1)	776311	8110327	11.8	0	0	0	0.000		

Figure 2 Scott Reef with surveyed station sites (2006)

Table 3 Station and transect data for Scott Reef (2006)

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	SOUTH SCOTT REEF		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
18-Sep-06	**Dive: South side outer slope**	**17**	**369212**	**8429152**	**20**	**0**	**0**	**0**	**0.000**	**S 14°12.360′**	**E121°47.273′**
	Gentle slope from edge of steep drop-off (20 m) to high energy reef edge with spur and groove. Many small coral heads providing a rich and highly diverse coral community. Surge channels with some coral slabs and coarse coral sands.		369241	8429216	3.5	72	1	72	0.007	S 14°12.325′	E121°47.289′
			369226	8429183	10.5	0	0	0	0.000	S 14°12.343′	E121°47.281′
			369241	8429216	3.5	37	1	37	0.004	S 14°12.325′	E121°47.289′
		Algae (A1)	369212	8429152	20	0	0	0	0.000		
		Algae (A2)	369241	8429216	3.5	72	1	72	0.007		
		Porifera (P1)	369226	8429183	10.5	15	1	15	0.002		
		Porifera (P2)	369241	8429216	3.5	15	1	15	0.002		
		Scleracterinia (S1)	369226	8429183	10.5	15	1	15	0.002		
		Scleracterinia (S2)	369241	8429216	3.5	15	1	15	0.002		
		Crustacea (C1)	369226	8429183	10.5	5	1	5	0.001		
		Crustacea (C2)	369241	8429216	3.5	5	1	5	0.001		
		Mollusca (M1)	369212	8429152	20	0	0	0	0.000		
		Mollusca (M2)	369241	8429216	3.5	72	1	72	0.007		
		Echinodermata (E1)	369212	8429152	20	0	0	0	0.000		
		Echinodermata (E2)	369241	8429216	3.5	72	1	72	0.007		
	Coordinates for Fish are approximate	Fish (F1)	369212	8429152	20	0	0	0	0.000		
	Dive: West side Sandy Cay (WAM4)	**18**	**367262**	**8445101**	**20**	**0**	**0**	**0**	**0.000**	**S 14°03.704′**	**E121°46.236′**
	Bottom gently sloping from 20 m with large compound coral outcrops that coalesce into a highly diverse coral reef with a rugged topographical aspect. Reef undulates at edges with large patches of coral sands.		367313	8445150	3	73	1	73	0.007	S 14°03.677′	E121°46.264′
			367272	8445106	12	0	0	0	0.000	S 14°03.701′	E121°46.241′
			367313	8445150	3	61	1	61	0.006	S 14°03.677′	E121°46.264′
		Algae (A1)	367262	8445101	20	0	0	0	0.000		
		Algae (A2)	367313	8445150	3	73	1	73	0.007		
		Porifera (P1)	367272	8445106	12	15	1	15	0.002		
		Porifera (P2)	367313	8445150	3	15	1	15	0.002		
		Scleracterinia (S1)	367272	8445106	12	15	1	15	0.002		
		Scleracterinia (S2)	367313	8445150	3	15	1	15	0.002		
		Crustacea (C1)	367272	8445106	12	5	1	5	0.001		
		Crustacea (C2)	367313	8445150	3	5	1	5	0.001		

		Mollusca (M1)	367262	8445101	20	0	0	0	0.000		
		Mollusca (M2)	367313	8445150	3	73	1	73	0.007		
		Echinodermata (E1)	367262	8445101	20	0	0	0	0.000		
		Echinodermata (E2)	367313	8445150	3	73	1	73	0.007		
	Coordinates for Fish are approximate	Fish (F1)	367262	8445101	20	0	0	0	0.000		
19-Sep-06	**Dive: Outer slope West Horn**	**19**	**363487**	**8444251**	**12.5**	**0**	**0**	**0**	**0.000**	**S 14°04.154′**	**E121°44.136′**
	Long gradual slope with very diverse coral cover and abundant soft corals (*Sarcophyton*, *Sinularia* and *Lobophyton*). Large coral outcrops at deeper depths. Shallower depths exhibit the effects of the increased surge with smaller coral heads, increased bare rock and deepening surge channels.		363620	8444196	5.5	144	1	144	0.014	S 14°04.184′	E121°44.209′
		Algae (A1)	363487	8444251	12.5	0	0	0	0.000		
		Algae (A2)	363620	8444196	5.5	144	1	144	0.014		
		Porifera (P1)	363487	8444251	12.5	15	1	15	0.002		
		Porifera (P2)	363620	8444196	5.5	15	1	15	0.002		
		Scleracterinia (S1)	363487	8444251	12.5	15	1	15	0.002		
		Scleracterinia (S2)	363620	8444196	5.5	15	1	15	0.002		
		Crustacea (C1)	363487	8444251	12.5	5	1	5	0.001		
		Crustacea (C2)	363620	8444196	5.5	5	1	5	0.001		
		Mollusca (M1)	363487	8444251	12.5	0	0	0	0.000		
		Mollusca (M2)	363620	8444196	5.5	144	1	144	0.014		
		Echinodermata (E1)	363487	8444251	12.5	0	0	0	0.000		
		Echinodermata (E2)	363620	8444196	5.5	144	1	144	0.014		
	Coordinates for Fish are approximate	Fish (F1)	363487	8444251	12.5	0	0	0	0.000		
	Dive: Outer slope - west horn	**20**	**361332**	**8438082**	**20**	**0**	**0**	**0**	**0.000**	**S 14°07.493′**	**E121°42.919′**
	Long gradual slope with abundant small coral heads and soft corals (*Sarcophyton*, *Sinularia* and *Lobophyton*) covering developing spur and grooves. Grooves (surge channels) with good coral coverage until shallower depths when they become scoured with coarse coralline sands along their bases. Coral cover very diverse.		361431	8438118	4.5	106	1	106	0.011	S 14°07.474′	E121°42.975′
			361394	8438112	12.4	0	0	0	0.000	S 14°07.477′	E121°42.954′
			361431	8438118	4.5	38	1	38	0.004	S 14°07.474′	E121°42.975′
		Algae (A1)	361332	8438082	20	0	0	0	0.000		
		Algae (A2)	361431	8438118	4.5	106	1	106	0.011		
		Porifera (P1)	361394	8438112	12.4	15	1	15	0.000		
		Porifera (P2)	361431	8438118	4.5	15	1	15	0.002		
		Scleracterinia (S1)	361394	8438112	12.4	15	1	15	0.000		
		Scleracterinia (S2)	361431	8438118	4.5	15	1	15	0.002		
		Crustacea (C1)	361394	8438112	12.4	5	1	5	0.000		
		Crustacea (C2)	361431	8438118	4.5	5	1	5	0.001		
		Mollusca (M1)	361332	8438082	20	0	0	0	0.000		
		Mollusca (M2)	361431	8438118	4.5	106	1	106	0.011		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	SOUTH SCOTT REEF		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Dive: Outer slope - west horn (continued)	Echinodermata (E1)	361332	8438082	20	0	0	0	0.000		
		Echinodermata (E2)	361431	8438118	4.5	106	1	106	0.011		
	Coordinates for Fish are approximate	Fish (F1)	361332	8438082	20	0	0	0	0.000		
	Intertidal: Lagoon side West Horn	**21**	**364564**	**8443446**	**0**	**100**	**1**	**100**	**0.010**	**S 14°04.593′**	**E121°44.732′**
	Lagoon side of easternmost wreck. Turf covered platform with isolated coral heads. A small intertidal sand cay exists at the waters edge (1.1 m tide). Wreck site has the only significant tidal pool. Few turnable rocks or coral slabs evident.	Porifera (P1)	364564	8443446	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except porifera)									
20-Sep-06	**Dive: Nth Sandy Islet outer slope**	**22**	**366266**	**8447267**	**12.7**	**0**	**0**	**0**	**0.000**	**S 14°02.526′**	**E121°45.688′**
	High energy area with a gradual slope dissected by surge channels that develop as the depth decreases. Soft corals slightly dominate the small coral heads covering the pavement. The whole area has shallow blowouts filled with coarse coralline sands.		366141	8447290	5.7	127	1	127	0.013	S 14°02.513′	E121°45.619′
		Algae (A1)	366266	8447267	12.7	0	0	0	0.000		
		Algae (A2)	366141	8447290	5.7	127	1	127	0.013		
		Porifera (P1)	366266	8447267	12.7	15	1	15	0.002		
		Porifera (P2)	366141	8447290	5.7	15	1	15	0.002		
		Scleracterinia (S1)	366266	8447267	12.7	15	1	15	0.002		
		Scleracterinia (S2)	366141	8447290	5.7	15	1	15	0.002		
		Crustacea (C1)	366266	8447267	12.7	5	1	5	0.001		
		Crustacea (C2)	366141	8447290	5.7	5	1	5	0.001		
		Mollusca (M1)	366266	8447267	12.7	0	0	0	0.000		
		Mollusca (M2)	366141	8447290	5.7	127	1	127	0.013		
		Echinodermata (E1)	366266	8447267	12.7	0	0	0	0.000		
		Echinodermata (E2)	366141	8447290	5.7	127	1	127	0.013		
	Coordinates for Fish are approximate	Fish (F1)	366266	8447267	12.7	0	0	0	0.000		
	Dive: Outcrop - East side lagoon	**23**	**0367114**	**8438114**	**20**	**0**	**0**	**0**	**0.000**	**S 14°07.493′**	**E121°46.133′**
	Isolated outcrop with extensive coral damage from natural causes. From 20 m the slope is steep to the reef crest. The slope consists of algal covered *Acropora* rubble. At the crest large		0367155	8438218	4.5	113	1	113	0.011	S 14°07.436′	E121°46.156′
			0367149	8438210	12.4	0	0	0	0.000	S 14°07.441′	E121°46.153′
			367155	8438218	5.4	12	1	12	0.001	S 14°07.436′	E121°46.156′
		Algae (A1)	0367114	8438114	20	0	0	0	0.000		

	outcrops dominate but with little coral growth. *Fromia multifora* (seastar) is prolific at this site.	Algae (A2)	0367155	8438218	4.5	113	1	113	0.011		
		Porifera (P1)	367149	8438210	12.4	15	1	15	0.002		
		Porifera (P2)	367155	8438218	5.4	15	1	15	0.002		
		Scleracterinia (S1)	367149	8438210	12.4	15	1	15	0.002		
		Scleracterinia (S2)	367155	8438218	5.4	15	1	15	0.002		
		Crustacea (C1)	367149	8438210	12.4	5	1	5	0.001		
		Crustacea (C2)	367155	8438218	5.4	5	1	5	0.001		
		Mollusca (M1)	0367114	8438114	20	0	0	0	0.000		
		Mollusca (M2)	0367155	8438218	4.5	113	1	113	0.011		
		Echinodermata (E1)	0367114	8438114	20	0	0	0	0.000		
		Echinodermata (E2)	0367155	8438218	4.5	113	1	113	0.011		
	Coordinates for Fish are approximate	Fish (F1)	0367114	8438114	20	0	0	0	0.000		
	Intertidal: West side of Sandy Islet	**24**	**367630**	**8445255**	**0**	**100**	**1**	**100**	**0.010**	**S 14°03.621′**	**E121°46.441′**
	Reef begins as small isolated coral outcrops surrounded by coralline sands. The platform is covered by algal turf with many dead coral slabs. Generally flat in profile the reef leads to Sandy Islet where the sand overflow meets the platform. Small patches of *Thalassia* thrive at this junction.	Porifera (P1)	367630	8445255	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
21-Sep-06	**Dive: Lagoon backslope - south side**	**25**	**379321**	**8432403**	**12.8**	**0**	**0**	**0**	**0.000**	**S 14°10.623′**	**E121°52.902′**
	Lagoon edge site is a complex of interconnecting outcrops. Coral cover has been devastated and the rubble is covered with a brown algae (*Dictyota*). Intermittent and sparse *Acropora* thicket surrounded by areas of fine coralline sand dominate the areas at the base of the outcrops. Rubble ridges connect the outcrops.		379307	8432375	5.8	32	1	32	0.003	S 14°10.639′	E121°52.894′
		Algae (A1)	379321	8432403	12.8	0	0	0	0.000		
		Algae (A2)	379307	8432375	5.8	32	1	32	0.003		
		Porifera (P1)	379321	8432403	12.8	15	1	15	0.002		
		Porifera (P2)	379307	8432375	5.8	15	1	15	0.002		
		Scleracterinia (S1)	379321	8432403	12.8	15	1	15	0.002		
		Scleracterinia (S2)	379307	8432375	5.8	15	1	15	0.002		
		Crustacea (C1)	379321	8432403	12.8	5	1	5	0.001		
		Crustacea (C2)	379307	8432375	5.8	5	1	5	0.001		
		Mollusca (M1)	379321	8432403	12.8	0	0	0	0.000		
		Mollusca (M2)	379307	8432375	5.8	32	1	32	0.003		
		Echinodermata (E1)	379321	8432403	12.8	0	0	0	0.000		
		Echinodermata (E2)	379307	8432375	5.8	32	1	32	0.003		
	Coordinates for Fish are approximate	Fish (F1)	379321	8432403	12.8	0	0	0	0.000		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	SOUTH SCOTT REEF		Easting	Northing	msw	m	m	m2	ha	Latitude	Longitude
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Dive: Sth end of lagoon (AIMS SL2-1)	**26**	**371241**	**8430894**	**20**	**0**	**0**	**0**	**0.000**	**S 14°11.421′**	**E121°48.407′**
	Inner lagoon coral reef with a gradual slope to the reef platform. Reef has been damaged by natural causes and is actively in the process of regrowth. Some larger plate corals (*Acropora*) still exist on reef tops. At deeper depths coral cover is low and evenly spread; as depth decreases the coral outcrops increase in size as does the distance between them, forming gutters of coralline sand.		371216	8430801	5.9	97	1	97	0.010	S 14°11.471′	E121°48.392′
			371228	8430837	12.9	0	0	0	0.000	S 14°11.451′	E121°48.399′
			371216	8430801	5.9	39	1	39	0.004	S 14°11.471′	E121°48.392′
		Algae (A1)	371241	8430894	20	0	0	0	0.000		
		Algae (A2)	371216	8430801	5.9	97	1	97	0.010		
		Porifera (P1)	371228	8430837	12.9	15	1	15	0.002		
		Porifera (P2)	371216	8430801	5.9	15	1	15	0.002		
		Scleracterinia (S1)	371228	8430837	12.9	15	1	15	0.002		
		Scleracterinia (S2)	371216	8430801	5.9	15	1	15	0.002		
		Crustacea (C1)	371228	8430837	12.9	5	1	5	0.001		
		Crustacea (C2)	371216	8430801	5.9	5	1	5	0.001		
		Mollusca (M1)	371241	8430894	20	0	0	0	0.000		
		Mollusca (M2)	371216	8430801	5.9	97	1	97	0.010		
		Echinodermata (E1)	371241	8430894	20	0	0	0	0.000		
		Echinodermata (E2)	371216	8430801	5.9	97	1	97	0.010		
	Coordinates for Fish are approximate	Fish (F1)	371241	8430894	20	0	0	0	0.000		
	Intertidal: South side of South Reef	**27**	**371831**	**8429844**	**0**	**100**	**1**	**100**	**0.010**	**S 14°11.991′**	**E121°48.731′**
	Flat reef platform extending from a sand plain with numerous small coral and rock outcrops. Platform has many small tide pools and *Porites* heads, which are wide in diameter and low in profile due to tidal influence. There are many coral slabs to turn but little in the way of biota beneath.	Porifera (P1)	371831	8429844	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
22-Sep-06	**Dive: Outside slope SE corner of atoll**	**28**	**380106**	**8431330**	**20**	**0**	**0**	**0**	**0.000**	**S 14°11.208′**	**E121°53.336′**
	High energy reef with isolated rock outcrops with minimal cnidarian cover. Plate corals, gorgonian fans and soft corals evident but not prolific. All the gorgonian fans are perpendicular		380031	8431459	5.4	150	1	150	0.015	S 14°11.137′	E121°53.294′
			380053	8431384	12.4	0	0	0	0.000	S 14°11.178′	E121°53.307′
			380031	8431459	5.4	78	1	78	0.008	S 14°11.137′	E121°53.294′
		Algae (A1)	380106	8431330	20	0	0	0	0.000		

	with the reef possibly indicating a long shore current. Reef is heavily dissected with well developed, steep sided surge channels, which meander rather than being straight. Tops of shallow reef bare and honeycombed.	Algae (A2)	380031	8431459	5.4	150	1	150	0.015		
		Porifera (P1)	380053	8431384	12.4	15	1	15	0.002		
		Porifera (P2)	380031	8431459	5.4	15	1	15	0.002		
		Scleracterinia (S1)	380053	8431384	12.4	15	1	15	0.002		
		Scleracterinia (S2)	380031	8431459	5.4	15	1	15	0.002		
		Crustacea (C1)	380053	8431384	12.4	5	1	5	0.001		
		Crustacea (C2)	380031	8431459	5.4	5	1	5	0.001		
		Mollusca (M1)	380106	8431330	20	0	0	0	0.000		
		Mollusca (M2)	380031	8431459	5.4	150	1	150	0.015		
		Echinodermata (E1)	380106	8431330	20	0	0	0	0.000		
		Echinodermata (E2)	380031	8431459	5.4	150	1	150	0.015		
	Coordinates for Fish are approximate	Fish (F1)	380106	8431330	20	0	0	0	0.000		
	Dive: Lagoon back slope - East side	**29**	**384866**	**8438472**	**20**	**0**	**0**	**0**	**0.000**	**S 14°07.346′**	**E121°56.000′**
	Back slope reef pool zone where the lagoon entrance is marked by a shallow reef bar at 10 m. The bar appears to be a series of interconnecting rocky outcrops. At 20 m a scree slope of broken coral rubble leads to the reef bar crest. Rocky outcrops with abundant remnant coral and other fauna exist amid coral rubble debris.		384903	8438503	13.3	49	1	49	0.005	S 14°07.329′	E121°56.021′
		Algae (A1)	384866	8438472	20	0	0	0	0.000		
		Algae (A2)	384903	8438503	13.3	49	1	49	0.005		
		Porifera (P1)	384903	8438503	13.3	15	1	15	0.002		
		Porifera (P2)	NOT DONE								
		Scleracterinia (S1)	384903	8438503	13.3	15	1	15	0.002		
		Scleracterinia (S2)	NOT DONE								
		Crustacea (C1)	384903	8438503	13.3	5	1	5	0.001		
		Crustacea (C2)	NOT DONE								
		Mollusca (M1)	384866	8438472	20	0	0	0	0.000		
		Mollusca (M2)	384903	8438503	13.3	49	1	49	0.005		
		Echinodermata (E1)	384866	8438472	20	0	0	0	0.000		
		Echinodermata (E2)	384903	8438503	13.3	49	1	49	0.005		
	Coordinates for Fish are approximate	Fish (F1)	384866	8438472	20	0	0	0	0.000		
	Dive: Outer slope NE East Hook	**30**	**389761**	**8443317**	**20**	**0**	**0**	**0**	**0.000**	**S 14°04.729′**	**E121°58.733′**
	Outer reef of bare rock heavily dissected by deep and steep sided surge channels. Corals are few and stunted. Some plate corals exist on		389703	8443316	3.5	60	1	60	0.006	S 14°04.730′	E121°58.701′
			389715	8443318	10.5	14	1	14	0.001	S 14°04.729′	E121°58.707′
			389703	8443316	3.5	14	1	14	0.001	S 14°04.730′	E121°58.701′

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	SOUTH SCOTT REEF		Easting	Northing	msw	m	m	m2	ha	Latitude	Longitude
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Dive: Outer slope NE East Hook (continued)	Algae (A1)	389761	8443317	20	0	0	0	0.000		
	the channel walls, shallow caves and deeper areas (20 m). Channels with coralline sand and coral rubble.	Algae (A2)	389703	8443316	3.5	60	1	60	0.006		
	Some small massive corals exist here. Tops of reef are bare with numerous urchins.	Porifera (P1)	389715	8443318	10.5	15	1	15	0.002		
		Porifera (P2)	389703	8443316	3.5	15	1	15	0.002		
		Scleracterinia (S1)	389715	8443318	10.5	15	1	15	0.002		
		Scleracterinia (S2)	389703	8443316	3.5	15	1	15	0.002		
		Crustacea (C1)	389715	8443318	10.5	5	1	5	0.001		
		Crustacea (C2)	389703	8443316	3.5	5	1	5	0.001		
		Mollusca (M1)	389761	8443317	20	0	0	0	0.000		
		Mollusca (M2)	389703	8443316	3.5	60	1	60	0.006		
		Echinodermata (E1)	389761	8443317	20	0	0	0	0.000		
		Echinodermata (E2)	389703	8443316	3.5	60	1	60	0.006		
	Coordinates for Fish are approximate	Fish (F1)	389761	8443317	20	0	0	0	0.000		
	NORTH SCOTT REEF										
23-Sep-06	**Dive: Outer slope SE side**	**31**	**383969**	**8452024**	**20**	**0**	**0**	**0**	**0.000**	**S 13°59.993′**	**E121°55.536′**
	Isolated outcrops surrounded by coral rubble over sand leading gently up the slope to a vertical reef abutment dissected by surge gullies. Sides of outcrops have encrusting corals - caves and underhangs have good cover of soft biota. In general hard corals are few. Top of reef is bare, fragmented and honeycombed providing shelter for a diverse invertebrate assemblage.		383875	8452097	3.5	120	1	120	0.012	S 13°59.953′	E121°55.484′
			383913	8452076	10.5	44	1	44	0.004	S 13°59.964′	E121°55.505′
			383875	8452097	3.5	44	1	44	0.004	S 13°59.953′	E121°55.484′
		Algae (A1)	383969	8452024	20	0	0	0	0.000		
		Algae (A2)	383875	8452097	3.5	120	1	120	0.012		
		Porifera (P1)	383913	8452076	10.5	15	1	15	0.002		
		Porifera (P2)	383875	8452097	3.5	15	1	15	0.002		
		Scleracterinia (S1)	383913	8452076	10.5	15	1	15	0.002		
		Scleracterinia (S2)	383875	8452097	3.5	15	1	15	0.002		
		Crustacea (C1)	383913	8452076	10.5	5	1	5	0.001		
		Crustacea (C2)	383875	8452097	3.5	5	1	5	0.001		
		Mollusca (M1)	383969	8452024	20	0	0	0	0.000		
		Mollusca (M2)	383875	8452097	3.5	120	1	120	0.012		
		Echinodermata (E1)	383969	8452024	20	0	0	0	0.000		
		Echinodermata (E2)	383875	8452097	3.5	120	1	120	0.012		
	Coordinates for Fish are approximate	Fish (F1)	383969	8452024	20	0	0	0	0.000		

	Dive: Lagoon site opposite stn 31	**32**	**382784**	**8453552**	**11**	**0**	**0**	**0**	**0.000**	**S 13°59.161′**	**E121°54.882′**
	A once rich and diverse flat coral reef but now coral rubble overlaid with new coral heads of many species. The site has large rocky outcrops that sometimes project above the otherwise flat reef. Site is lacking any large *Tridacna* clams.		382726	8453544	6	59	1	59	0.006	S 13°59.165′	E121°54.850′
		Algae (A1)	382784	8453552	11	0	0	0	0.000		
		Algae (A2)	382726	8453544	6	59	1	59	0.006		
		Porifera (P1)	382784	8453552	11	15	1	15	0.002		
		Porifera (P2)	382726	8453544	6	15	1	15	0.002		
		Scleracterinia (S1)	382784	8453552	11	15	1	15	0.002		
		Scleracterinia (S2)	382726	8453544	6	15	1	15	0.002		
		Crustacea (C1)	382784	8453552	11	5	1	5	0.001		
		Crustacea (C2)	382726	8453544	6	5	1	5	0.001		
		Mollusca (M1)	382784	8453552	11	0	0	0	0.000		
		Mollusca (M2)	382726	8453544	6	59	1	59	0.006		
		Echinodermata (E1)	382784	8453552	11	0	0	0	0.000		
		Echinodermata (E2)	382726	8453544	6	59	1	59	0.006		
	Coordinates for Fish are approximate	Fish (F1)	382784	8453552	11	0	0	0	0.000		
	Intertidal: East side south channel	**33**	**375790**	**8450404**	**0**	**100**	**1**	**100**	**0.010**	**S 14°00.850′**	**E121°50.988′**
	Flat algal covered platform dotted with rocks of turnable size - many have created small shallow pools. Bio-diversity appears to be low.	Porifera (P1)	375790	8450404	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
24-Sep-06	**Dive: AIMS site (SL4-1) SE corner**	**34**	**376983**	**8449288**	**20**	**0**	**0**	**0**	**0.000**	**S 14°01.459′**	**E121°51.648′**
	Gentle coralline sand slope with large coral outcrops that tend to coalesce into an irregular reef with surge channels at shallower depths. The outcrops have a covering of hard and soft corals and sea fans - the latter are perpendicular to the reef front indicating a long-shore current. The hard corals are generally massive and encrusting with small *Acropora* colonies evident. Little coral rubble at this site.		377014	8449348	4.7	69	1	69	0.007	S 14°01.426′	E121°51.666′
			376994	8449314	11.7	0	0	0	0.000	S 14°01.445′	E121°51.654′
			377014	8449348	4.7	40	1	40	0.004	S 14°01.426′	E121°51.666′
		Algae (A1)	376983	8449288	20	0	0	0	0.000		
		Algae (A2)	377014	8449348	4.7	69	1	69	0.007		
		Porifera (P1)	376994	8449314	11.7	15	1	15	0.002		
		Porifera (P2)	377014	8449348	4.7	15	1	15	0.002		
		Scleracterinia (S1)	376994	8449314	11.7	15	1	15	0.002		
		Scleracterinia (S2)	377014	8449348	4.7	15	1	15	0.002		
		Crustacea (C1)	376994	8449314	11.7	5	1	5	0.001		
		Crustacea (C2)	377014	8449348	4.7	5	1	5	0.001		
		Mollusca (M1)	376983	8449288	20	0	0	0	0.000		
		Mollusca (M2)	377014	8449348	4.7	69	1	69	0.007		
		Echinodermata (E1)	376983	8449288	20	0	0	0	0.000		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	NORTH SCOTT REEF		Easting	Northing	msw	m	m	m2	ha	Latitude	Longitude
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
	Dive: AIMS site (SL4-1) SE corner (contined)	Echinodermata (E2)	377014	8449348	4.7	69	1	69	0.007		
	Coordinates for Fish are approximate	Fish (F1)	376983	8449288	20	69	1	69	0.007		
	Intertidal: Between stn 31 & 32	**35**	**383297**	**8452748**	**0**	**100**	**1**	**100**	**0.010**	**S 13°59.598′**	**E121°55.165′**
	Snorkel/scuba dive site at intertidal lagoon edge. Coral sands with scattered outcrops and large pieces of coral rubble overlaying rock pavement. Some low but wide Porites heads evident.	Porifera (P1)	383297	8452748	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
	Dive: Outer slope NE side	**36**	**385578**	**8457949**	**20**	**0**	**0**	**0**	**0.000**	**S 13°56.783′**	**E121°56.445′**
	1984 WAM sites (stn15,16). Irregular reef with steep sided surge channels that gently slope upwards. Fine coral or coralline sands with coral rubble cover the channel floors. Massive and encrusting corals are dominant with some small plate *Acropora*. Reef top and much of the deeper outcrops are bare but with good invertebrate assemblages in holes and crevices. Reef underhangs and caves have a good coverage of soft biota.		385445	8457882	5.2	150	1	150	0.015	S 13°56.819′	E121°56.371′
			385541	8457932	12.2	0	0	0	0.000	S 13°56.792′	E121°56.424′
			385445	8457882	5.2	108	1	108	0.011	S 13°56.819′	E121°56.371′
		Algae (A1)	385578	8457949	20	0	0	0	0.000		
		Algae (A2)	385445	8457882	5.2	150	1	150	0.015		
		Porifera (P1)	385541	8457932	12.2	15	1	15	0.002		
		Porifera (P2)	385445	8457882	5.2	15	1	15	0.002		
		Scleracterinia (S1)	385541	8457932	12.2	15	1	15	0.002		
		Scleracterinia (S2)	385445	8457882	5.2	15	1	15	0.002		
		Crustacea (C1)	385541	8457932	12.2	5	1	5	0.001		
		Crustacea (C2)	385445	8457882	5.2	5	1	5	0.001		
		Mollusca (M1)	385578	8457949	20	0	0	0	0.000		
		Mollusca (M2)	385445	8457882	5.2	150	1	150	0.015		
		Echinodermata (E1)	385578	8457949	20	0	0	0	0.000		
		Echinodermata (E2)	385445	8457882	5.2	150	1	150	0.015		
	Coordinates for Fish are approximate	Fish (F1)	385578	8457949	20	0	0	0	0.000		
	Intertidal: East side outer reef	**37**	**385353**	**8457595**	**0**	**100**	**1**	**100**	**0.010**	**S 13°56.974′**	**E121°56.319′**
	Outer reef flat with many small boulders covered with algal turf. No coral cover or sand cays.	Porifera (P1)	385353	8459595	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									

25-Sep-06	**Dive: Rocky outcrop in channel**	**38**	**381511**	**8460151**	**11.4**	**0**	**0**	**0**	**0.000**	**S 13°55.578′**	**E121°54.192′**
	One of a series of rocky outcrops at the lagoon mouth of the NE channel. The outcrops are bare except for soft corals and scattered hard coral recruits of various morphologies. Surrounding area is coral rubble and evidence of significant destruction. Sea whips and gorgonian fans indicate strong current flow.		381470	8460174	4.4	48	1	48	0.005	S 13°55.566′	E121°54.169′
		Algae (A1)	381511	8460151	11.4	0	0	0	0.000		
		Algae (A2)	381470	8460174	4.4	48	1	48	0.005		
		Porifera (P1)	381511	8460151	11.4	15	1	15	0.002		
		Porifera (P2)	381470	8460174	4.4	15	1	15	0.002		
		Scleracterinia (S1)	381511	8460151	11.4	15	1	15	0.002		
		Scleracterinia (S2)	381470	8460174	4.4	15	1	15	0.002		
		Crustacea (C1)	381511	8460151	11.4	5	1	5	0.001		
		Crustacea (C2)	381470	8460174	4.4	5	1	5	0.001		
		Mollusca (M1)	381511	8460151	11.4	0	0	0	0.000		
		Mollusca (M2)	381470	8460174	4.4	48	1	48	0.005		
		Echinodermata (E1)	381511	8460151	11.4	0	0	0	0.000		
		Echinodermata (E2)	381470	8460174	4.4	48	1	48	0.005		
	Coordinates for Fish are approximate	Fish (F1)	381511	8460151	11.4	0	0	0	0.000		
	Dive: Coral outcrop - east lagoon	**39**	**382731**	**8457673**	**13.2**	**0**	**0**	**0**	**0.000**	**S 13°56.925′**	**E121°54.863′**
	Large outcrop with smaller rocky outcrops surrounding the crown and extending to deeper depths where coral rubble is extensive. Outcrop covered in rubble but with a lot of new coral growth. Two very large *Porites* heads project above the rubble.		382715	8457683	6.2	20	1	20	0.002	S 13°56.920′	E121°54.854′
		Algae (A1)	382731	8457673	13.2	0	0	0	0.000		
		Algae (A2)	382715	8457683	6.2	20	1	20	0.002		
		Porifera (P1)	382731	8457673	13.2	15	1	15	0.002		
		Porifera (P2)	382715	8457683	6.2	15	1	15	0.002		
		Scleracterinia (S1)	382731	8457673	13.2	15	1	15	0.002		
		Scleracterinia (S2)	382715	8457683	6.2	15	1	15	0.002		
		Crustacea (C1)	382731	8457673	13.2	5	1	5	0.001		
		Crustacea (C2)	382715	8457683	6.2	5	1	5	0.001		
		Mollusca (M1)	382731	8457673	13.2	0	0	0	0.000		
		Mollusca (M2)	382715	8457683	6.2	20	1	20	0.002		
		Echinodermata (E1)	382731	8457673	13.2	0	0	0	0.000		
		Echinodermata (E2)	382715	8457683	6.2	20	1	20	0.002		
	Coordinates for Fish are approximate	Fish (F1)	382731	8457673	13.2	0	0	0	0.000		

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	NORTH SCOTT REEF		Easting	Northing	msw	m	m	m2	ha	Latitude	Longitude
			UTM ZONE 5OS							WGS84 Datum	
	Drift dive: NE channel	**40**	**0382192**	**8461469**	**0**	**0**	**0**	**0**	**0.000**	**S 13°54.865′**	**E121°54.573′**
	Well scoured channel with good coverage of encrusting soft biota on the walls of the underhangs and lee side of the larger rocks. Highly mobile, coarse sand has settled in the eddy areas of the channel along the wall edges but diversity low. The rock surfaces are bare except for encrusting coralline algae.		0381025	8461402	12	1169	1	1169	0.117	S 13°54.898′	E121°53.925′
		Qualitative - biodiversity sampling (except Porifera)									

Above: Station 35, North Scott Reef. Sand over rock pavement. (Photo: John Huisman)

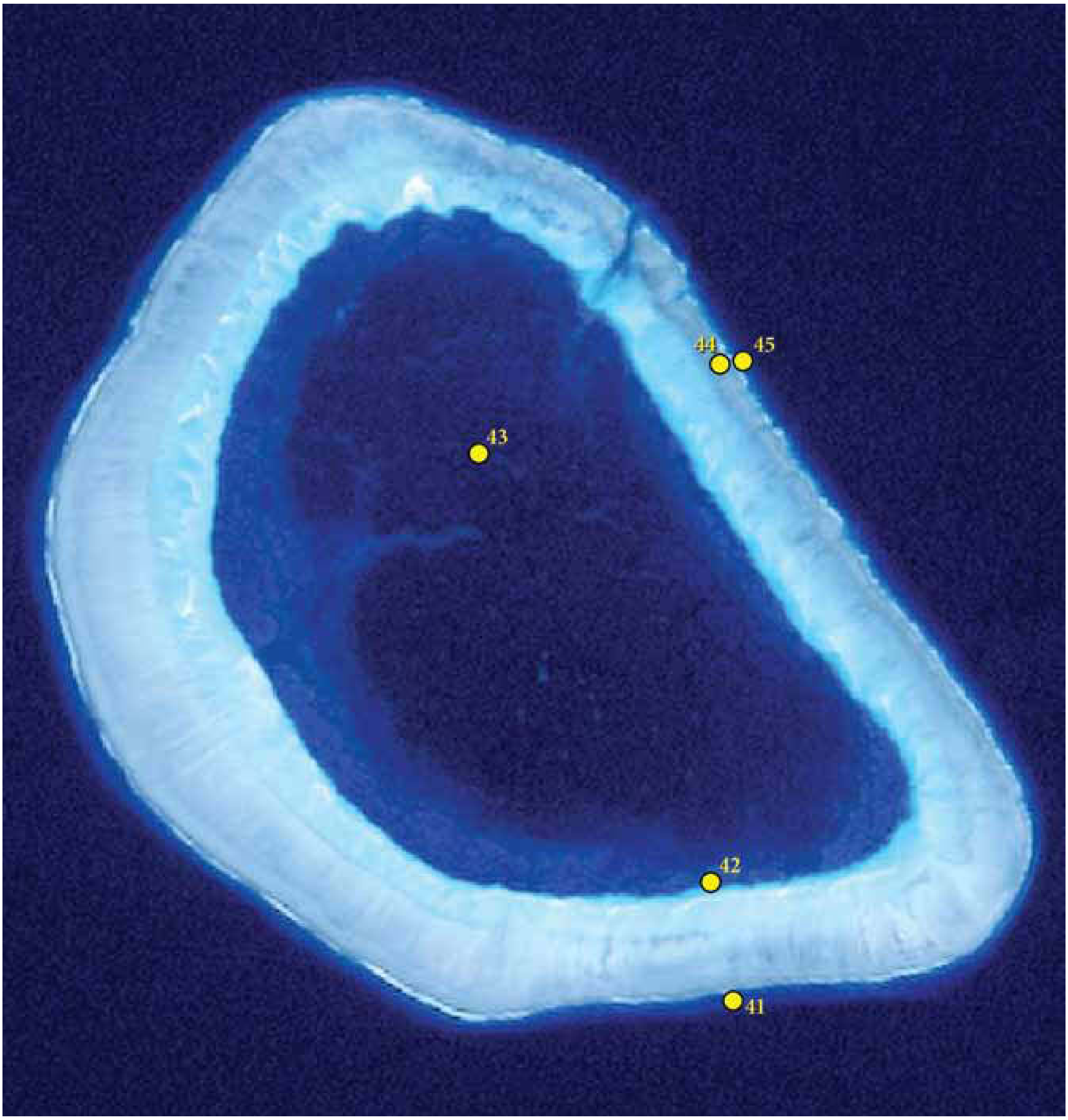

Figure 3 Seringapatam Reef with surveyed station sites (2006)

Table 4 Station and transect data for Seringapatam (2006)

Date	Site	Station	Transect (T)		T-depth	T-length	T-width	T-area	T-area	Station coordinates	
	SERINGAPATAM REEF		**Easting**	**Northing**	msw	m	m	m2	ha	**Latitude**	**Longitude**
			UTM ZONE 5OS (+/- ca.10 m)							WGS84 Datum	
26-Sep-06	**Dive: South side outer slope**	**41**	**395253**	**8485323**	**20**	**0**	**0**	**0**	**0.000**	**S 13°41.956′**	**E122°01.879′**
	At deeper depths a gently rising coral rubble slope leads to bare rocky outcrops that merge to form a dissected reef. Surge channels dissect the reef forming steep sided but broken gutters. Little coral growth is present but caves and underhangs have reasonable soft biota cover. The reef top is bare, covered with coralline algae and forms an ideal habitat for cryptic phyla (Mollusca, Crustacea etc)		395228	8485404	4.1	86	1	86	0.009	S 13°41.912′	E122°01.866′
			395221	8485353	10.5	0	0	0	0.000	S 13°41.939′	E122°01.862′
			395228	8485404	3.5	52	1	52	0.005	S 13°41.912′	E122°01.866′
		Algae (A1)	395253	8485323	20	0	0	0	0.000		
		Algae (A2)	395228	8485404	4.1	86	1	86	0.009		
		Porifera (P1)	395221	8485353	10.5	15	1	15	0.002		
		Porifera (P2)	395228	8485404	3.5	15	1	15	0.002		
		Scleracterinia (S1)	395221	8485353	10.5	15	1	15	0.002		
		Scleracterinia (S2)	395228	8485404	3.5	15	1	15	0.002		
		Crustacea (C1)	395221	8485353	10.5	5	1	5	0.001		
		Crustacea (C2)	395228	8485404	3.5	5	1	5	0.001		
		Mollusca (M1)	395253	8485323	20	0	0	0	0.000		
		Mollusca (M2)	395228	8485404	4.1	86	1	86	0.009		
		Echinodermata (E1)	395253	8485323	20	0	0	0	0.000		
		Echinodermata (E2)	395228	8485404	4.1	86	1	86	0.009		
	Coordinates for Fish are approximate	Fish (F1)	395253	8485323	20	0	0	0	0.000		
	Dive: Lagoon edge/platform interface	**42**	**395052**	**8486404**	**10**	**100**	**1**	**100**	**0.010**	**S 13°41.369′**	**E122°01.770′**
	Lagoon rises gently as a sandy slope with scattered small *Acropora* thickets. At the lagoon edge the sand rises steeply to a sandy plain where a small scattered rubble reef and occasional coral outcrops provide biotic cover. The sand is rich with infauna. Dead coral and empty *Tridacna* shells on the bottom.	Porifera (P1)	395052	8486404	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
	Dive: Inner lagoon reef outcrop	**43**	**392934**	**8490320**	**20**	**0**	**0**	**0**	**0.000**	**S 13°39.240′**	**E122°00.604′**
	Inner lagoon rocky knoll with a mix of coral rubble and scattered coral colonies, both old and new, overlying coral rubble. Larger rocky outcrops		392931	8490429	7	110	1	110	0.011	S 13°39.181′	E122°00.603′
			392934	8490395	13	0	0	0	0.000	S 13°39.199′	E122°00.604′
			392931	8490429	7	35	1	35	0.003	S 13°39.181′	E122°00.603′

	intermingle with coral colonies on a gradual slope to the knoll's crown. Empty giant clam shells are evident. Rambling thicket of *Acropora* present on rocky outcrops.	Algae (A1)	392934	8490320	20	0	0	0	0.000		
		Algae (A2)	392931	8490429	7	110	1	110	0.011		
		Porifera (P1)	392934	8490395	13	15	1	15	0.002		
		Porifera (P2)	392931	8490429	7	15	1	15	0.002		
		Scleracterinia (S1)	392934	8490395	13	15	1	15	0.002		
		Scleracterinia (S2)	392931	8490429	7	15	1	15	0.002		
		Crustacea (C1)	392934	8490395	13	5	1	5	0.001		
		Crustacea (C2)	392931	8490429	7	5	1	5	0.001		
		Mollusca (M1)	392934	8490320	20	0	0	0	0.000		
		Mollusca (M2)	392931	8490429	7	110	1	110	0.011		
		Echinodermata (E1)	392934	8490320	20	0	0	0	0.000		
		Echinodermata (E2)	392931	8490429	7	110	1	110	0.011		
	Coordinates for Fish are approximate	Fish (F1)	392934	8490320	20	0	0	0	0.000		
27-Sep-06	**Intertidal:Sth of channel (AIMS SS-3)**	**44**	**395136**	**8491135**	**0**	**100**	**1**	**100**	**0.010**	**S 13°38.803′**	**E122°01.827′**
	Reef flat covered in algal turf and the alga, *Turbinaria*. Shallow flow channels dissect the reef creating small water falls. At highest part of the reef scattered coral slabs provide shelter for biota . At lower levels the reef is honeycombed in parts and flat with tidal pools in other sections.	Porifera (P1)	395136	8491135	0	15	1	15	0.002		
		Qualitative - biodiversity sampling (except Porifera)									
	Dive: Outer slope NE channel	**45**	**395345**	**8491164**	**12.1**	**0**	**0**	**0**	**0.000**	**S 13°38.788′**	**E122°01.944′**
	Steep sided reef with deep and meandering gutters forming reef blocks. Gutters quite wide in shallows forming small rubble and sand plains. A variety of corals - massive encrusting and *Acropora* plate are present At greater depths (20 m) the gutters are narrow and the reef is encrusted with massive and encrusting corals with soft corals on both sides and tops.		395301	8491153	5.1	46	1	46	0.005	S 13°38.794′	E122°01.919′
		Algae (A1)	395345	8491164	12.1	0	0	0	0.000		
		Algae (A2)	395301	8491153	5.1	46	1	46	0.005		
		Porifera (P1)	395345	8491164	12.1	15	1	15	0.002		
		Porifera (P2)	395301	8491153	5.1	15	1	15	0.002		
		Scleracterinia (S1)	395345	8491164	12.1	15	1	15	0.002		
		Scleracterinia (S2)	395301	8491153	5.1	15	1	15	0.002		
		Crustacea (C1)	395345	8491164	12.1	5	1	5	0.001		
		Crustacea (C2)	395301	8491153	5.1	5	1	5	0.001		
		Mollusca (M1)	395345	8491164	12.1	0	0	0	0.000		
		Mollusca (M2)	395301	8491153	5.1	46	1	46	0.005		
		Echinodermata (E1)	395345	8491164	12.1	0	0	0	0.000		
		Echinodermata (E2)	395301	8491153	5.1	46	1	46	0.005		
	Coordinates for Fish are approximate	Fish (F1)	395345	8491164	20	0	0	0	0.000		

Above: Station 14, Mermaid Reef lagoon - *Acropora* coral and seagrass. (Photo: Clay Bryce)

Records of the Western Australian Museum Supplement No. 77: 29–49 (2009).

Subtidal Habitats of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia.

Peter F. Morrison

Sinclair Knight Merz Pty. Ltd. 7th floor Durack Centre, PO Box H615
263 Adelaide Terrace, Perth, Western Australia 6001, Australia
Email: pfmorrison@skm.com.au

Abstract – The sub-tidal habitats at Mermaid (Rowley Shoals), Scott and Seringapatam Reefs were recorded on video during a survey in 2006 and analysed for percentage cover. Recording was undertaken along 25 m transects at two water depths (5 m and 12 m relative to mean sea level). The purpose of the video recording was to provide a permanent record of each station while the video transect analysis provided a quantitative description of the benthic habitat to complement semi-quantitative specimen collections.

The general benthic cover on the outer reef at Mermaid Reef was at least 60% sand, rubble or rock (abiotic) while the lagoon sites varied greatly between 23–97% abiotic cover. The outer reef stations had a higher proportion of encrusting coral while the lagoon stations were more heavily dominated by tabulate and branching corals. The coral morphologies found on the outer reef areas are characteristic of high energy environments, i.e. outer reefs were characterised by the presence of more robust species attached to or encrusting coral rock. The near vertical aspect of the outer reef precluded the deposition of coral sand, which was a major feature of the lagoonal areas. Much of the lagoonal habitat surveyed was associated with bommies, in particular, the slopes and top surfaces.

Unlike the outer reef areas of Mermaid Reef, South Scott Reef had a more gradual slope rather than vertical walls. This slope was often heavily dissected with gutters indicating the high energy nature of the surrounding environment. As a result, the benthic cover at the outer reef stations was at least 40% abiotic. Like the outer reef stations at Mermaid Reef those at South Scott Reef had a higher proportion of encrusting coral. However, the significant abundance of soft corals, tabulate and digitate corals were in stark contrast. The lagoon stations were more heavily dominated by abiotic cover, in particular, rubble and rock.

All stations at North Scott Reef were dominated by the abiotic categories sand, rubble and rock ranging from 65–95% cover. The hard corals were dominated by massive and encrusting corals as well as branching corals.

Only two offshore reef stations and one lagoon station were surveyed at Seringapatam Reef, thus, it is difficult to generalise about the habitats of this reef or differences between outer and lagoonal reef habitats. Habitat cover varied from 100% abiotic at a shallow outer reef transect to 60% abiotic and 40% biotic at a deep outer reef transect, with the biotic component comprising soft coral and seven hard coral categories.

AIM

The purpose of the video recording was to provide a permanent record of each station while the video transect analysis provided a quantitative description of the benthic habitat to complement semi-quantitative specimen collections.

METHODS

Video recording was undertaken at two depths (approximately 5 m and 12 m relative to mean sea level) at each of 32 of a total of 45 surveyed stations in triplicate (three replicate transects) parallel to each other and one metre apart. Recordings were acquired by movement of a Digital Video camera in a housing along 25 m transects according to the protocol developed by the Australian Institute of Marine Science (Carelton and Done 1995). At each depth a transect was marked by laying a 25 m measuring tape along the substrate of relatively uniform depth. A SCUBA diver maintained a constant speed of 0.2 m/sec. and the video was kept 0.5 m above the surface of the benthic habitat. This captured a band width of approximately 0.6 m resulting in an area of 15 m^2 per transect and 45 m^2 for the three transects.

Video recordings of the 32 stations were captured electronically, saved to file and then stored on compact disc. The SKM Video Transect Analysis

System then retrieved the electronically recorded transect for analysis. The program randomly selects 150 frames for analysis from approximately 3,125 recorded along the 25 m transect. Each selected frame was allocated with one randomly placed spot on the monitor by the program. The substrate type beneath the respective spot was assigned one of the following 15 benthic descriptors (refer to Figure 1):

- three abiotic categories (sand, rubble and rock);
- one macroalgae category;
- one sponge category;
- one gorgonian category;
- one soft coral category comprised of neptheids and alcyoniids; and
- eight hard coral categories (branching, digitate, tabulate, encrusting, foliose, sub-massive, massive and mushroom corals).

Since the purpose of the transect analysis was to provide a general description of the benthic habitat, the benthos was identified to functional group level rather than genus or species. Once a benthic descriptor was assigned and the respective frame completed, the program advanced the recording to the next randomly selected frame and this process was repeated until the designated number of frames were completed. Upon completion, the program computed tallied counts and percentage cover (Osborne and Oxley 1997). The results of the triplicate transects were averaged to increase the area covered rather than for statistical purposes. The data for each station was exported into an Excel spreadsheet for graphical presentation.

The mean values for each habitat at each depth per station were used to create a Bray-Curtis dissimilarity correlation matrix. Analysis by Non-metric Multidimensional Scaling (MDS) was then undertaken using the dissimilarity matrix to produce a plot. The purpose of the analysis was to provide a comparison of the stations and depths to complement the semi-quantitative specimen collections.

RESULTS

The general description of the physical characteristics of the seabed at each station for the four reefs is presented in Table 1 through Table 4.

The mean percentage cover by benthic habitat at each station transect is presented graphically for each of the four reefs in Figure 2 through Figure 15. The data is presented as percentage cover by the 15 benthic categories as well as by a reduced category data set, which amalgamates the abiotic, soft coral and hard coral categories resulting in a set of 5 categories.

Above: East Hook, South Scott Reef. The edge of a small mobile sand cay. (Photo: Clay Bryce)

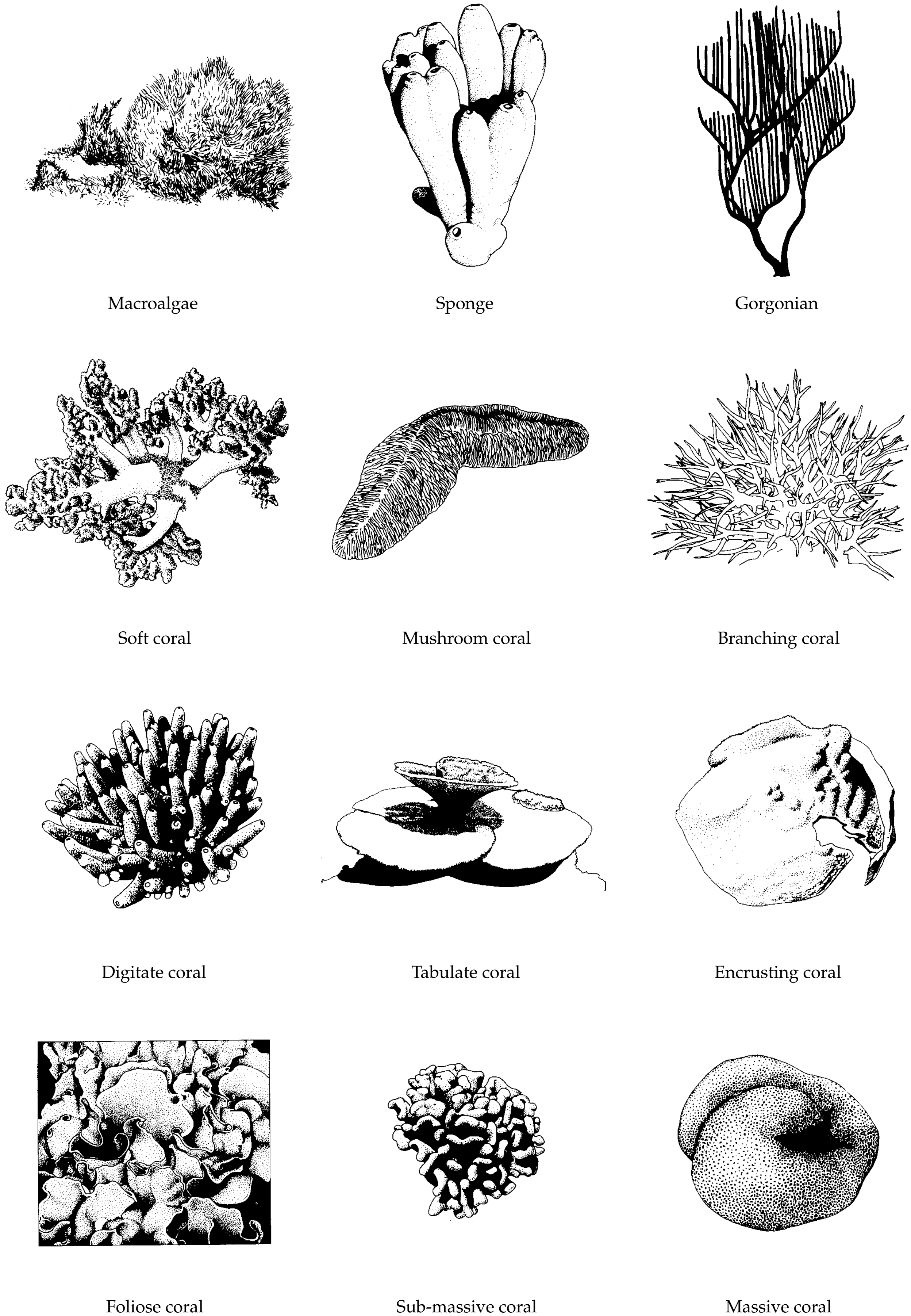

Figure 1 Benthic life-form categories

MERMAID REEF

The general description of the physical characteristics of the seabed at each station for Mermaid Reef is presented in Table 1. The mean percentage cover at each station transect is presented graphically by the 15 benthic categories in Figure 2. The data is also presented as percentage cover by a reduced category data set, which amalgamates the abiotic, soft coral and hard coral categories resulting in a set of 5 categories in Figure 3.

Analysis of the data indicates that the outer reef and lagoon transects were distinctly different, particularly the shallow transects in 5 m of water (see Figure 4 and Figure 5).

The benthic cover at the outer reef stations was at least 60% abiotic, with the exception of station 2, while the lagoon sites varied greatly between 23–97% abiotic cover (Figure 3). The outer reef stations had a higher proportion of encrusting coral while the lagoon stations were more heavily dominated by tabulate and branching corals (Figure 2).

The coral morphologies found on the outer reef areas were characteristic of high energy environments, i.e. outer reefs were characterised by the presence of more robust species attached to or encrusting coral rock. The near vertical aspect of the outer reef precluded the deposition of coral sand, which was a major feature of the lagoonal areas.

Much of the lagoonal habitat surveyed was associated with bommies, in particular, the slopes and top surfaces. The lagoonal areas were far more protected from wave action were dominated by the more fragile species were deposition areas for coral rubble and sand. The benthic cover differed greatly between the deep (12 m) and shallow (5 m) transects. Much of this variation was associated with the position of the transect on the bommie. The flat seabed around the base of the bommies supported a greater cover of branching coral, whereas the slopes were more sparsely covered by live coral. The tops of bommies were relatively similar in coral cover.

Table 1 Transect topography at Mermaid Reef

Station	Habitat	Depth (m)	Description
1	Lagoon	5	Bommie slope with coral rubble.
		12	Relatively flat seabed of fine coral sand and rubble.
2	Outer reef	5	Reef wall dissected with gutters.
		12	Reef wall dissected with gutters.
4	Outer reef	5	Shallow reef wall from 3m dropping onto coral rubble at 7m.
		12	Reef wall dissected by large gutters with a coral rubble floor.
5	Outer reef	5	Near vertical wall.
		12	Near vertical wall.
7	Lagoon	5	Bommie slope with coral rubble.
		12	Relatively flat seabed of fine coral sand and rubble.
8	Lagoon	5	Bommie slope with coral rubble.
		12	Relatively flat seabed of fine coral sand and rubble.
9	Lagoon	5	Slope with coral rubble.
		12	Relatively flat seabed of fine coral sand and rubble.
11	Lagoon	5	Base of coral bommie.
		12	Coral sand with low relief bommies.
12	Lagoon	5	Top of bommie with undulating surface.
		12	Coral sand with many small bommies.
14	Lagoon	5	Base of coral bommie.
		12	Relatively flat seabed of fine coral sand and rubble.
15	Outer reef	5	Crest of steep drop-off.
		12	Near vertical wall.
16	Outer reef	5	Heavily dissected reef edge.
		12	Gradually sloping seabed with deeply cut gutters.

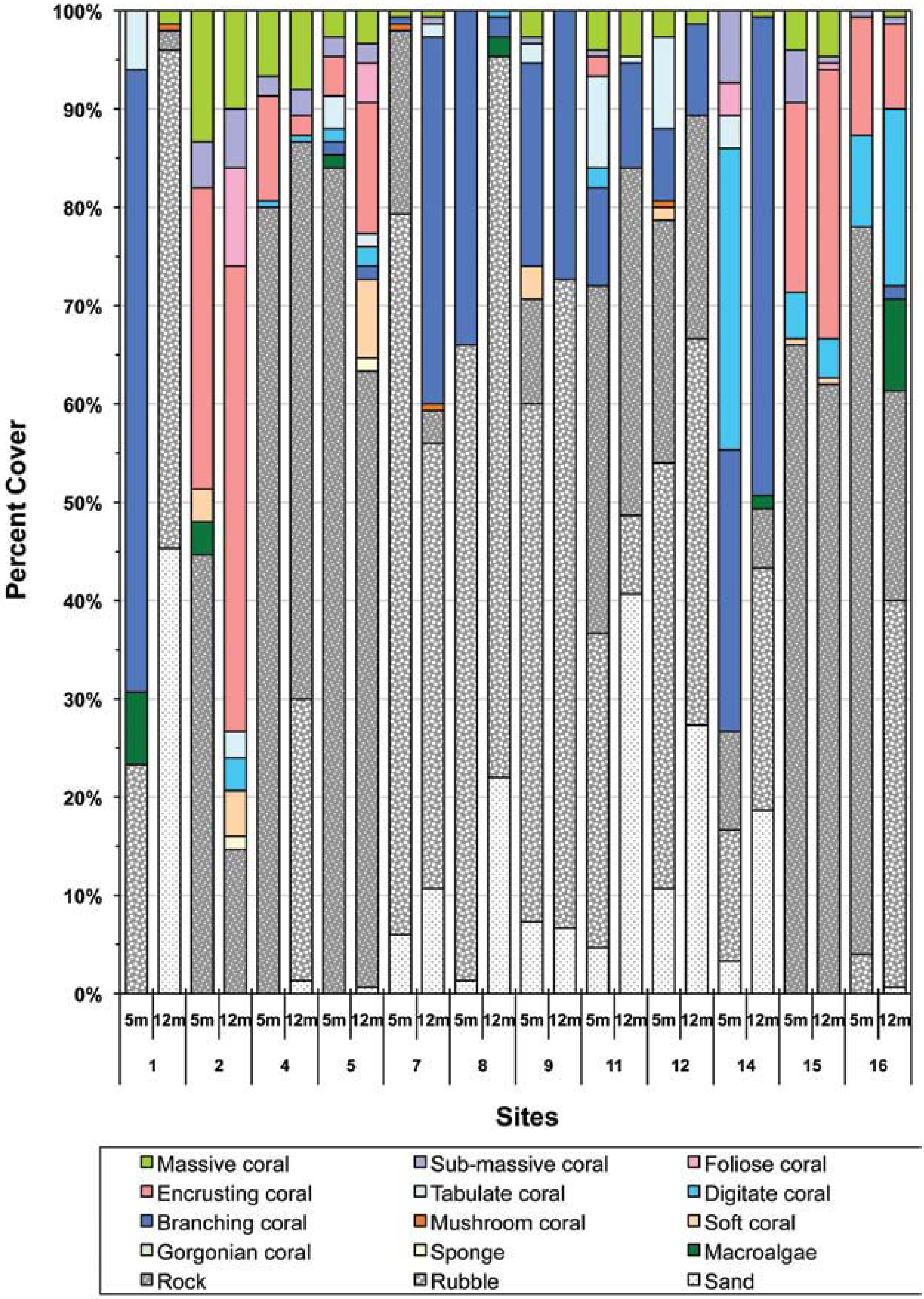

Figure 2 Mermaid Reef habitat cover

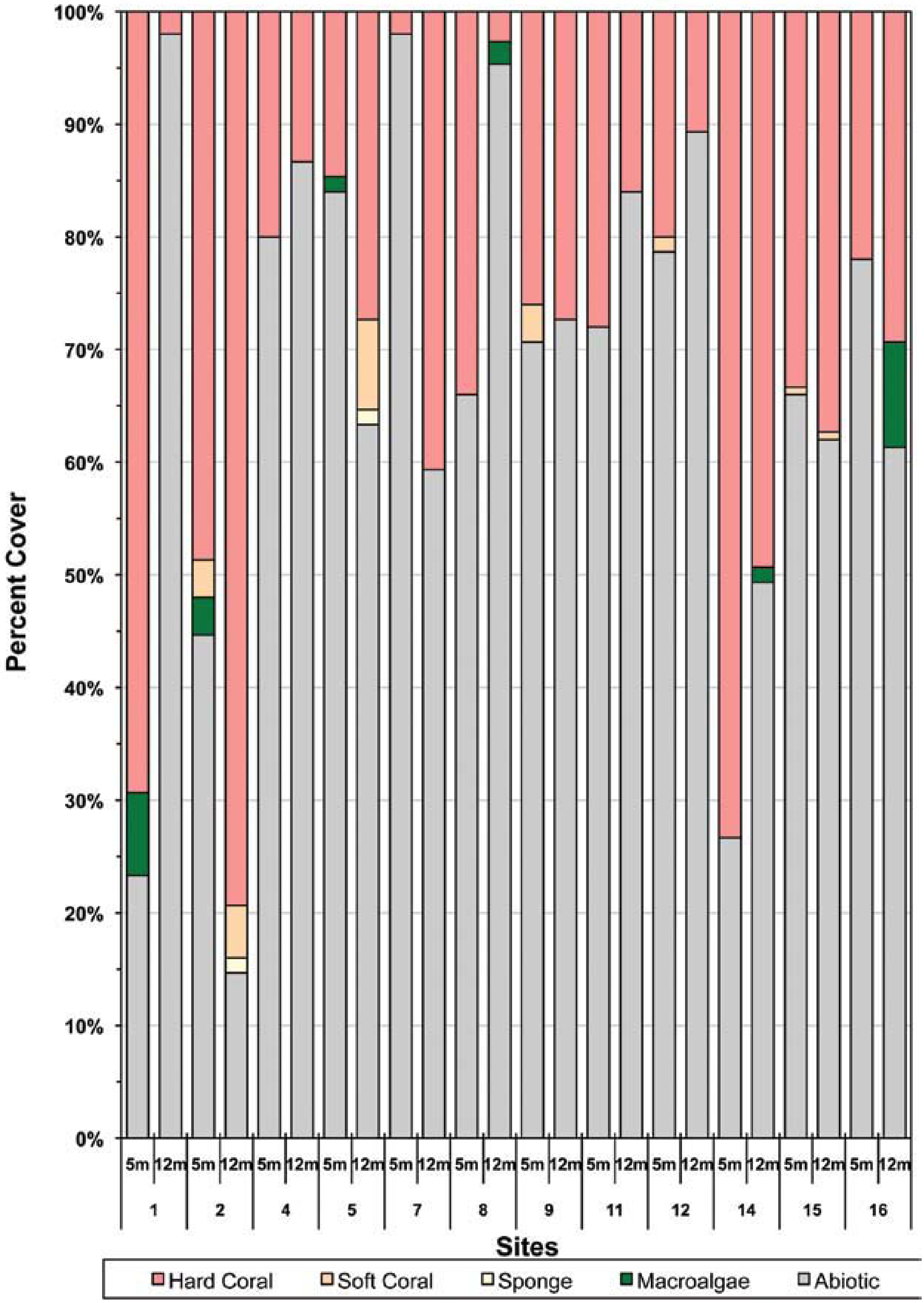

Figure 3 Mermaid Reef grouped habitat cover

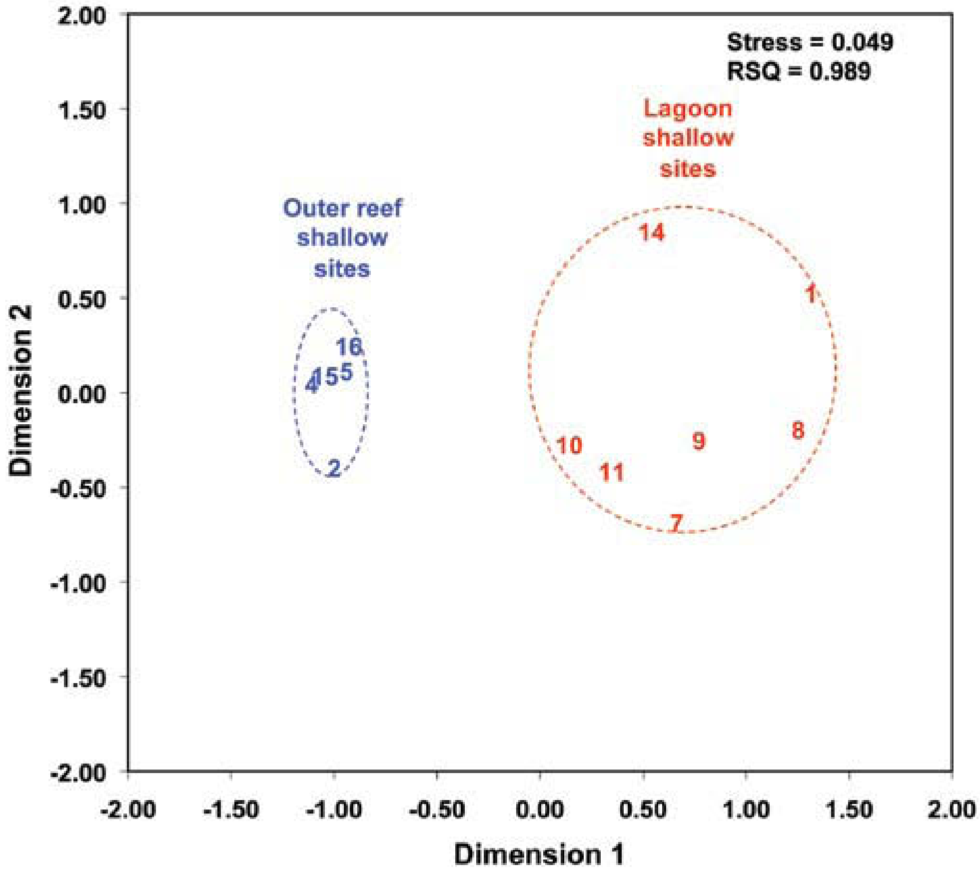

Figure 4 MDS Plot of Mermaid Reef shallow transects

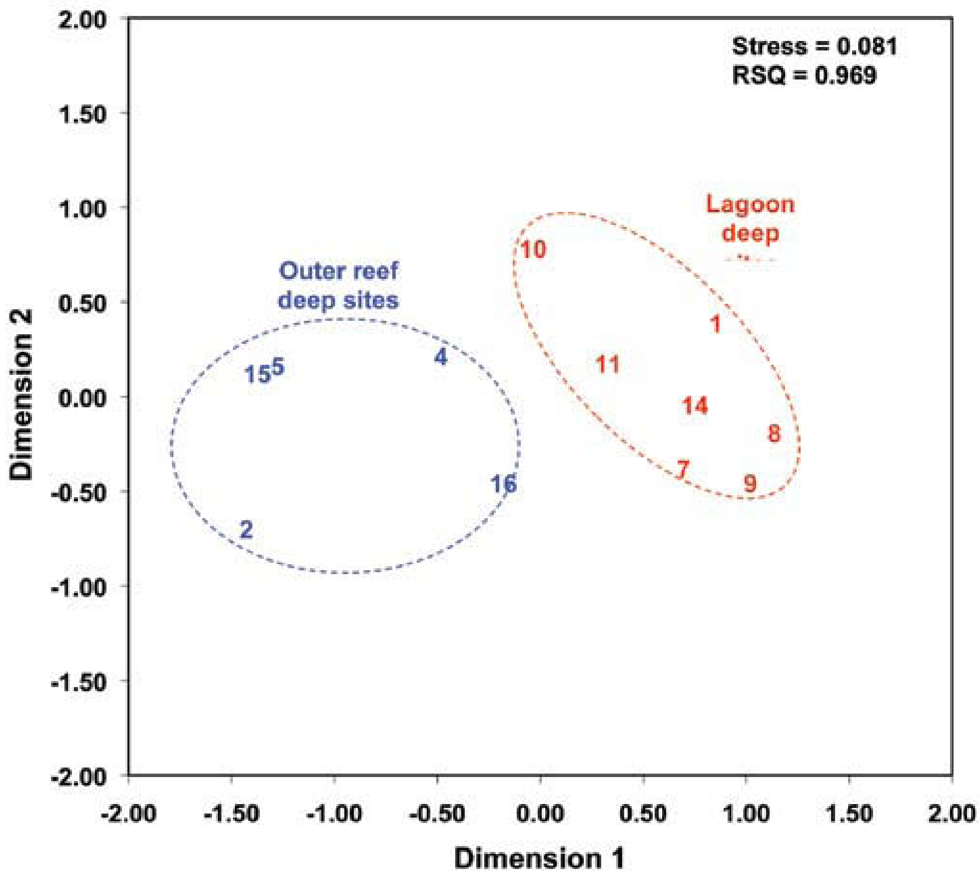

Figure 5 MDS Plot of Mermaid Reef deep transects

Above: Station 3, Mermaid Reef. Outer reef platform. (Photo: Clay Bryce)

Above: Station 24, South Scott Reef intertidal station. (Photo: John Huisman)

SOUTH SCOTT REEF

The general description of the physical characteristics of the seabed at each station for South Scott Reef is presented in Table 2. The mean percentage cover by benthic habitat at each station transect is presented graphically by the 15 benthic categories in Figure 6. The data is also presented as percentage cover by a reduced category data set, which amalgamates the abiotic, soft coral and hard coral categories resulting in a set of 5 categories in Figure 7.

Analysis of the data indicates that the outer reef and lagoon transects were different but less so than was observed at Mermaid Reef (see Figure 8 and Figure 9).

Unlike the outer reef areas of Mermaid Reef, South Scott Reef had a more gradual slope rather than vertical walls. This slope was often heavily dissected with gutters indicating the high energy nature of the surrounding environment. As a result, the benthic cover at the outer reef stations was at least 40% abiotic (Figure 7). Like the outer reef stations at Mermaid Reef those as South Scott Reef had a higher proportion of encrusting coral. However, the significant abundance of soft corals, tabulate and digitate corals were in stark contrast.

Above: Coral regrowth at South Scott Reef. (Photo: Clay Bryce)

The lagoon stations were more heavily dominated by abiotic cover (Figure 7) and, in particular, rubble and rock (Figure 6). Only the deep transect at station 29 had coral cover similar to that of the outer reef stations.

Table 2 Transect topography at South Scott Reef

Station	Habitat	Depth (m)	Description
17	Outer reef	5	Gradual sloping seabed.
		12	Gradual slope towards a steep drop-off.
18	Outer reef	5	Gradual sloping seabed.
		12	Broken reef with high and low relief lumps on sand patches
19	Outer reef	5	Gradual slope dissected by gutters.
		12	Gradual sloping seabed.
20	Outer reef	5	Gradual slope dissected by gutters.
		12	Gradual sloping seabed.
22	Outer reef	5	Gradual slope dissected by gutters.
		12	Gradual sloping seabed.
23	Lagoon	5	Top of bommie with a very uneven surface.
		12	Base of bommie with coral rubble.
25	Lagoon	5	Top of bommie with a very uneven surface.
		12	Relatively flat seabed of fine coral sand and rubble.
26	Lagoon	5	Bommie slope with coral rubble.
		12	Base of coral bommie.
28	Outer reef	5	Heavily dissected reef.
		12	Heavily dissected reef.
29	Lagoon	12	Top of bommie with fine coral sand and rubble.
30	Outer reef	5	Heavily dissected reef with very steep gutter sides.
		12	Heavily dissected reef with very steep gutter sides.

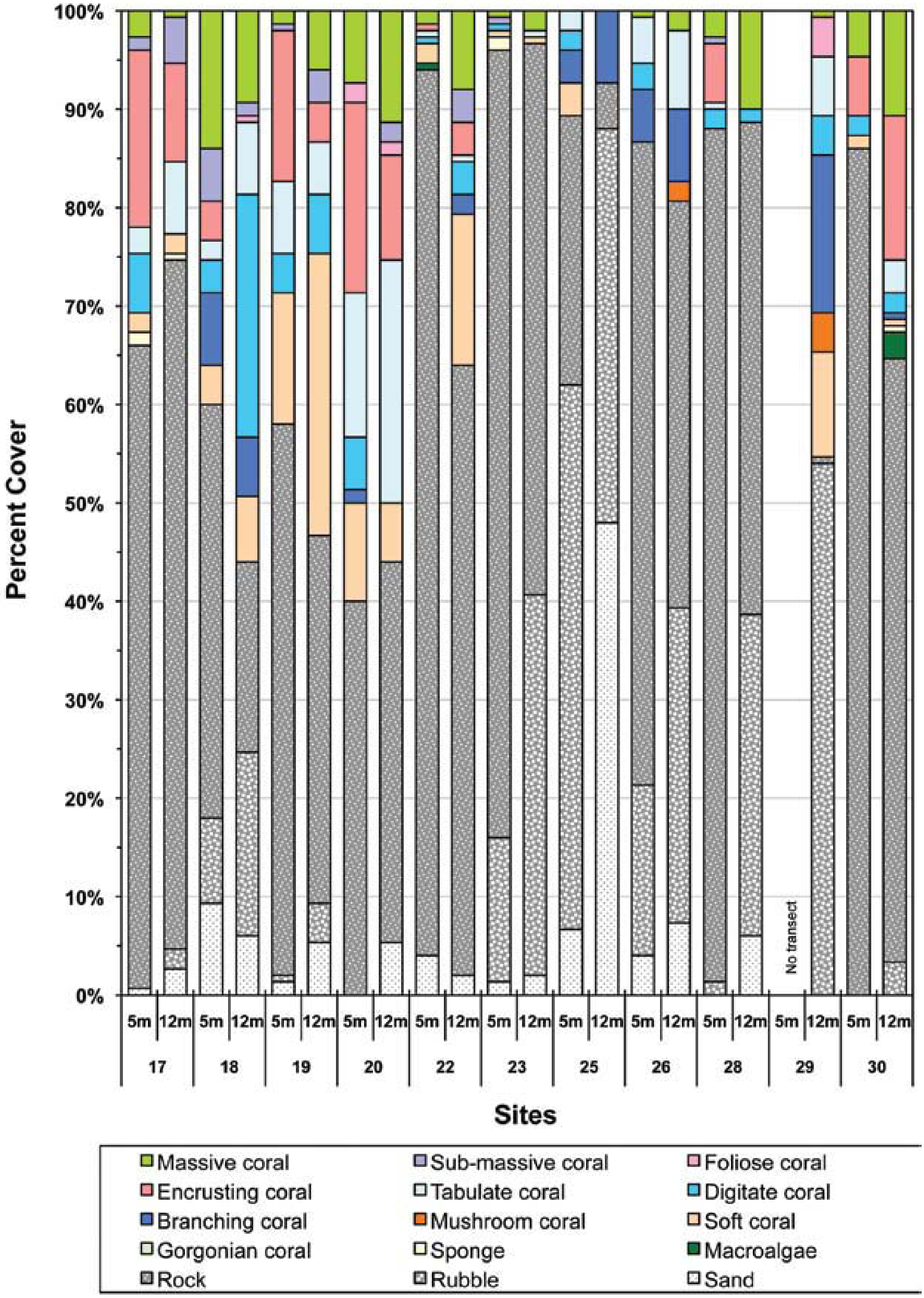

Figure 6 South Scott Reef habitat cover

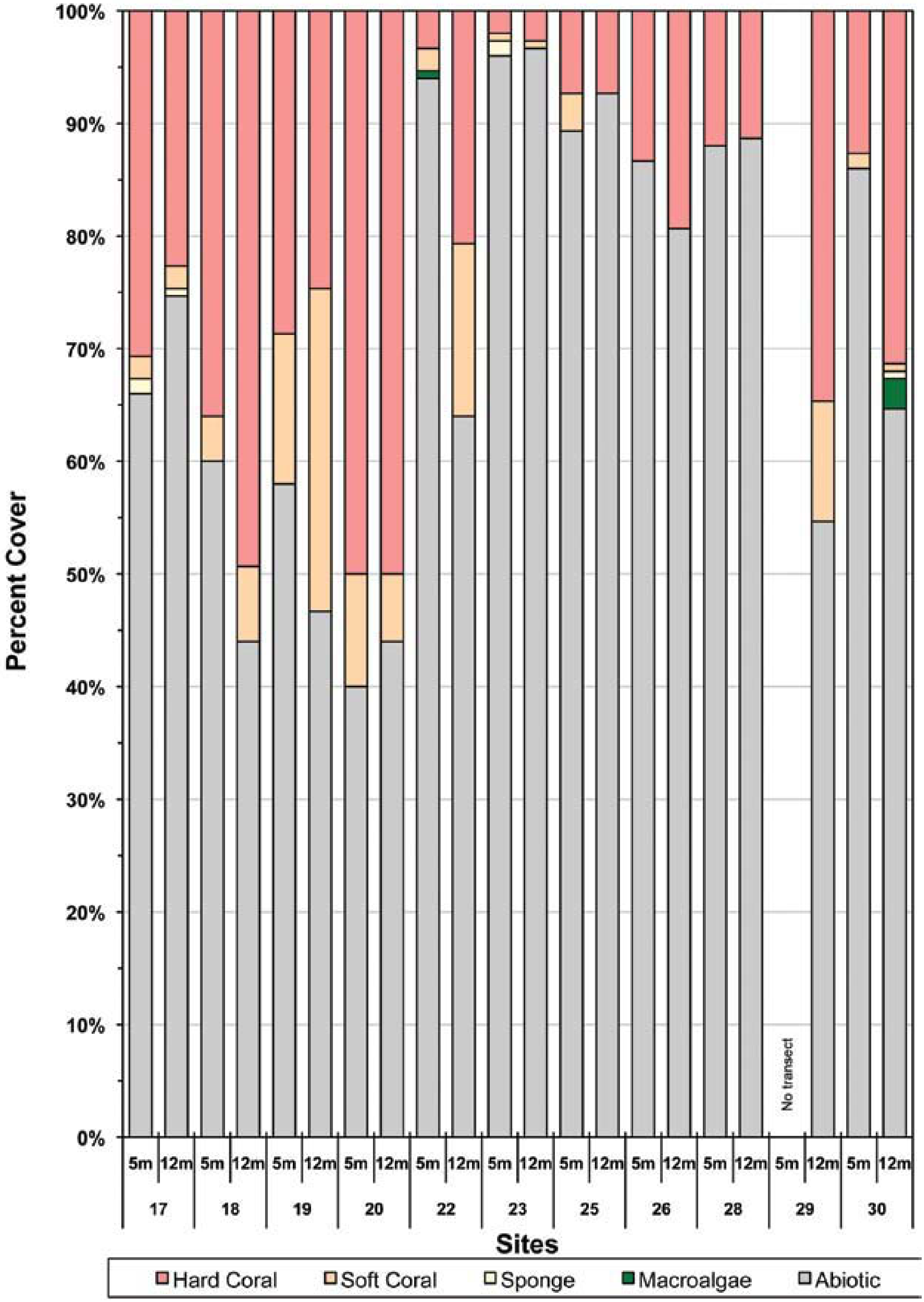

Figure 7 South Scott Reef grouped habitat cover

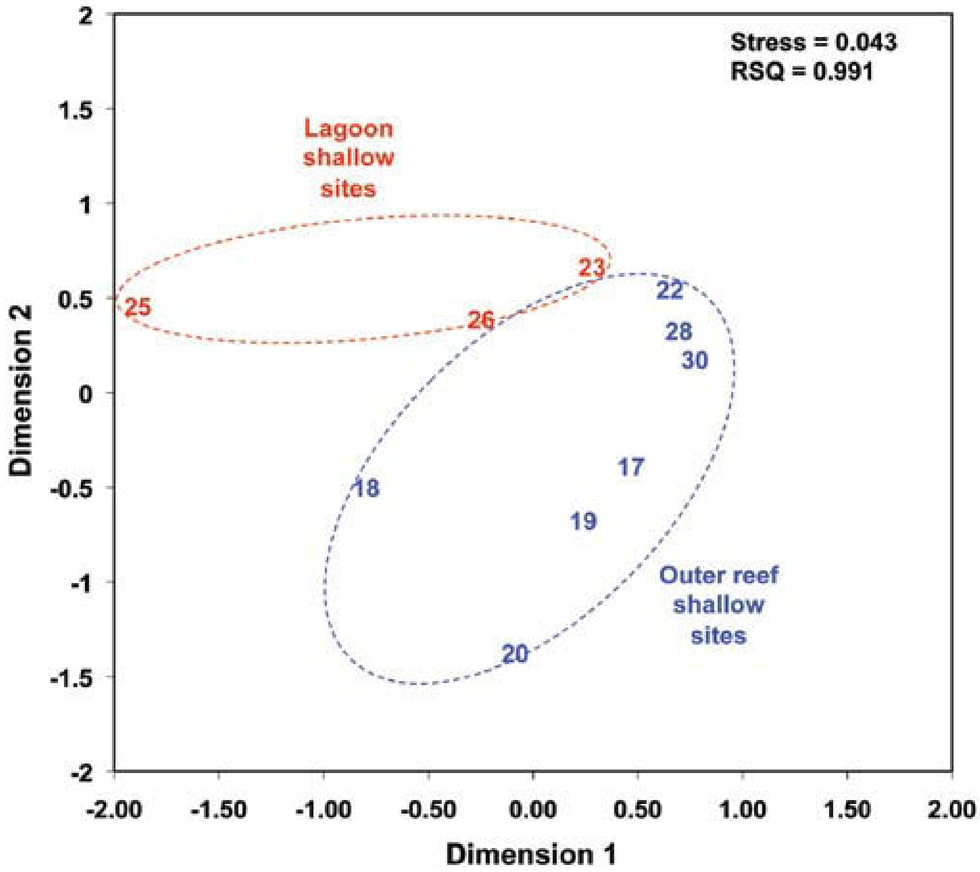

Figure 8 MDS Plot of South Scott Reef shallow transects

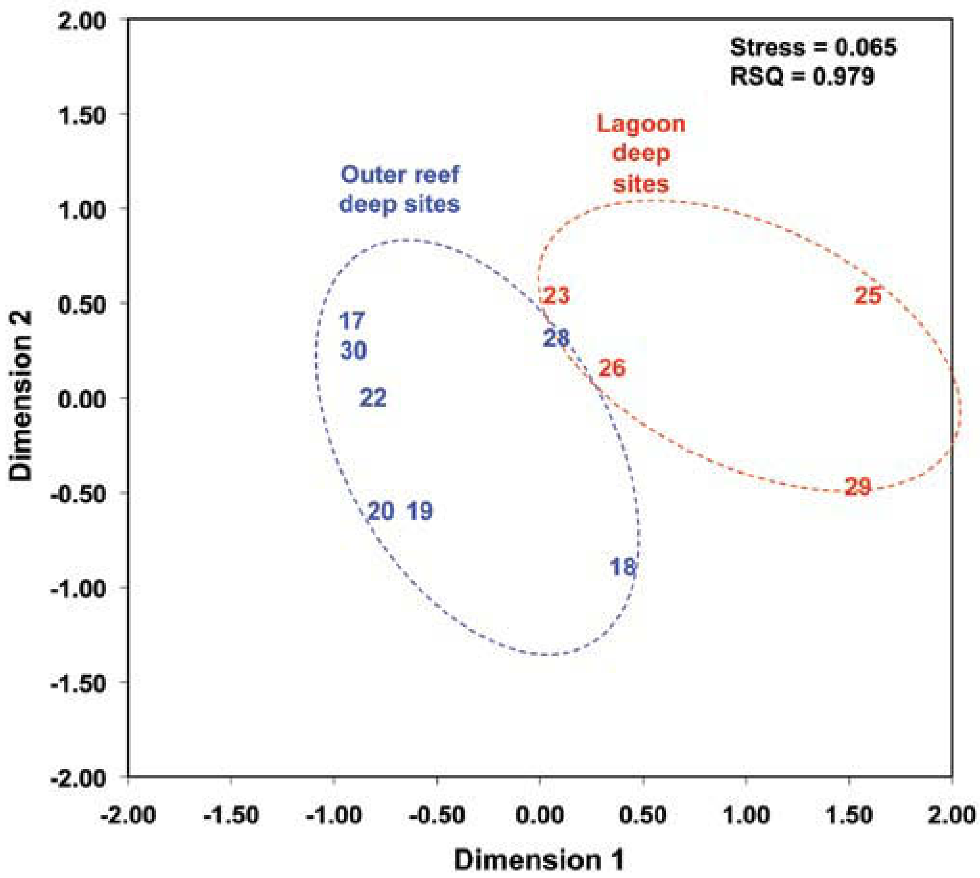

Figure 9 MDS Plot of South Scott Reef deep transects

Above: Station 44, Mermaid Reef. Shallow drainage channels dissect the reef platform. (Photo: Clay Bryce)

NORTH SCOTT REEF

The general description of the physical characteristics of the seabed at each station for North Scott is presented in Table 3. The mean percentage cover by benthic habitat at each station transect is presented graphically by the 15 benthic categories graphically in Figure 10. The data is also presented as percentage cover by a reduced category data set, which amalgamates the abiotic, soft coral and hard coral categories resulting in a set of 5 categories in Figure 11.

Analysis of the data indicates that the outer reef and lagoon transects were distinctly different at both shallow and deep transects (see Figure 12 and Figure 13).

All stations at North Scott Reef were dominated by the abiotic categories sand, rubble and rock ranging from 65–95% cover (Figure 10). The hard corals were dominated by massive and encrusting corals as well as branching corals. Gorgonians were found at the shallow lagoon station 38 and were not recorded on any other transect in the four reefs surveyed.

Table 3 Transect topography at North Scott Reef

Station	Habitat	Depth (m)	Description
31	Outer reef	5	Heavily dissected reef with near vertical walls and rubble bases.
		12	Heavily dissected reef with near vertical walls and rubble bases.
32	Lagoon	5	Bommie top with coral rubble.
		12	Sandy seabed with coral bommies and rocky outcrops.
34	Outer reef	5	Heavily dissected reef with deep gutters and sandy patches.
		12	Heavily dissected reef with deep gutters and patches of rubble.
36	Outer reef	5	Heavily dissected reef with undulating ridges and gutters.
		12	Heavily dissected reef with deep gutters and flattened ridges.
38	Lagoon	5	Slope of small bommie.
		12	Small lumps surrounded by coral sand and rubble.
39	Lagoon	5	Bommie slope with coral rubble.
		12	Coral sand and rubble with several small rocky outcrops.

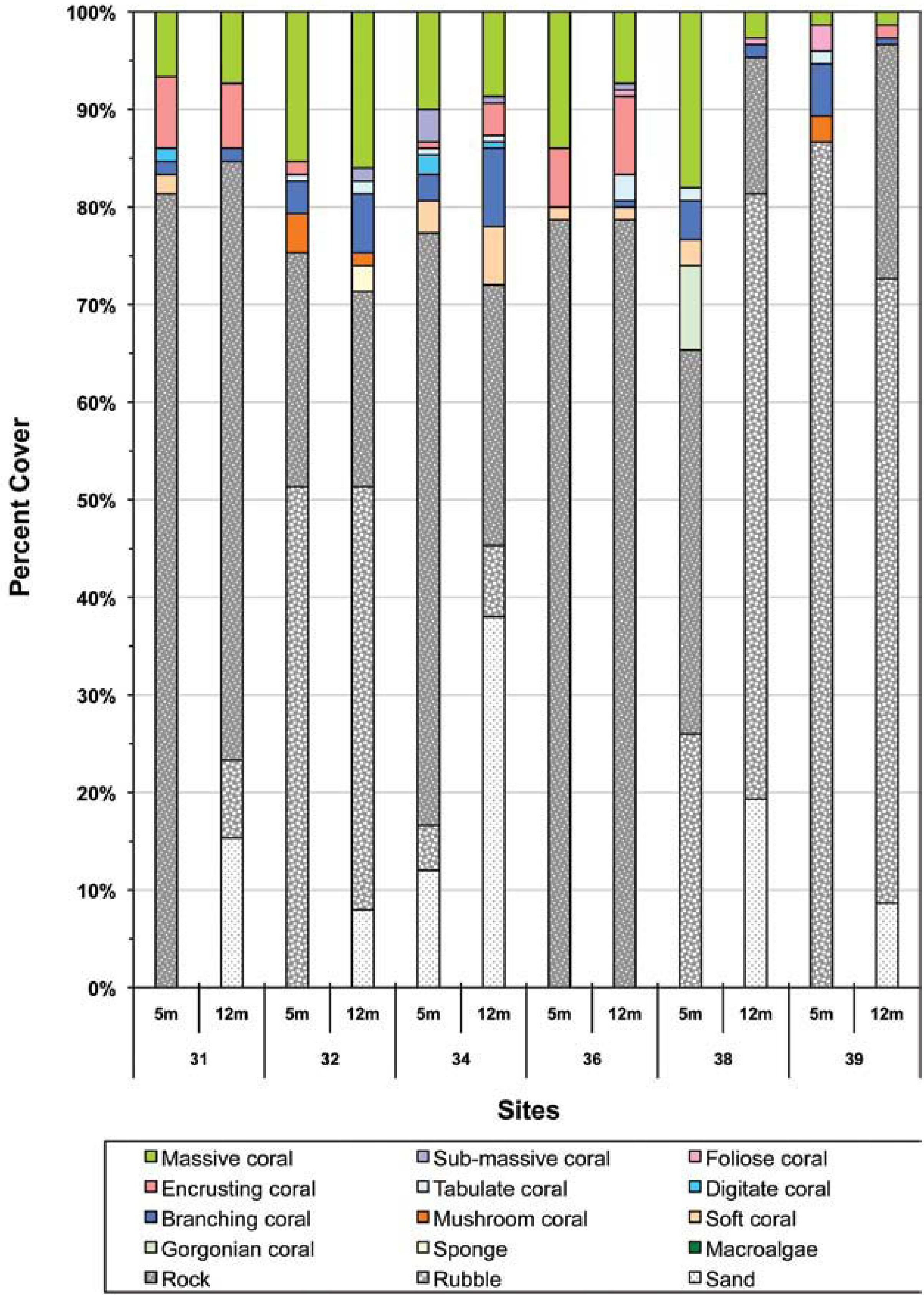

Figure 10 North Scott Reef habitat cover

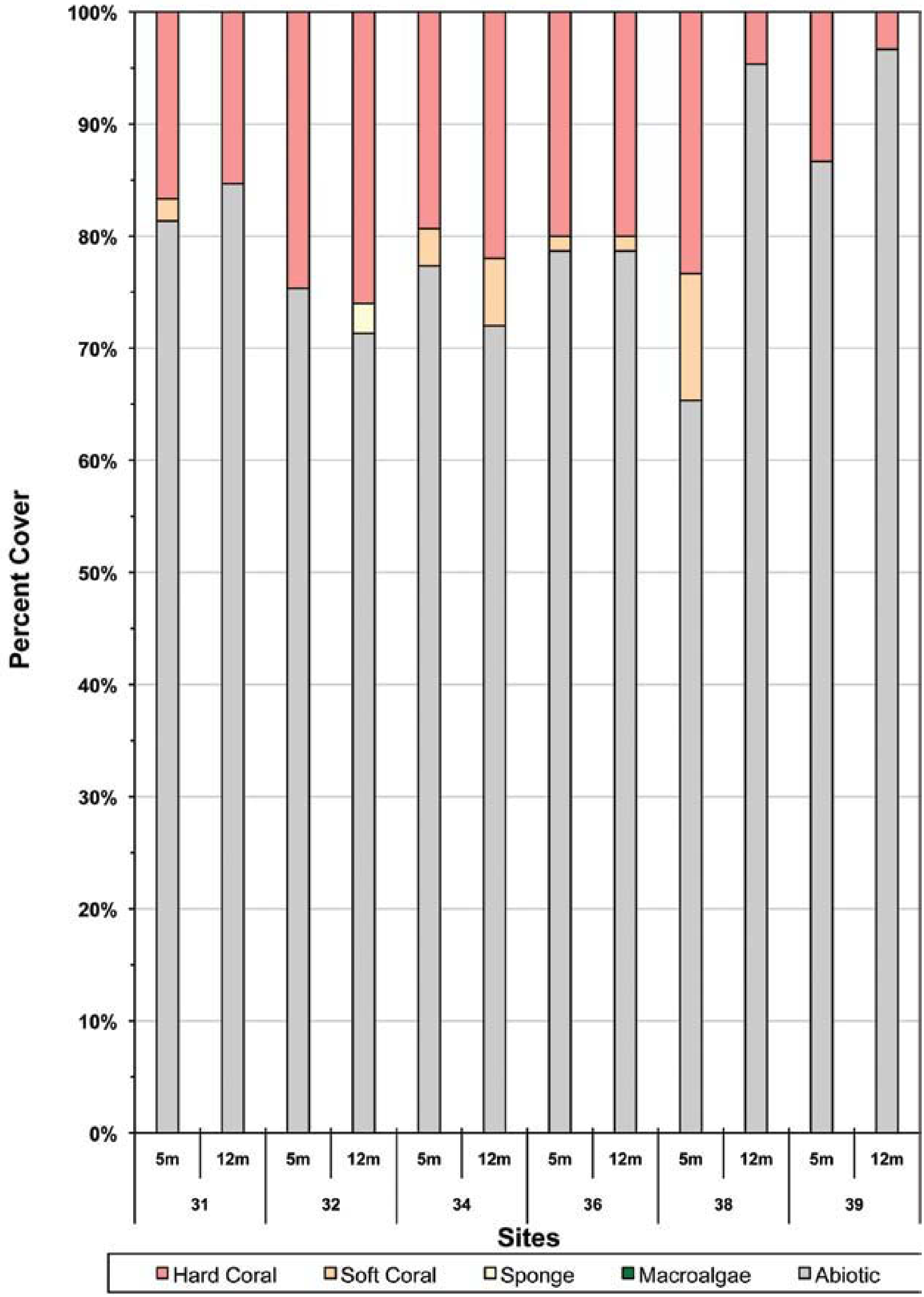

Figure 11 North Scott Reef grouped habitat cover

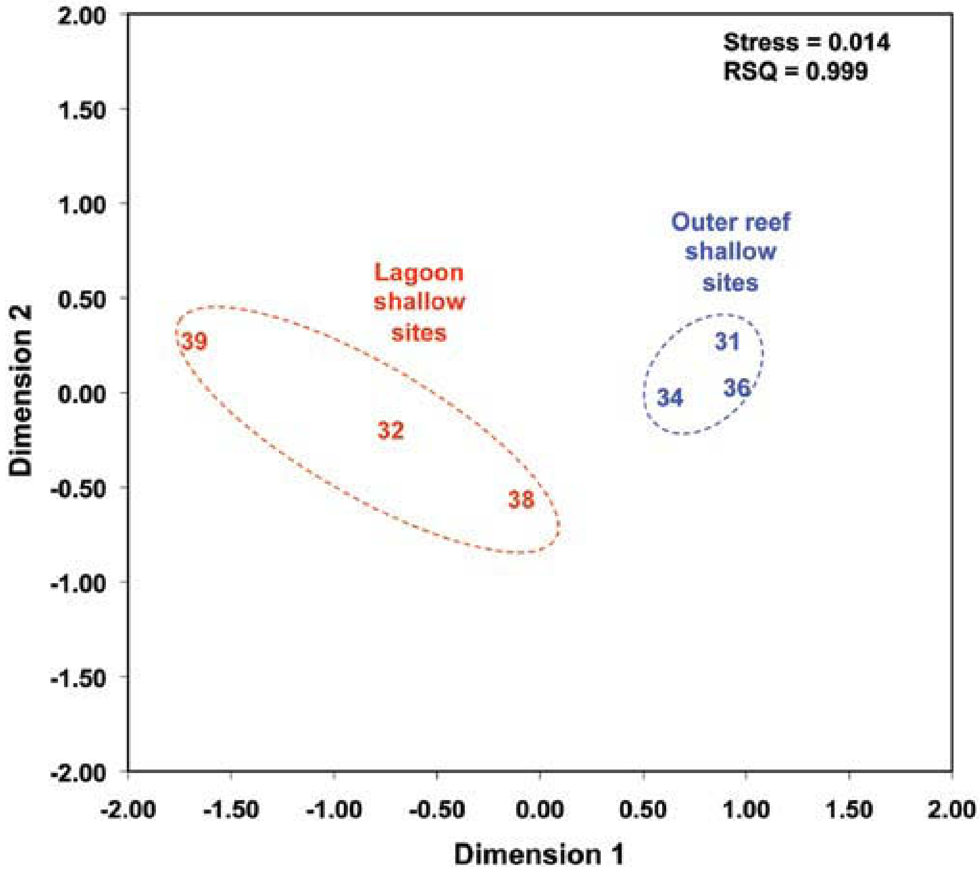

Figure 12 MDS Plot of North Scott Reef shallow transects

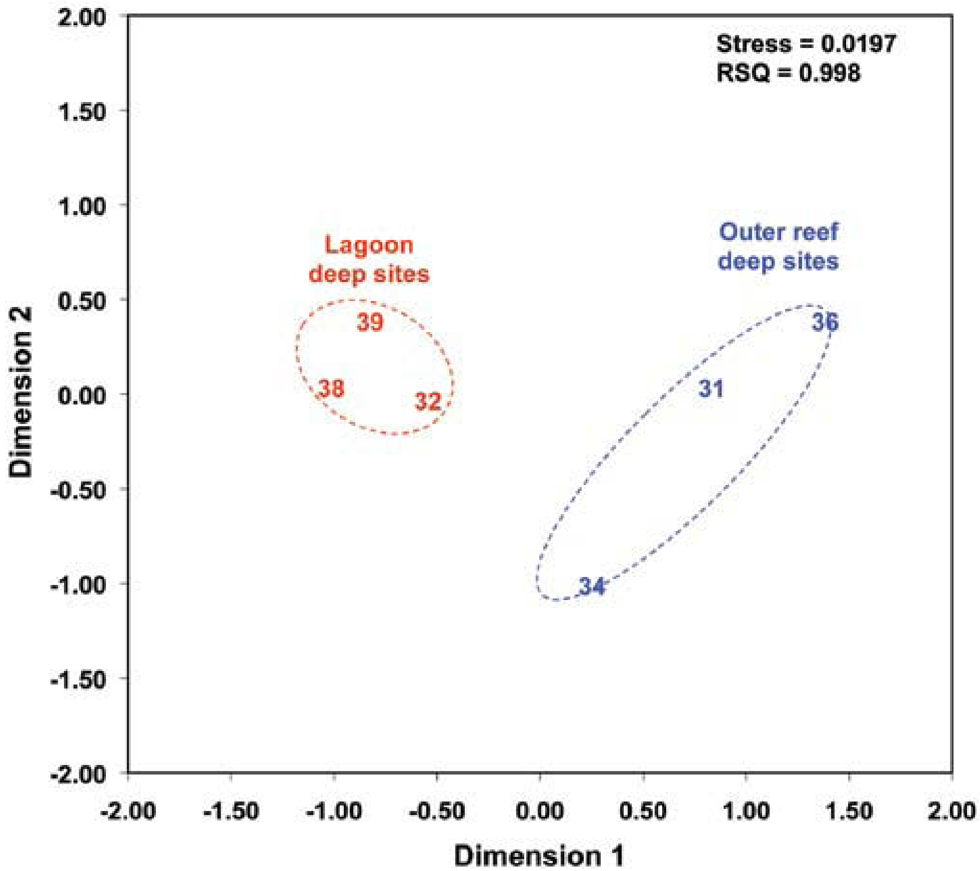

Figure 13 MDS Plot of North Scott Reef deep transects

Above: Station 24, South Scott Reef. *Thalassia* seagrass. (Photo: Clay Bryce)

Above: Mermaid Reef exposed by the tide. (Photo: John Huisman)

Above: Station 37, North Scott Reef. Well tumbled coral-boulders at the outer edge of the reef platform. (Photo: Clay Bryce)

SERINGAPATAM REEF

The general description of the physical characteristics of the seabed at each station for Seringapatam is presented in Table 4. The mean percentage cover by benthic habitat at each station transect is presented graphically by the 15 benthic categories in Figure 14. The data is also presented as percentage cover by a reduced category data set, which amalgamates the abiotic, soft coral and hard coral categories resulting in a set of 5 categories in Figure 15.

Analysis of the data indicates that the outer reef and lagoon shallow transects were distinctly different; however, the variability of the deeper offshore reef transects encompasses the deep lagoon transect (see Figure 16 and Figure 17).

Table 4 Transect topography at Seringapatam Reef

Station	Habitat	Depth (m)	Description
41	Outer reef	5	Heavily dissected reef.
		12	Rocky patches surrounded by coral rubble.
43	Lagoon	5	Top of bommie with rocky lumps.
		12	Uneven seabed with several rocky lumps.
45	Outer reef	5	Heavily dissected reef with deep gutters.
		12	Heavily dissected reef with large isolated blocks and deep gutters.

Only two offshore reef and one lagoon stations were surveyed at Seringapatam, thus, it is difficult to generalise about the habitats of this reef or differences between outer and lagoonal reef habitats. Habitat cover varied from 100% abiotic at the shallow outer reef transect at station 41 to 60% abiotic and 40% biotic at the deep outer reef transect at station 45, which comprised soft coral and seven hard coral categories.

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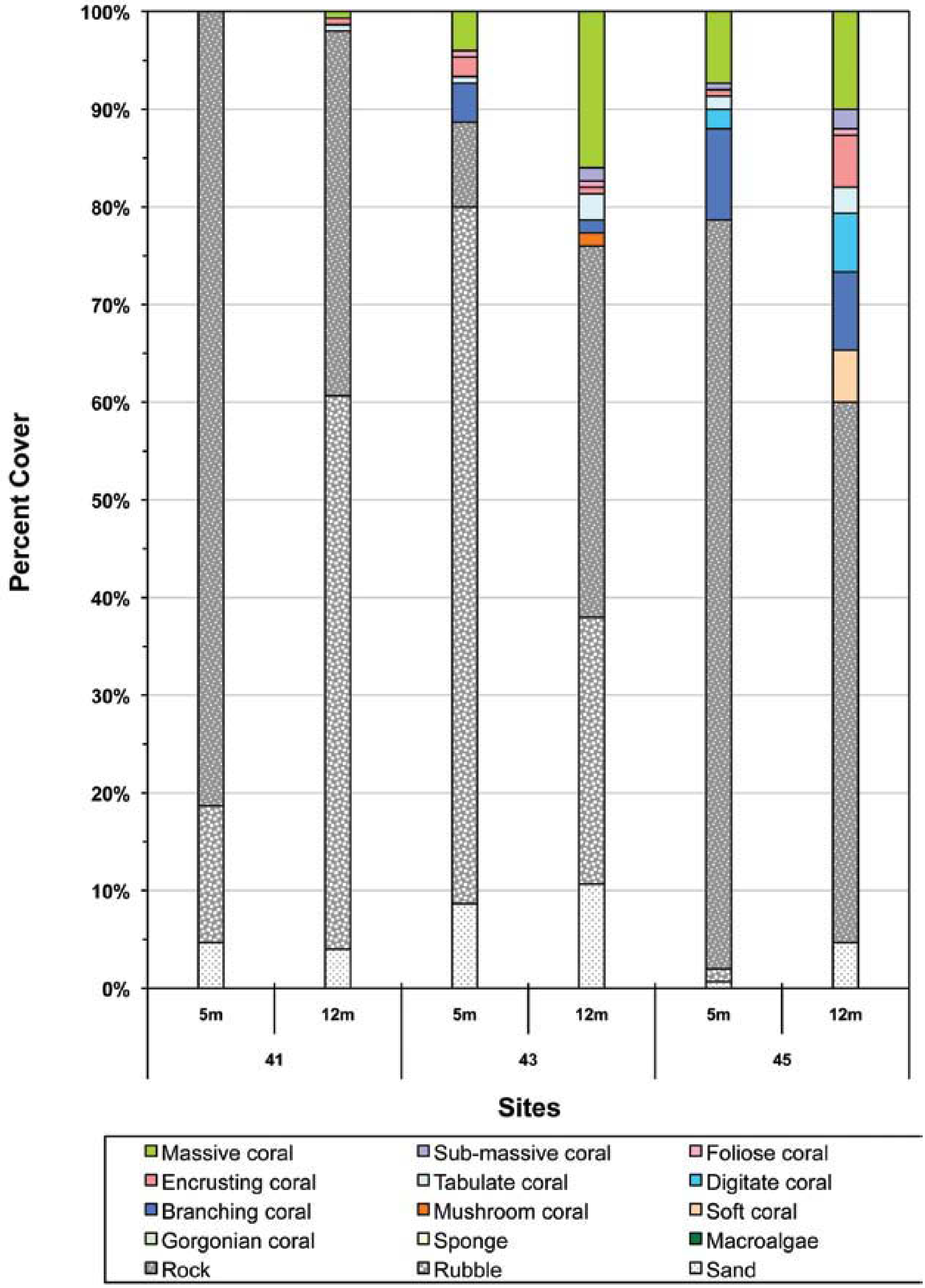

Figure 14 Seringapatam Reef habitat cover

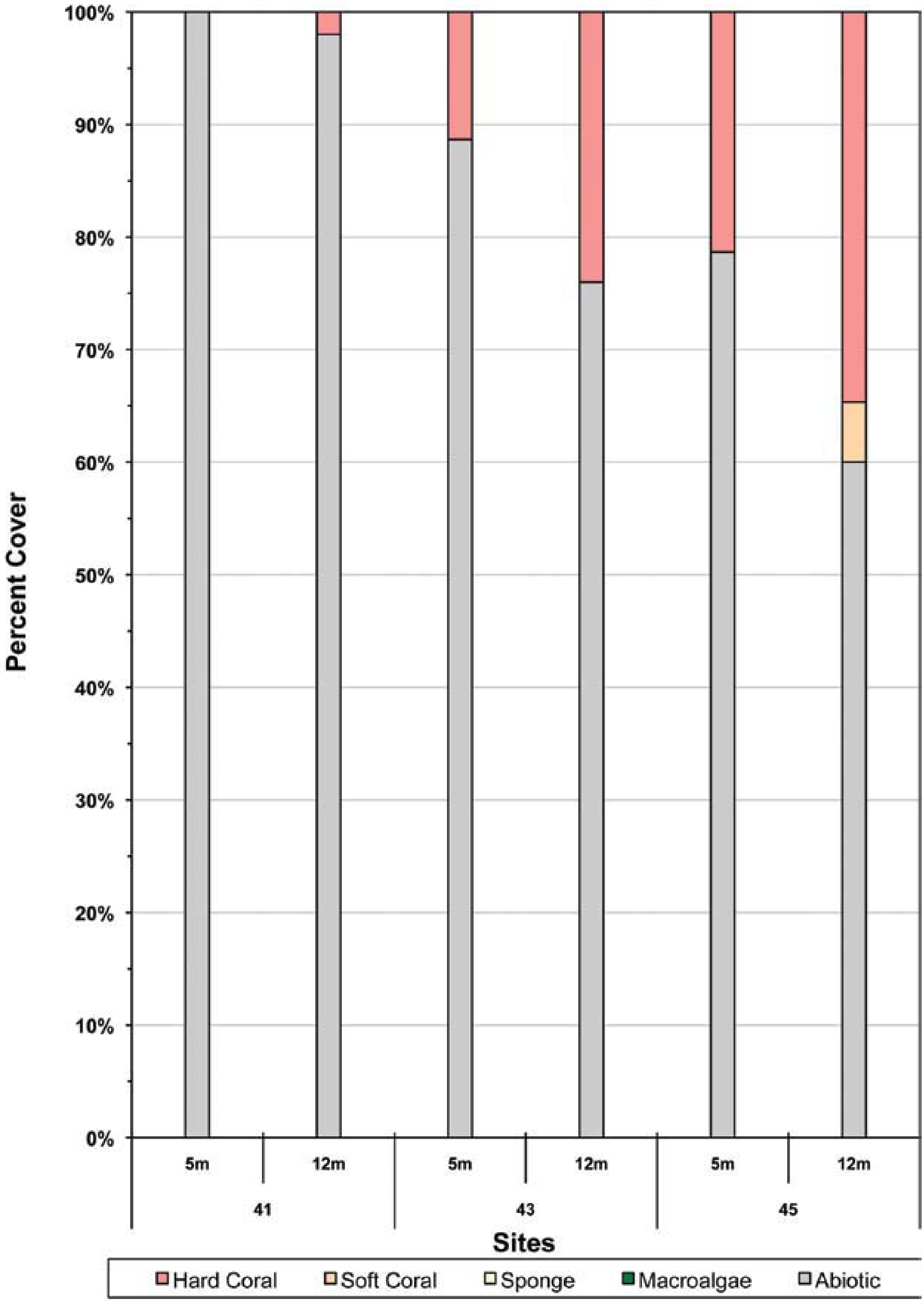

Figure 15 Seringapatam Reef Grouped habitat cover

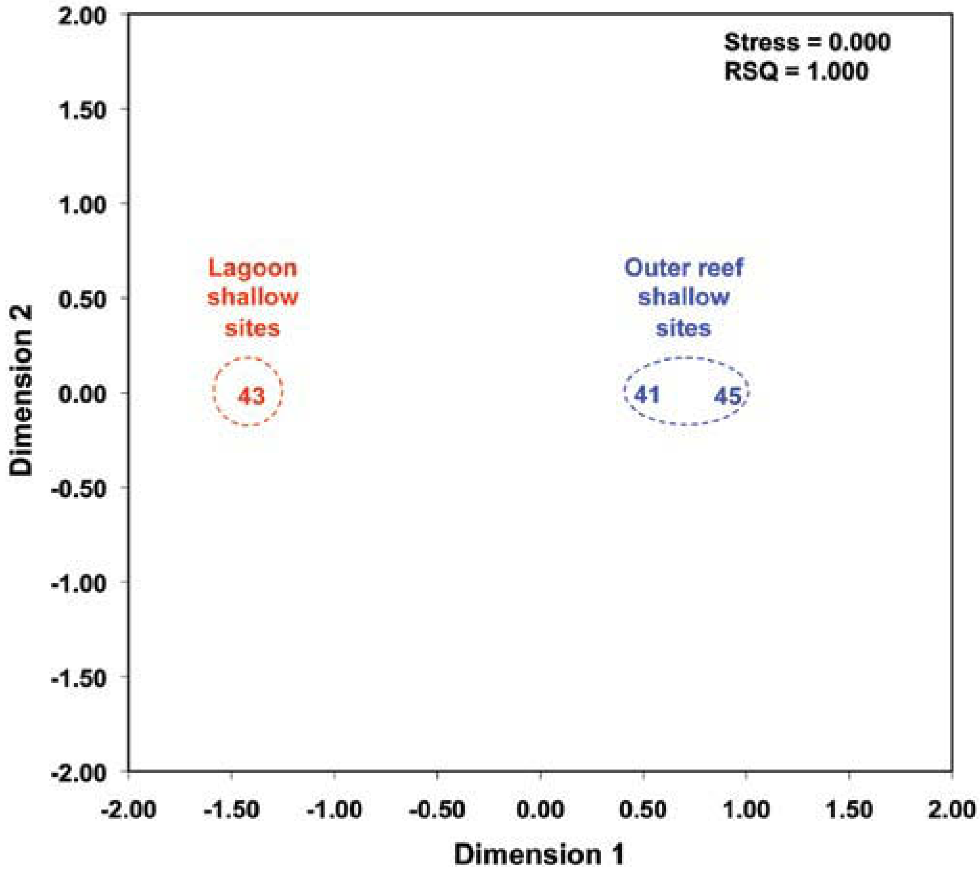

Figure 16 MDS Plot of Seringapatam Reef shallow transects

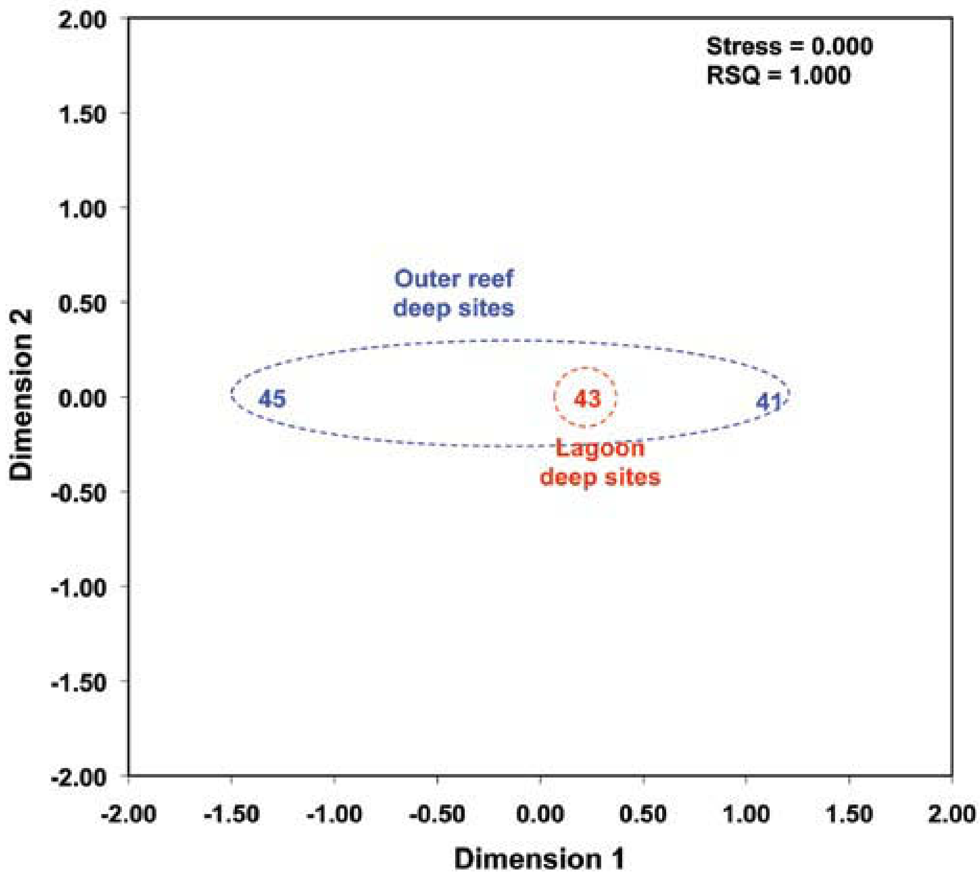

Figure 17 MDS Plot of Seringapatam Reef deep transects

Records of the Western Australian Museum Supplement No. 77: 50–87 (2009).

Marine Benthic Plants of Western Australia's Shelf-Edge Atolls

John M. Huisman[1, 2], Frederik Leliaert[3], Heroen Verbruggen[3] and Roberta A. Townsend[1]

[1] School of Biological Sciences and Biotechnology, Murdoch University, Murdoch, W.A. 6150

[2] Western Australian Herbarium, Department of Environment and Conservation, Kensington, W.A. 6151

[3] Phycology Research Group and Centre for Molecular Phylogenetics and Evolution, Biology Department, Ghent University, Krijgslaan 281 (S8), 9000 Ghent, Belgium.

Abstract – One hundred and twenty-one species of marine algae, seagrasses and cyanobacteria are reported from the offshore atolls of northwestern Western Australia (the Rowley Shoals, Scott Reef and Seringapatam Reef). Included are 65 species of Rhodophyta, 40 species of Chlorophyta, nine species of Phaeophyceae, three species of Cyanophyta and four species of seagrasses. This report presents the first detailed account of marine benthic algae from these atolls. Twenty-four species are newly recorded for Western Australia, with four species (*Anadyomene wrightii*, *Rhipilia nigrescens*, *Ceramium krameri* and *Zellera tawallina*) also newly recorded for Australia.

Key words: Algae; Australia; Biogeography; Systematics

INTRODUCTION

The Rowley Shoals, Scott Reef and Seringapatam Reef are shelf edge atolls lying some 300 km off the coast of northwestern Australia, on the continental slope in clear oceanic waters. Prior to an unpublished survey undertaken by the first author for environmental consultants URS (in February, 2006), records of macroalgae from these reefs were extremely limited, as is generally true for much of north-western Australia. Several expeditions collecting biological samples have visited the reefs, but none have made a concerted effort to collect the marine algae. A Russian expedition in 1978 resulted in the description of a new genus and species of coralline red algae, *Rhizolamellia collum* Shevejko (Shevejko, 1982), but the distinctiveness of this taxon was questioned by Woelkerling (1988) and it requires further study. No further records of algae were published from the Russian expedition. Skewes *et al.,* (1999) conducted visual surveys and gave a list of taxa for Scott and Seringapatam Reefs, mostly identified to genus only. They recorded 11 taxa or growth forms, presented here in Table 1 along with the reported percent cover.

These results give an indication of the ecological significance of macroalgae for the reefs, but as no voucher specimens were collected there would appear to be no way to confirm the taxon identifications.

Other than the new genus described by Shevejko (1982) and the list presented by Skewes *et al.,* (1999), there are no published accounts of macroalgae from the Rowley Shoals and Scott and Seringapatam Reefs. Moreover, prior to the present additions, no specimens were lodged in the Western Australian State Herbarium (search undertaken October 2006), the official repository of the State's plant collections. On a broader scale, a 1995 survey of the marine biota of the northern Kimberley (Walker *et al.,* 1996) was undertaken, but did not include the offshore atolls. The macroalgal component of that survey included 90 species, most of which were widespread tropical taxa. Walker (1996, p. 38) commented that 'the diversity and abundance of the algal flora was generally poor' in the northern Kimberley.

Walker & Prince (1987) recorded three species of seagrass in their collections from Scott Reef and the Rowley Shoals: *Thalassia hemprichii*, *Halophila ovalis* and *Thalassodendron ciliatum*. The first two are common at the atolls and were re-collected during the recent surveys that provided the specimens documented in the present paper, along with a third species, *Halophila decipiens*. *Thalassodendron ciliatum*, however, was not observed. Walker & Prince (1987), in what was the first record for Western Australia, note that it usually grows attached to rock or course grit, in areas of high currents.

On a larger geographical scale, the macroalgal flora of north-western Australia is poorly known, but is the subject of intensive and ongoing studies.

Table 1 Macroalgae and percent cover recorded from Scott and Seringapatam Reefs by Skewes *et al*., (1999).

Taxon/ Growth form	**Scott Reef % cover**		**Seringapatam Reef % cover**
	South	**North**	
Halimeda spp.	3.15	1.26	1.02
Dictyota spp.	0.00	0.20	0.43
Turbinaria ornata	0.11	0.46	0.07
Caulerpa spp.	0.15	0.87	4.63
Ceratodictyon spp.	0.63	0.57	1.12
Gracilaria spp.	0.83	0.07	0.00
Laurencia spp.	0.68	0.02	0.00
Turf Algae	7.88	10.89	8.12
Padina spp.	0.01	0.10	0.00
Crustose coralline	1.14	3.06	1.10
Cladophora socialis	2.96	3.64	6.56
Total Algal Cover	**19.76**	**22.38**	**23.05**

The first author of the present chapter is presently compiling a marine flora for the region, funded in-part by the 'Australian Biological Resources Study'. Thus, while published records are scant, the author's unpublished knowledge of the marine flora is considerable and has been incorporated to a degree in the present account.

The aims of the present survey were to assess the species composition and distribution of macroalgal and seagrass species occurring at the Rowley Shoals, Scott and Seringapatam Reefs.

METHODS

The present publication is based on collections made by the first author on three separate field surveys. The first was undertaken in February 2006 by environmental consultants URS on behalf of Woodside Energy. This trip visited Scott Reef and Seringapatam Reef. The second, in September 2006, was by the Western Australian Museum (W A Museum) with funding support from Woodside Energy. This survey also visited those reefs but in addition included Mermaid Reef, the northernmost atoll of the Rowley Shoals. The third trip (December 2007) was a survey of the three atolls of the Rowley Shoals (Imperieuse, Clerke and Mermaid Reefs) undertaken jointly by the Western Australian Department of Environment and Conservation (DEC) and the Australian Institute of Marine Science (AIMS). These surveys yielded a large number of specimens that have been lodged in the Western Australian State Herbarium (PERTH).

During each survey, the algal flora was assessed visually and by specimen collection, either by SCUBA, snorkelling or reef walking. SCUBA diving was only undertaken during the September 2006 and December 2007 surveys. Sampling

Figure 1 *Turbinaria ornata*, dense cover at Seringapatam Reef.

Figure 2. *Hydrolithon onkodes*, typical of high energy reef crests.

Table 2 Collection Data for URS Survey, February, 2006 (URS Transect (Tr.) in text). Only including sites mentioned in text.

Date	Site	Transect (Tr.)	Lat		Long	
16-Feb-06	South Scott: East side West Hook, reef walk	2	14	4.738	121	44.869
18-Feb-06	South Scott: Outer reef flat edge in to reef flat, snorkel	12	14	10.733	121	54.068
19-Feb-06	South Scott: Outer reef edge into lagoon, snorkel	17	14	7.300	121	58.250
19-Feb-06	South Scott: Northern east horn, across the island reef flat, snorkel	21	14	3.290	121	57.622
20-Feb-06	North Scott: Reef flat -east, snorkel	23	14	1.383	121	51.539
21-Feb-06	North Scott: NE channel, snorkel	27	13	54.996	121	54.538
21-Feb-06	North Scott: Snorkel transect of reef flat, snorkel	28	13	55.495	121	54.936
22-Feb-06	Seringapatam: Southside of channel, reef walk	32	13	38.394	122	1.409
22-Feb-06	Seringapatam: South-east reef flat, Snorkel	35	13	40.584	122	3.146

effort during the latter was somewhat hampered by the majority of the dive time being required to undertake benthic monitoring (5 x 50 m transects), thus regular collecting was limited. During the September 2006 survey, depending on the topography, sites were sampled by: (1) a roughly linear transect from 20 m depth (where available) towards the shallows (outer reef and some lagoon bommies); (2) transects across the reef flat, perpendicular to the reef crest (reef flats and shallows). Initial attempts to assess percent cover by random photo quadrats proved futile, as the algae were mostly too sparsely distributed. The number of quadrats required to gain even a reasonable assessment of the diversity and cover would have been very large and therefore an inefficient use of limited dive times. At locations where individual species were present in large numbers, a gross assessment of maximum cover was made.

Macroalgae and seagrasses were assessed at all stations visited during the WA Museum survey and station details are provided in the Station and Transect Data section (this volume). Presence/absence data for the macroalgae and seagrasses were incorporated into the overall station comparisons.

Representative specimens were collected from each location and preserved in 5% Formalin/seawater (2006 surveys) or pressed directly on herbarium sheets on-site (2007). These specimens have been lodged in the State Herbarium (PERTH). Additional material was also preserved in 100% Etoh (green algae) or dried in silica gel (red algae) for DNA analysis. Locations visited during the URS 2006 survey are listed in Table 2. Table 5 gives the presence of individual taxa at each location observed during the WA Museum survey of 2006.

Figure 3 *Rhipilia nigrescens*, a spongy green alga found in reef front habitats.

Figure 4 *Halimeda minima*, common in shaded areas in most habitats.

Figure 5 *Dichotomaria marginata*, generally in reef front habitats.

Figure 6 *Rhizolamellia collum*, restricted to dark crevices on reef fronts

RESULTS

A systematic list of taxa observed and/or collected during the three surveys is presented below. Table 5, however, includes only those species recorded during the WA Museum survey of 2006 and is included here to enable combined analyses with the fauna. The taxa observed and/or collected at each station are listed in Table 5.

General algal cover was estimated at only approximately 5–10%, but was extremely variable with some areas approaching 100% cover (e.g. *Turbinaria ornata* on the reef flat at Seringapatam, figure 1). The overall diversity of marine algae at the reefs visited is low, with only a small number of conspicuous species recorded. Several of these are consistently present in certain habitats:

Reef front - Crustose corallines (primarily *Hydrolithon onkodes,* figure 2) dominated the shallow reef crest, where they grew over and consolidated dead coral and rubble. In some places crustose corallines covered almost all available hard surfaces, occasionally reaching up to 65% cover. These areas were typically more exposed to wave action and the non-coralline algal species were restricted to localized protected microhabitats (on edges of outcrops, in gaps etc.). Non-coralline species observed at the shallow reef crest include *Rhipilia nigrescens* (Figure 3), *Sphacelaria tribuloides*, *Dictyosphaeria versluysii*, and *Valonia ventricosa*. In deeper water, species of *Halimeda* (e.g., *H. minima*, figure 4), *Galaxaura*, *Dichotomaria* (Figure 5) and *Tricleocarpa* were occasionally common in exposed areas, but most of the algal diversity was restricted to protected areas under overhangs and within crevices. In these habitats, several crustose corallines (including *Rhizolamellia collum*, figure 6) and species of *Peyssonnelia* (Figure 7) were common, more sporadically the red alga *Corynocystis prostrata* (Figure 8), *Zellera tawallina* and the gelatinous *Gibsmithia hawaiiensis* (Figure 9). At one station (16) large stands of *Halimeda opuntia* were observed at depth.

Reef flats - The brown algae *Turbinaria ornata* (Figure 1) was present in most situations in the reef flat where hard substrata were available, but only at Seringapatam Reef did it reach high densities. The only other brown alga regularly encountered was the crustose form of *Lobophora variegata* (Figure

Table 3 Macroalgal species recorded from various localities (partially from Huisman et al., 1998)

Region/Island	Recorded taxa	Source
Philippines	911	Silva *et al.*, 1987
Indonesia	452	Verheij & Prud'homme van Reine 1993
Australia, Dampierian province	>350	Huisman, unpublished obs.
Dampier Archipelago	210	Huisman & Borowitzka 2003
Lord Howe I., N.S.W.	298	Australian Marine Algal Name Index
Barrow I.	170	Huisman, unpublished obs.
Eastern Kimberley	90	Walker 1996
Scott & Seringapatam Reefs	± 50	URS Survey (2006)
Rowley Shoals, Scott & Seringapatam Reefs	± 121	This survey

Table 5 Presence of individual taxa (X) at each station observed during the Western Australian Museum Survey of 2006.

TAXA	STATIONS															
	Mermaid Reef															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Chlorophyta (Green Algae)																
ANADYOMENACEAE																
Anadyomene plicata C.Agardh 1823			X		X								X		X	X
Anadyomene wrightii Harvey ex J.E.Gray 1866													X	X		
Microdictyon okamurae Setchell 1925																
Phyllodictyon anastomosans (Harvey) Kraft & Wynne 1996										X			X			
BRYOPSIDACEAE																
Bryopsis sp.															X	
CAULERPACEAE																
Caulerpa cupressoides (Vahl) C.Agardh 1817						X		X								
Caulerpa serrulata (Forssk.) J.Agardh 1837	X		X								X				X	
Caulerpa taxifolia (Vahl) C.Agardh 1817						X										
Caulerpa webbiana Montagne 1837																X
Caulerpa verticillata J.Agardh 1847																
CHAETOPHORACEAE																
Uronema marinum Womersley 1984														X		
CHAETOSIPHONACEAE																
Blastophysa rhizopus Reinke 1889																
CLADOPHORACEAE																
Cladophora herpestica (Montagne) Kützing 1849					X											
CODIACEAE																
Codium arabicum Kützing 1856							X									
Codium dwarkense Børgesen 1947								X								
Codium sp.						X		X				X				
DASYCLADACEAE																
Neomeris bilimbata Koster 1937			X			X						X			X	
HALIMEDACEAE																
Halimeda cylindracea Decaisne 1842																
Halimeda discoidea? Decaisne 1842											X					
Halimeda macroloba Decaisne 1841								X								
Halimeda macrophysa Askenasy 1888	X								X							
Halimeda minima (Taylor) Hillis-Colinvaux 1968	X	X	X	X		X	X		X		X			X	X	X
Halimeda opuntia(Linnaeus) Lamouroux 1816	X	X		X								X		X	X	X
SIPHONOCLADACEAE																
Boodlea composita (Harvey) Brand 1904						X										
Boodlea vanbosseae Reinbold 1905																
Boergesenia forbesii (Harvey) Feldmann 1938																
Cladophora herpestica (Montagne) Howe 1914		X		X	X				X			X			X	X
Dictyosphaeria cavernosa(Forssk.) Børgesen 1932					X											
Dictyosphaeria versluysii Weber -van Bosse 1905		X		X									X	X	X	X
UDOTEACEAE																
Avrainvillea amadelpha (Montagne) Gepp & Gepp 1908																
Rhipidosiphon javensis Montagne 1842																
Rhipilia crassa Millar & Kraft 2001																
Rhipilia nigrescens Coppejans & Prud'homme 1990																

STATIONS																												
Scott Reef																								Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
X	X	X	X	X				X	X					X		X	X		X		X	X	X	X				X
														X														
																					X							
					X					X			X	X				X	X									
X		X	X		X			X	X						X				X		X			X	X			X
																									X			
																									X			
														X														
								X																				
																									X			
	X																											
		X	X		X	X		X	X	X	X		X	X		X	X	X	X	X	X	X			X		X	X
							X																					
				X												X												
X	X	X	X		X	X		X	X		X	X	X	X	X		X		X		X	X		X	X	X		X
X	X				X			X	X			X	X	X	X	X	X	X	X					X			X	X
				X			X		X																X		X	
				X			X			X						X		X		X							X	
				X																								
X			X					X					X	X					X									
X			X	X			X			X	X													X				
X		X											X	X		X			X		X							
													X		X		X		X		X	X						
																					X							
X																										X		
X		X	X		X									X												X		

TAXA	STATIONS															
	Mermaid Reef															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Rhipiliopsis echinocaulos (Cribb) Farghaly 1986																X
Udotea glaucescens J.Agardh 1887	X						X	X				X		X		
ULVACEAE																
Ulva flexuosa Wulfen 1803								X								
VALONIACEAE																
Valonia fastigiata J.Agardh 1887				X												
Valonia ventricosa J.Agardh 1887		X		X							X			X	X	X
Phaeophyceae (Brown Algae)																
ECTOCARPACEAE																
Hincksia sp.																
DICTYOTACEAE																
Dictyopteris repens (Okamura) Børgesen 1924																
Dictyota friabilis Setchell 1926																X
Dictyota sp.																
Lobophora variegata (Lamouroux) Oliviera 1977			X	X		X			X		X	X		X		X
Padina boryana Thivy in W.R. Taylor 1966						X						X				
Stypopodium flabelliforme Weber-van Bosse 1913	X															
SCYTOSIPHONACEAE																
Hydroclathrus clathratus (C.Agardh) Howe 1920						X										
Rosenvingea intricata (J.Agardh) Børgesen 1914						X										
SARGASSACEAE																
Turbinaria ornata (Turner) J.Agardh 1848	X	X	X		X	X			X		X			X		
SPHACELARIACEAE																
Sphacelaria tribuloides Meneghini 1840																
Rhodophyceae (Red Algae)																
BONNEMAISONIACEAE																
Asparagopsis taxiformis (Delile) Trevisan 1845						X										
CERAMIACEAE																
Aglaothamnion cordatum (Børgesen) Feldmann-Mazoyer, 1941														X		
Anotrichium tenue (C.Agardh) Nägeli 1862																
Antithamnion antillanum Børgesen 1917																
Antithamnionella sp.																
Centroceras clavulatum (C.Agardh) Montagne 1846																
Ceramium codii (Richards) Mazoyer 1938							X	X								
Ceramiun krameri South & Skelton 2000																
Ceramiun vagans Silva 1987																
Corallophila apiculata (Yamada) R.Norris, 1993														X		
Crouania attenuata (C.Agardh) J.Agardh 1842						X										
Gayliella flaccida (Kütz.) Cho et al. 2008													X			
Griffithsia heteromorpha Kützing 1863																
Haloplegma duperreyi Montagne 1842										X				X		
Seirospora orientalis Kraft 1988																
Spyridia filamentosa (Wulfen) Harvey 1833																
Wrangelia sp.																X

STATIONS																												
Scott Reef																								Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
																									X			
X		X	X								X		X	X								X	X					X
X	X	X	X		X	X		X	X		X	X	X	X	X		X		X		X	X		X	X	X		X
										X																		
																						X						
						X						X			X						X	X				X		
								X	X																X			
				X	X		X	X		X	X	X	X	X				X		X	X		X	X		X	X
							X	X	X																X			
								X																				
				X			X	X	X	X				X		X		X				X			X		X	
									X																			
									X																			
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													X															
							X	X																				
																							X					
																							X					
													X															
								X																				
											X													X				X
								X																				
										X															X			
		X			X																							

TAXA	STATIONS															
	Mermaid Reef															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CORALLINACEAE																
Amphiroa fragilissima (Linnaeus) Lamouroux 1816																
Hydrolithon onkodes (Heydrich) Penrose & Woelkerling 1992		X	X	X	X				X		X	X	X	X	X	X
Jania adhaerens Lamouroux 1816														X	X	
Rhizolamellia collum Shevejko 1982				X												
Hydrolithon gardineri (Foslie) Verheij & Prud'homme van Reine 1993																
Lithophyllum tamiense (Heydrich) Foslie 1900																
Lithothamnion proliferum Foslie 1904																
CORYNOCYSTACEAE																
Corynocystis prostrata Kraft 1999																
DASYACEAE																
Dasya sp.						X										
Heterosiphonia crispella (C.Agardh) Wynne 1985																
DELESSERIACEAE																
Zellera tawallina Martens 1868																
DUMONTIACEAE																
Gibsmithia hawaiiensis Doty 1963												X				
GALAXAURACEAE																
Actinotrichia fragilis (Forssk.) Børgesen 1932									X					X		X
Dichotomaria marginata (Ellis & Solander) Lamarck 1816														X		
Galaxaura rugosa (Ellis & Solander) Lamouroux 1816																
Tricleocarpa cylindrica (Ellis & Solander) Huisman & Borowitzka 1990																
GELIDIACEAE																
Gelidiella acerosa (Forssk.) Feldmann & Hamel 1934			X													
Pterocladiella caerulescens (Kützing) Santelices & Hommersand 1997																
HYPNEACEAE																
Hypnea sp.						X										X
KALLYMENIACEAE																
Kallymenia sp.																
LIAGORACEAE																
Ganonema pinnatum (Harvey) Huisman 2002						X										
Ganonema farinosum (Lamouroux) Fan & Wang 1974											X					
Liagora ceranoides Lamouroux 1816																
Titanophycus validus (Harvey) Huisman et al. 2006																
NEMASTOMATACEAE																
Predaea weldii Kraft & Abbott 1971												X				
Predaea laciniosa Kraft 1984																X
PEYSSONNELIACEAE																
Peyssonnelia inamoena Pilger 1911		X			X			X	X	X		X		X	X	X
Peyssonnelia sp. (mottled)								X								
Peyssonnelia sp. (orange)		X			X				X					X	X	
Peyssonnelia sp. (deep red, tightly encrusting)																
PIHIELLACEAE																
Pihiella liagoraciphila Huisman, Sherwood & Abbott 2003																

STATIONS																												
Scott Reef																								Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
																										X		
X		X	X		X						X		X	X		X	X		X					X			X	X
						X	X	X	X		X			X	X			X							X		X	X
X											X		X				X		X		X	X		X				X
												X		X					X		X					X		X
															X							X						
														X														
																							X					
		X			X									X									X					
X		X	X		X			X	X					X					X									
											X		X						X							X		
					X								X	X			X		X									X
	X	X					X	X		X	X					X		X		X							X	
					X	X							X	X			X		X					X				X
				X																								
						X																	X	X			X	X
																		X							X			
			X																									
							X			X										X							X	
						X		X	X			X																
																								X				
							X			X						X		X		X							X	
									X																			
X		X	X																X									
X					X	X					X	X	X	X	X		X		X		X	X		X		X		X
X	X	X									X																	
			X		X						X	X	X	X			X		X		X							X
																								X				
							X																					

TAXA	STATIONS															
	Mermaid Reef															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RHODOMELACEAE																
Acanthophora spicifera (Vahl) Børgesen 1910	X					X										
Herposiphonia secunda (C.Agardh) Ambronn 1880																
Leveillea jungermannioides (Hering & G.Martens) Harvey 1855																
Neosiphonia poko (Hollenberg) Abbott 2002																
Polysiphonia spp.																
Tolypiocladia glomerulata (C.Agardh) Schmitz 1897																
RHODYMENIACEAE																
Asteromenia sp.					X											
Ceratodictyon spongiosum Zanardini 1878																
Coelothrix irregularis (Harvey) Børgesen 1920						X										
Gelidiopsis intricata (C.Agardh) Vickers 1905																
RHIZOPHYLLIDACEAE																
Portieria hornemannii (Lyngbye) Silva 1987																
SARCOMENIACEAE																
Platysiphonia delicata (Clemente y Rubio) Cremades 1990																
SCHIZYMENIACEAE																
Platoma cyclocolpum (Montagne) Schmitz 1889																
Titanophora pikeana (Dickie) Feldmann 1942																
Cyanobacteria (Blue-green Algae)																
Lyngbya majuscula (Dillwyn) Harvey 1833																
Symploca hydnoides (Harvey) Kützing 1849																
Leptolyngbya crosbyana (Tilden) Anagnostidis & Komárek 1988																
Magnoliophyta (Sea Grasses)																
Thalassia hemprichii (Ehrenberg) Aschersson 1871									X		X			X		
Halophila ovalis (R.Brown) J.D.Hooker 1859	X						X	X			X			X		
Halophila decipiens Ostenfeld 1902																

STATIONS																												
Scott Reef																								Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
																									X			
																X							X					
							X																					
																							X					
		X																										
								X																	X			
																		X										
								X	X																			
		X	X		X														X		X	X						
								X																				
									X																			
												X		X												X		
				X																								
																						X				X		
				X									X															
				X			X			X																		
	X								X								X								X			X

Table 4 New Records for Western Australia (*new for Australia)

*Anadyomene wrightii**	*Halimeda opuntia*
Avrainvillea amadelpha	*Lithophyllum tamiense*
Boodlea vanbosseae	*Microdictyon okamurae*
Bryopsis indica	*Neomeris bilimbata*
*Ceramium krameri**	*Neosiphonia poko*
Ceramium vagans	*Peyssonnelia inamoena*
Cladophoropsis sundanensis	*Phyllodictyon orientale*
Corynocystis prostrata	*Rhipilia crassa*
Dictyopteris repens	*Rhipilia nigrescens**
Halimeda distorta	*Rhipiliopsis echinocaulos*
Halimeda macrophysa	*Sporolithon ptychoides**
Halimeda minima	*Zellera tawallina**

12), which grew on exposed coral rubble on reef flats. Species of the genus *Halimeda* were commonly present, as was the green turf *Boodlea vanbosseae*. Turfs such as *Coelothrix irregularis* were also common.

Lagoon/bommies - on outcrops the green algae *Halimeda opuntia*, *H. minima* and *H. discoidea* generally occurred, the former also typically on the shaded sides and in hollows. *Halimeda macrophysa* (Figure 11) was occasionally present. The turf green alga *Boodlea vanbosseae* was almost always present on outcrops, as was the spongy green *Boodlea composita*. Other turfs included the red algae *Polysiphonia* spp., *Coelothrix irregularis*, and *Gelidiopsis* sp.

Sandy pools - *Halimeda cylindracea* was common in shallow sandy habitats, where its large bulbous holdfasts gave it some purchase. Also in these situations were *Halimeda macroloba* (Figure 10) and *Udotea glaucescens* (Figure 14). In some sandy habitats *Caulerpa cupressoides* and *Caulerpa serrulata* were also common. All of these species are adapted to growth in unconsolidated substrata, either by producing sand-binding bulbous holdfasts or by having prostrate stolons that attach at numerous points. In turn, the *Halimeda* and *Caulerpa* provide habitats for numerous epiphytic species, such as *Padina* sp., *Herposiphonia secunda*, *Anotrichium tenue*, *Gayliella flaccida* and *Centroceras clavulatum*. The seagrasses *Thalassia hemprichii* (Figure 13) and *Halophila ovalis* were occasionally common in shallow sandy areas, the former sometimes forming small but dense beds. The occurrence of *Halophila decipiens* in deeper water, as suggested by video evidence in the URS report, is confirmed for Scott and Seringapatam Reefs.

DISCUSSION

Over 120 species of macroalgae and seagrasses are reported for the Rowley Shoals, Scott Reef and Seringapatam Reef. This represents a significant contribution towards documenting the marine flora of these reefs. Once the smaller, cryptic epiphytic algae are fully assessed, the species

Figure 7 *Peyssonnelia inamoena*, on vertical walls in many habitats

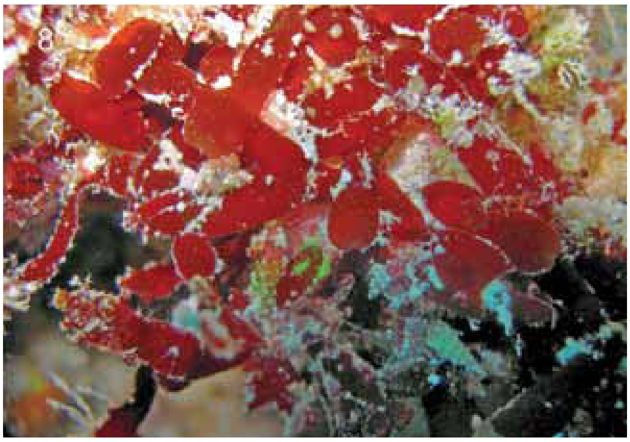

Figure 8 *Corynocystis prostrata*, newly recorded for Western Australia

number will probably approach 140. Several of the specimens collected represent new records for Australia or Western Australia, including the red alga *Corynocystis prostrata* Kraft and the green alga *Rhipiliopsis echinocaulos* (Cribb) Farghaly (see Table 4). As these reefs have not been intensively sampled previously, the majority of the species represent new records.

From an algal perspective there were very few differences in the floras of the Rowley Shoals, Scott and Seringapatam Reefs, and most of those noted were probably site specific or habitat related rather than between reef differences. The higher energy reef fronts typically supported the encrusting coralline *Hydrolithon onkodes* near the crest. This species is characteristic of this zone in most Indo-Pacific reefs. The mat-forming green alga *Cladophora herpestica* was common on vertical walls in shallow, relatively exposed locations at the Rowley Shoals, whereas it was seemingly absent from Scott and Seringapatam Reefs. This species furnishes perhaps the only clear floristic difference between the two reef systems. Other species from reef front habitats were often associated with dark recesses within the vertical walls. These include species such as *Peyssonnelia inamoena* and the recently described *Corynocystis prostrata*, both new records for Western Australia.

At Seringapatam there were more dense stands of the brown alga *Turbinaria ornata*, a species that was observed less frequently at the Rowley Shoals and Scott Reef. In places at Seringapatam it covered the reef entirely, but this was very patchy. This contrasts to the observation of Skewes *et al.*, (1999), who recorded a greater cover of *Turbinaria* at Scott Reef compared to Seringapatam. These differences are probably not significant and reflect within-reef or seasonal variation. The green turf *Boodlea vanbosseae* also formed dense but patchy stands on reef flats. This species was recorded less frequently at the Rowley Shoals but reflects the fact that suitable habitats were not visited. Most other recorded species occurred at all three reefs and in similar densities. There were several species recorded from single specimens (e.g. *Platoma cyclocolpum* at Stn 26). Most of the commonly observed species occurred at the three reefs.

Mermaid/Scott/Seringapatam Reefs compared to the Indo-Pacific Biogeographic Region

The Indo-Pacific algal flora is very diverse and covers a large area. Some subsets of the region are regarded as biodiversity hotspots, for example the Philippines with some 900 species recorded (Silva *et al.*, 1987), but this high diversity often also reflects collection effort. Macroalgal studies in some regions have been ongoing for over a century (e.g. Indonesia, beginning with Weber-van Bosse & Foslie 1904) and these regions continue to be studied by primarily European botanists (e.g

Figure 9 *Gibsmithia hawaiiensis*, an unusual gelatinous red alga.

Figure 10 *Halimeda macroloba*, a species restricted to sandy habitats

Figure 11 *Halimeda macrophysa*, with ruffled segments

Figure 12 *Lobophora varegiata*, common in lagoonal habitats.

Figure 13 *Thalassia hemprichii*, occasionally in dense stands in sandy habitats

Figure 14 *Udotea glaucescens*, a fan shaped green alga.

Verheij & Prud'homme van Reine 1993). However, much of the Indo-Pacific region is also currently poorly known, particularly so tropical northwestern Australia where, up until some 8 years ago, less than 30 algal species were recorded (Huisman *et al.*, 1998). Ongoing studies are rapidly changing this situation and presently the known (but mostly unpublished) northwestern Australian flora totals over 350 species. Specimens of possibly another 100 species have been collected, but these are as yet unidentified (unpublished obs.). Thus any assessment of the Rowleys/Scott/Seringapatam algal floras must be viewed against this backdrop, acknowledging that there is much that is still unknown.

The algal flora of the Rowley Shoals, Scott and Seringapatam Reefs forms a small subset of the Indo-Pacific algal flora, with virtually all of the species identified thus far having been previously collected from north-western Australia or from localities further north. Several of the collected species represent new records for Western Australia, but these are likely to be revealed as much more widespread once more extensive collections are made from the region. From an algal perspective, there is nothing to suggest that the Rowley Shoals, Scott and Seringapatam Reefs are unique within the Indo-Pacific. A comparison of the total number of species recorded from various regions and localities is given in Table 3. This is obviously a superficial comparison, as neither collecting effort, area, nor habitat diversity is taken into account. Nevertheless, it does serve to illustrate that the reefs support only a small number of macroalgal species.

Mermaid/Scott/Seringapatam reefs compared to the mainland

Compared with the northwest coast of the mainland, the diversity of Scott Mermaid/Scott/Seringapatam Reefs is markedly lower. Over 350 species are recorded from the mainland (Huisman, unpublished observations), whereas only approximately 120 species were found at the reefs. This disparity is obviously biased by the larger area and more diverse habitats of the mainland, plus a greater sampling effort. Nevertheless, even comparably smaller subsets of the mainland (e.g.

Barrow Island with 170 spp.; Huisman, unpublished obs.) show a greater diversity than that found at the offshore atolls. Moreover, several taxa common in the Indo-Pacific and often typical of tropical regions were not found. The most conspicuous in their absence were the brown algal genera *Sargassum* and *Cystoseira*. Other usually species-rich genera were only represented by a small number of species. For example, 16 species and varieties of the green alga *Caulerpa* have been recorded from the north-western Australian mainland, but only five species were found at the offshore atolls. The reasons for this low diversity are uncertain, as suitable microhabitats for many of these taxa appear to be present at the reefs.

FURTHER OUTCOMES

Specimens of the rare *Rhizolamellia collum* Shevejko 1982 (previously known only from the type collection from Scott Reef) were collected and will form the basis of a separate taxonomic and DNA sequence study to assess the affinities of this enigmatic genus. Other studies generated wholly or in part by these collections, or to which specimens have been contributed, include a reassessment of *Boodlea vanbosseae* (Leliaert *et al.*, 2007), an assessment of *Phyllodictyon orientale* (Leliaert *et al.*, 2008), an analysis of the affinities of Australian *Acanthophora spicifera* (McDonald & Sherwood, in prep.) and the description of a new species of *Asteromenia* (Huisman & Saunders, in prep.). Moreover, all of the species recorded will be included in the '*Marine Benthic Flora of Northwestern Australia*' (Huisman, in prep.) and all of the *in situ* specimen photographs (of which only a selection are included here) will be made available on the Department of Environment and Conservation's 'FloraBase' website.

CONCLUSIONS

The algal flora of the Rowley Shoals, Scott and Seringapatam reefs represents a small subsection of the highly diverse Indo-Pacific flora, with the majority of species recorded during the present survey having been previously recorded from mainland northwestern Australia or from Indonesia. Some 100 species of macroalgae and seagrasses are reported for the reefs (a doubling of the previously known flora), but once cryptic and turf species are fully examined this number is likely to increase further to ± 140 spp. Several species represent new records for Australia (*Zellera tawallina*) or Western Australia (*Corynocystis prostrata*, *Rhipiliopsis echinocaulos*, *Halimeda macrophysa*).

The algal floras of the three reef systems were essentially similar. Differences between stations were observed, but these were primarily habitat based (i.e. reef front versus reef flat versus lagoon). Several species were characteristic of each of these habitats at the three reefs.

TAXONOMIC ACCOUNT

Taxa are arranged into Divisions (Chlorophyta = green algae, Heterokontophyta: Phaeophyceae = brown algae, Rhodophyta = red algae, Cyanophyta = cyanobacteria = blue-green algae, Magnoliophyta = seagrasses. Divisions are subdivided into Orders, Families, Genera and Species, generally arranged according to Silva *et al.*, (1996). Species are arranged alphabetically and each entry includes nomenclatural information, an 'Illustrations' section for previously published photographs or drawings, distribution information, and a list of selected specimens. Habitat notes pertain to local collections. In specimen citations, 'URS' refers to the February 2006 URS survey, and 'NWA' refers the to September 2006 WA Museum survey. Where no PERTH accession numbers are given, the specimens are yet to be curated and databased. Further information can be obtained from the first author. The format of this compendium essentially follows that of earlier catalogues of marine plants for Western Australia (Huisman, 1997; Huisman & Borowitzka, 2003; Goldberg & Kendrick, 2005).

Division Chlorophyta (Green Algae)

Order CHAETOPHORALES

Family CHAETOPHORACEAE

URONEMA Lagerheim, 1887: 518.

Uronema marinum Womersley, 1984: 131.

Type Locality: Coffin Bay, South Australia, epiphytic on *Chaetomorpha linum*. *Illustrations*: Kraft, 2007: Figure 6. *Distribution*: Tropical and temperate regions of the Indo-west Pacific; epiphytic. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie near south tip of reef (NWA Stn 14), epiphytic on *Dictyota* sp., 16 Sept. 2006, *J.M. Huisman* (PERTH). Scott Reef (NWA Site 31), 23 Sept. 2006, epiphytic on *Microdictyon okamurae* Setch. in crevices in shallows, *J.M. Huisman* (on PERTH 07720343). *Remarks*: This is a small filamentous epiphyte that is probably widespread in Australian seas.

Order ULVALES

Family ULVACEAE

ULVA Linnaeus, 1753: 1163.

Ulva flexuosa Wulfen, 1803: 1.

Type Locality: Duino, near Trieste, Italy. *Illustrations*: Kraft, 2007: 39–41, figure 15.

Distribution: Probably cosmopolitan; on sand, rock or epiphytic. *Specimens*: Seringapatam Reef, south east reef flat, (URS Tr. 35), 22 Feb. 2006, *J.M. Huisman* (PERTH 07788932). *Remarks*: This species formed a dense bloom on a sand flat (see Figure 1). Distal branches of the specimens are extremely elongate, unbranched and remain a uniform width throughout their length, remarkably similar to *Ulva ralfsii* (Harvey) Le Jolis. However, that species forms free-floating or entangled masses (Womersley, 1984: 152, as *Enteromorpha ralfsii*; Kraft 2007: 35), unlike the present specimens. Basal branching occurs in the Seringapatam Reef specimens and also the occasional uniseriate filament, features that suggest *Ulva flexuosa* subsp. *paradoxa* (C. Agardh) Kraft (2007). Further studies (including DNA sequence analyses) are desirable, however, to confirm this identification.

Order CLADOPHORALES

Family CLADOPHORACEAE

CLADOPHORA Kützing, 1843: 262.

Cladophora coelothrix Kützing, 1843: 272.

Type Locality: Golfo di Genova, Italy. *Illustrations:* Van den Hoek, 1963: 40–43, plate 5, figures 55–67, plate 6, figures 68–71, plate 7, figures 72–77, plate 8, figure 78; Leliaert & Coppejans, 2003, figure 2. *Distribution*: tropical to warm-temperate seas; intertidal to subtidal. *Specimens*: Seringapatam Reef, (URS Tr. 22, Tr. 32), 22 Feb. 2006, *J.M. Huisman* (GENT). *Remarks*: Molecular data revealed that *C. coelothrix* is placed in the Siphonocladales clade, along with a number of other *Cladophora* species, including *C. socialis*, *C. prolifera*, *C. liebetruthii*, *C. catenata* and *C. sibogae* (Leliaert *et al.*, 2007). *Cladophora coelothrix* is comprised of multiple cryptic species with tropical representatives forming a clade that is unrelated to the European representatives.

Cladophora socialis Kützing, 1849: 416.

Type locality: Tahiti. *Illustrations*: Van den Hoek, 1963: 43, 46–47, plate 8, figures 79–85, plate 9, figures 86–91; 1982: 52–57, figures 30–40); Leliaert & Coppejans, 2003, figure 3. *Distribution*: tropical to warm-temperate regions of the Atlantic and Indo-Pacific Oceans; intertidal. *Specimen*: Scott Reef, (URS Tr. 28), mixed with *Cladophoropsis sundanensis*, 21 Feb. 2006, *J.M.Huisman* (GENT). *Remarks*: *Cladophora socialis* closely resembles *C. coelothrix* from which it mainly differs by its smaller cell diameter. Molecular data showed that *C. socialis* is nested within the tropical *C. coelothrix* clade (Leliaert *et al.*, 2007).

Cladophora herpestica (Montagne) Kützing 1849: 415.

Conferva herpestica Montagne, 1842: 15. *Type Locality*: Bay of Islands, New Zealand. *Illustrations*: Huisman, 2000: 239 (as *Cladophoropsis herpestica*). Kraft 2007: Figure 36. *Distribution*: Houtman Abrolhos, Western Australia, to Queensland; Indo-Pacific; Japan; New Zealand. *Specimens*: Imperieuse Reef, Rowley Shoals, outer east side, 4 Dec. 2007, *J.M. Huisman* (PERTH 07729340). Meramid Reef, Rowley Shoals, outer slope east side, (NWA Stn 5), 13 Sept. 2006, *J.M. Huisman* (PERTH 07626584). *Remarks*: Most records of this species are as *Cladophoropsis herpestica* (Montagne) Howe (e.g. Womersley, 1984; Huisman, 2000), but Leliaert & Coppejans (2006) showed that the taxon aligned more closely with *Cladophora* (see also Kraft, 2007).

Order SIPHONOCLADALES

Family ANADYOMENACEAE

ANADYOMENE Lamouroux, 1812: 187.

Anadyomene plicata C. Agardh, 1823: 400–401.

Type Locality: 'Ravak' [Rauki], Waigeo Island, Moluccas, Indonesia. *Illustrations*: Huisman, 2000: 232 (as *A. brownii*). *Distribution*: Known from northern Australia south to the Houtman Abrolhos on the west coast. Indonesia. Solomon Islands. Philippines; epilithic in the intertidal and shallow subtidal. *Specimens*: Mermaid Reef, Rowley Shoals, outside slope middle east side, 13 Sept. 2006, *J.M. Huisman* (PERTH 07626576). Scott Reef, channel (NWA Stn 40) 25 Sept. 2006, *J.M. Huisman* (PERTH 07719183). *Remarks*: This species has previously been reported from north-western Australia as *A. brownii*, but there seems little to distinguish that species from the earlier-named *A. plicata*.

Anadyomene wrightii Harvey ex J.E.Gray, 1866: 48–49, plate 44: Figure 5.

Type Locality: Ryukyuretto, Japan [Loochoo Islands]. *Illustrations*: Abbott *et al.*, 2002. *Distribution*: Widespread in tropical waters of the Indian and Pacific Oceans. *Specimens*: Mermaid Reef, Rowley Shoals (NWA Stn 14) 16 Sept. 2006, *J.M. Huisman* (PERTH 078165510). *Remarks*: This species is similar in appearance to *A. plicata*, but differs in the axial cells becoming subdivided and remaining uncorticated. This is a new record for Western Australia and Australia.

MICRODICTYON Decaisne, 1841: 115

Microdictyon okamurae Setchell, 1925: 107.

Type Locality: Ryukyu Island, Japan. *Illustrations*: Setchell, 1929: Figures 76–84. *Distribution*: Warmer waters of the Indo-Pacific. *Specimens*: Scott Reef

(NWA Site 31), 23 Sept. 2006, in crevices in shallows, *J.M. Huisman* (PERTH 07720343). *Remarks*: This represents a new record for Western Australia.

PHYLLODICTYON J.E.Gray, 1866: 69

Phyllodictyon orientale (A.Gepp & E.Gepp) Kraft & Wynne, 1996: 139–140.

Struvea orientalis A.Gepp & E.Gepp, 1908: 167–168, plate 22: Figures 6–9; 1909: 377–378, plate 47: Figures 6–9. *Type Locality:* SW of Poivre Atoll, Amirante Isles, Seychelles. *Illustrations:* Kraft & Wynne, 1996: Figures 22–45. Leliaert & Coppejans, 2007: Figures 22–45. *Distribution*: *P. orientale* is only known from some scattered localities in the Indo-Pacific, generally growing in deep subtidal biotopes (Leliaert & Coppejans, 2007)**.** *Specimens*: Mermaid Reef, Rowley Shoals, in channel at 21 m depth (NWA Stn 13), 16 Sept. 2006, *J.M. Huisman* (PERTH 07788894). Scott Reef, (NWA Stn 38), 25 Sept. 2006, *J.M. Huisman* (GENT 17 / F624). *Remarks*: Specimens from the Rowley Shoals and Scott Reef collected during the present surveys were included in molecular analyses by Leliaert *et al.*, (2008) and were identical to specimens from near the Seychelles type locality. This represents a new record for Western Australia.

Family SIPHONOCLADACEAE

BOODLEA G.Murray & De Toni, 1889: 245.

Boodlea composita (Harvey) Brand, 1904: 187.

Conferva composita Harvey, 1834: 157. *Type Locality:* Cap Malheureux, N-coast of Mauritius. *Illustrations:* Oliveira *et al*., 2005: 199. Huisman, 2000: 238. Kraft, 2000: Figure 24A-C. Huisman *et al.,* 2007: 172. *Distribution*: Widespread in tropical and warmer seas. *Specimens*: Clerke Reef, Rowley Shoals, lagoon, 11 Dec. 2007, *J.M. Huisman* (PERTH 07729235).

Boodlea vanbosseae Reinbold, 1905: 148.

Type Locality: Lucipara Island, Indonesia. *Illustrations*: Leliaert *et al.*, 2007: Figures 1–23 (Figure 14 is from Scott Reef). *Distribution*: Known from several locations in the tropical waters of the Indian and West Pacific Oceans (see Leliaert *et al.,* 2007); in Australia from northern WA and south-eastern Queensland (Cribb, 1960). *Specimens*: Mermaid Reef, Rowley Shoals, NE corner of reef, 13 Sept. 2006, *J.M. Huisman* (PERTH 07626525). *Remarks: B. vanbosseae* is common at Scott Reef and Seringapatam Reef, where it forms low, dense mats on hard substrata. The analyses of Leliaert *et al.,* (2007, including NW Australian material) clearly indicate that the species is not a member of *Boodlea*, and instead aligned closely with *Cladophora catenata* in the *Anadyomene* clade. Leliaert *et al.,* (2007) did not make any taxonomic changes pending further revision.

BOERGESENIA Feldmann, 1938: 1504.

Boergesenia forbesii (Harvey) Feldmann, 1938: 1503.

Valonia forbesii Harvey, 1860: 333. *Type Locality:* Ryukyu-retto, Japan; Sri Lanka. *Illustrations:* Huisman, 2000: 237; Oliveira *et al.,* 2005: 198. *Distribution:* Widespread in the tropical Indo-West Pacific; in Australia recorded from the central and northern Great Barrier Reef and tropical Western Australia from Ningaloo Reef northward; epilithic in the intertidal/shallow subtidal, often in clusters at the edges of shallow pools. *Specimens:* Scott Reef (URS Tr. 2), intertidal, 16 Feb. 06, *J.M. Huisman* (PERTH 07816383). *Remarks*: This species occupies a very restricted habitat, occurring only in the intertidal on the edges of rock pools or at the rock/ sand interface.

DICTYOSPHAERIA Decaisne ex Endlicher, 1843: 18.

Dictyosphaeria cavernosa (Forssk.) Børgesen, 1932: 2.

Ulva cavernosa Forssk., 1775: 187. *Type Locality:* "Gomfodae" (Al-Qunfidha), Saudi Arabia; Mokha, Yemen. *Illustrations:* Huisman, 2000: 240. Huisman *et al.,* 2007: 173. *Distribution*: Widely distributed in tropical and subtropical seas. Epilithic in the intertidal and shallow subtidal, often in small clusters. *Specimens*: Scott Reef (South), east side (URS Tr. 17), 19 Feb. 2006, *J.M. Huisman* (PERTH 07788924). Seringapatam Reef, intertidal, eastern side south of channel (URS Tr. 32), 22 Feb. 2006, *J.M. Huisman* (PERTH).

Dictyosphaeria versluysii Weber-van Bosse, 1905: 144.

Type Locality: Indonesia. *Illustrations:* Huisman *et al.,* 2007: 173. *Distribution*: Widely distributed in tropical and subtropical seas. *Specimens:* Imperieuse Reef, Rowley Shoals, east side, in shallows, 5 Dec. 2007, *J.M. Huisman* (PERTH). *Remarks:* Differs from *D. cavernosa* in its solid rather than hollow habit. Plants also tend to be a gray-green colour, whereas *D. cavernosa* is typically dark green.

CLADOPHOROPSIS Børgesen, 1905: 288.

Cladophoropsis sundanensis Reinbold, 1905: 147.

Lectotype locality: Kangean, Indonesia. *Illustrations*: Leliaert & Coppejans, 2006: Figures 40–46. *Distribution*: Indo-Pacific and Mediterranean Sea (also been reported from the Atlantic Ocean); high intertidal to shallow subtidal. *Specimen*: Scott Reef, 21 Feb. 2006 (URS Tr. 28) (mixed with *Cladophora socialis*), *J.M. Huisman* (GENT). *Remarks*: *Cladophoropsis sundanensis* can be distinguished from *C. membranacea* by its narrower filaments.

Family VALONIACEAE

***VALONIA* C. Agardh, 1823: 428.**

Valonia fastigiata Harvey ex J. Agardh, 1887: 101.

Type Localities: Sri Lanka; Tonga. *Illustrations*: Littler & Littler, 2003: 206–207.

Specimens: Scott Reef (South), north east outer slope (NWA Stn 30), 22 Sept. 2007, *J.M. Huisman* (PERTH 07720246). Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH 07719191).

Remarks: This species forms hummocks of tightly packed, vesiculate branches.

Valonia ventricosa J.Agardh, 1887: 96.

Type Locality: Guadeloupe, West Indies. Illustrations: Huisman, 2000: 243 (as *Ventricaria ventricosa*). *Distribution*: Widely distributed in tropical and subtropical seas. Epilithic in the shallow subtidal. *Specimens*: Imperieuse Reef, Rowley Shoals, 2 Dec. 2007, *J.M. Huisman* (PERTH 07789327). *Remarks*: Previously reported as *Ventricaria ventricosa* (J.Agardh) Olsen & J.West, but this species, originally segregated from *Valonia*, has been returned to that genus based on the molecular analyses of Leliaert *et al.,* (2003) (a move first made by Kraft, 2007). *Valonia ventricosa* is known by the common name 'sailor's eyeballs' and can be very common and conspicuous on reef substrata, particularly in higher energy zones.

Order BRYOPSIDALES

Family CHAETOSIPHONACEAE

***BLASTOPHYSA* Reinke, 1889: 87.**

Blastophysa rhizopus Reinke, 1889: 87.

Type Locality: Kieler Förde, Germany (Baltic Sea). *Illustrations*: Kraft, 2000: 587, figure 30A-D. Huisman *et al.,* 2007: 184. *Distribution*: Widespread in temperate and tropical seas; endophytic in various soft-bodied algae. *Specimens*: Scott Reef (South), entrance to false lagoon (NWA Stn 25), endophytic in *Ganonema farinosum*, 21 Sept. 2006, *J.M. Huisman* (PERTH 07816650).

Family BRYOPSIDACEAE

***BRYOPSIS* Lamouroux, 1809: 333.**

Bryopsis indica A.Gepp & E.Gepp, 1908: 169–170, plate 22, figures 10, 11.

Type Locality: Chagos Archipelago, Seychelles, Mauritius, Sri Lanka. *Illustrations*: Kraft, 2007: Figure 102. *Distribution*: Known from various locations in the tropical Indo-Pacific. *Specimens*: Clerke Reef, Rowley Shoals, from 5 m depth, 9 Dec. 2007, *J.M. Huisman* (PERTH). *Remarks*: The local specimens are identical to those described by Kraft (2007) from eastern Australia. This represents a new record for Western Australia.

Family CAULERPACEAE

***CAULERPA* Lamouroux, 1809: 332**

Caulerpa cupressoides (Vahl) C.Agardh, 1817: XXIII.

Fucus cupressoides Vahl, 1802: 38. *Type Locality:* St. Croix, Virgin Is. *Illustrations:* Huisman, 2000: 250. *Distribution:* Widely distributed in tropical seas. Occurs in the shallow subtidal, associated with sandy/silty substrata.

Specimens: Scott Reef (South), near Guano wreck, intertidal, 16 Feb. 2006, *J.M. Huisman* (PERTH 07720297). Scott Reef (South), southeast side (URS Tr. 12), 18 Feb. 2006, *J.M. Huisman* (PERTH 07788940).

Caulerpa lentillifera J. Agardh, 1837: 2.

Type Locality: Ethiopia. *Illustrations:* Huisman, 2000: 253. Kraft, 2007: plate 6C, figures 68A-C. *Distribution:* Widespread in the tropical Indo-Pacific. Occurs in the shallow subtidal, associated with sandy substrata. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon, 4 Dec. 2007, *J.M. Huisman* (PERTH 07729278).

Caulerpa serrulata (Forsskål) J. Agardh, 1837: 174.

Fucus serrulatus Forsskål, 1775: 189. *Type Locality:* Mokha, Yemen. *Illustrations:* Huisman, 2000: 257; Huisman *et al.,* 2007: 182. *Distribution:* Widely distributed in tropical seas. Epilithic in the intertidal and subtidal. *Specimens:* Imperieuse Reef, Rowley Shoals, 2 Dec. 2007, *J.M. Huisman* (PERTH 07729316). Mermaid Reef, Rowley Shoals, lagoon near channel, 14 Dec. 2007, *J.M. Huisman* (PERTH 07789394). Scott Reef (South), near Guano wreck, intertidal, 16 Feb. 2006, *J.M. Huisman* (PERTH 07720505). Seringapatam Reef, Sth side outer slope at 20 m depth, (NWA Stn 41) 26 Sept. 2006, *J.M. Huisman* (PERTH 07720351).

***Caulerpa taxifolia* (Vahl) C.Agardh, 1817: XXII.**

Fucus taxifolius Vahl, 1802: 36. *Type Locality:* St. Croix, Virgin Is. *Illustrations:* Huisman, 2000: 258–259. Huisman *et al.,* 2007: 183. *Distribution:* Widely distributed in tropical seas. Epilithic on rock or sand. *Specimens*: Mermaid Reef, Rowley Shoals (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788835). Seringapatam Reef, at lagoon edge/ platform interface at 10 m depth (NWA Stn 42), 26 Sept. 2006, *J.M. Huisman* (PERTH 07725256)

Caulerpa verticillata J. Agardh, 1847: 6.

Type Locality: Not specified. *Illustrations:* Taylor, 1960: 138–139, plate 10, figures 1, 2. *Distribution:*

Widely distributed in warmer waters of the Indian and Pacific Oceans and Caribbean; epilithic on sand-covered rock in the shallow subtidal. *Specimens:* Seringapatam Reef, at lagoon edge/ platform interface at 10 m depth (NWA Stn 42), 26 Sept. 2006, *J.M. Huisman* (PERTH 07725205).

Caulerpa webbiana Montagne, 1837: 354.

Type Locality: Arrecife, Isla Lanzarote, Islas Canarias [Canary Is.]. *Illustrations*: Huisman, 2000: 259. Huisman *et al.,* 2007: 183. *Distribution*: Widespread in tropical and warmer seas; grows on rock or sand. *Specimens*: Mermaid Reef, Rowley Shoals, in shallows on inner side of western reef (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788827).

Family CODIACEAE

CODIUM Stackhouse, 1797: Xvi, xxiv.

Codium arabicum Kützing, 1856: 35, plate 100, figure 2.

Type Locality: Tor, Sinai Peninsula, Gulf of Suez. *Illustrations*: Jones & Kraft, 1984: 255–258, figures 1–2. Van den Heede & Coppejans, 1996: 391–392, figures 1, 5, 7. *Distribution*: Indo-Pacific Tropics. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie on west side at 10 m depth (NWA Stn 7), 14 Sept. 2006, *J.M. Huisman* (PERTH 07718772).

Codium dwarkense Børgesen, 1947: 6–8, figures 3–5.

Type Locality: Dwarka and Port Okha, Gujarat, India. *Illustrations*: Van den Heede & Coppejans, 1996: 397–398, figures 4, 6, 14. *Distribution*: Known from India, east Africa, and northwestern Australia; epilithic in the intertidal. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie on west side at 10 m depth (NWA Stn 8), 14 Sept. 2006, *J.M. Huisman* (PERTH).

Family HALIMEDACEAE

HALIMEDA Lamouroux, 1812: 186.

Halimeda cylindracea Decaisne, 1842: 103.

Type Locality: Nosy-Bé, Madagascar. *Illustrations*: Huisman, 2000: 264. Hillis-Colinvaux, 1980: Figures 4, 5, 104. *Distribution*: Warmer waters of the Indo-Pacific; typically grows in unconsolidated substrata. *Specimens*: Scott Reef (North) (URS Tr. 23), 20 Feb 2006, *J.M. Huisman* (PERTH).

Halimeda distorta (Yamada) Hillis-Colinvaux, 1968: 33.

Halimeda incrassata f. *distorta* Yamada, 1941: 119, figure 14. *Type Locality*: Atoll of Ant, Ponape, East Caroline Islands, Micronesia. *Illustrations*: Yamada, 1944: 28, plate 4. Hillis-Colinvaux, 1980: Figure 34. *Specimens*: South Scott Reef, on wellhead in deep lagoon, 19 June 2007, *B.Wilson & URS* (PERTH 07816715). *Remarks*: Video footage indicates that Halimeda distorta can occur in dense beds at Scott Reef. Similarly dense *Halimeda* banks were reported for the Big Bank Shoals in the Timor Sea (Smith *et al.,* http://www.aims.gov.au/pages/reflib/bigbank/pages/bb-08.html). While the species was not identified, the images suggest it is likely to be *H. distorta*. Coverages of up to 35% were reported and the *Halimeda* was regarded as one of the dominant carbonate structures.

Halimeda macroloba Decaisne, 1841: 118. (Figure 10)

Type Locality: Red Sea. *Illustrations*: Hillis-Colinvaux, 1980: Figure 28. *Distribution*: Common in the Indian and west Pacific Oceans, generally growing in unconsolidated substrata. *Specimens*: Mermaid Reef, Rowley Shoals, Sth end lagoon, 14 Sept. 2006, *J.M. Huisman* (PERTH 07643934). Scott Reef, on sandy lagoon floor at 2 m depth, *J.M.Huisman* (PERTH). *Remarks*: This species is distinctive amongst the sand-inhabiting *Halimeda* in producing flat segments.

Halimeda macrophysa Askenasy, 1888: 14, plate 4, figures 1–4. (Figure 11)

Type Locality: Matuku, Fiji Islands. *Illustrations*: Hillis-Colinvaux, 1980: 134, figures 40; Kraft, 2007: Plate 8C; figures 74F-K. *Distribution*: Widespread in the Indo-West Pacific; in Western Australia known only from the Rowley Shoals. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon east side at 10.5 m depth (NWA Stn 1), 12 Sept. 2006, *J.M.Huisman* (PERTH 07719051). Mermaid Reef, lagoon, 14 Dec. 2007, *J.M. Huisman* (PERTH 07729251). *Remarks*: This distinctive species was found only on a couple of occasions, forming loose clusters attached to reef outcrops in lagoonal sites.

Halimeda minima (W.R.Taylor) Colinvaux, 1968: 32. (Figure 4)

Halimeda opuntia f. *minima* Taylor, 1950: 82–83, 206. *Type Locality:* Bikini Lagoon, Bikini Atoll, Marshall Islands. *Distribution*: Widespread in the Indo-West Pacific. *Specimens*: Mermaid Reef, Rowley Shoals, west side at 8 m depth, 13 Dec. 2007, *J.M. Huisman* (PERTH). *Remarks*: This species is variable in gross morphology, with some specimens having reniform segments and others distinctly trilobed. They are united by their internal structure and dimensions of the peripheral utricles in surface view (10–25 µm diameter).

Halimeda opuntia (Linnaeus) Lamouroux, 1816: 308.

Corallina opuntia L., 1758: 805. *Type Locality:*

Jamaica. *Illustrations*: L.Hillis-Colinvaux, 1980: 41, figure 19. *Distribution*: Common in the tropics worldwide; forms imbricating patches between coral. Local specimens were often collected from shallow reef flats. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon east side at 10.5 m depth (NWA Stn 1), 12 Sept. 2006, *J.M.Huisman* (PERTH 07719094). Scott Reef (South), intertidal, near Guano wreck, 16 Feb. 2006, *J.M. Huisman* (PERTH 07720491).

Family UDOTEACEAE

AVRAINVILLEA Decaisne, 1842: 108.

Avrainvillea amadelpha (Montagne) A.Gepp & E.Gepp, 1908: 178.

Udotea amadelpha Montagne, 1857: 136. *Type Locality:* Galega I., Indian Ocean. *Illustrations:* Olsen-Stojkovich, 1985: 37, figure 19. *Distribution*: Widespread in the tropical waters of the Indo-Pacific. *Specimens:* Scott Reef, (NWA Stn 34), 24 Sept. 2006, *J.M.Huisman* (PERTH 07789211). *Remarks*: This species in regarded as an introduced pest in the Hawaiian Islands (Huisman *et al.,* 2007).

RHIPIDOSIPHON Montagne, 1842: 14.

Rhipidosiphon javensis Montagne, 1842: 14.

Type Locality: Leiden Island [Nyamuk-besar], near Jakarta, Java, Indonesia. *Illustrations*: Huisman *et al.*, 2007: 191. *Distribution:* Tropical waters of the eastern Indian Ocean and western and central Pacific. *Specimens*: Seringapatam Reef, at lagoon edge/ platform interface at 10 m depth (NWA Stn 42), 26 Sept. 2006, *J.M.Huisman* (PERTH 07725078).

RHIPILIA Kützing, 1858: 12

Rhipilia crassa Millar & Kraft, 2001: 32.

Type Locality: Heron Is., Capricorn Group, southern Great Barrier Reef, Qld. *Illustrations*: Millar & Kraft, 2001: Figures 37–40, 53–58. *Distribution*: Known from the southern Great Barrier Reef, the Philippines, and Scott Reef. *Specimens*: Scott Reef (South), south side outer edge (NWA Stn 17), 18 Sept. 2006, *J.M. Huisman* (PERTH). Seringapatam Reef, inner lagoon reef (NWA Stn 43), 26 Sept. 2006, *J.M. Huisman* (PERTH 07816502). *Remarks: R. crassa* is closely related to *R. nigrescens*, which is also recorded from Scott Reef in similar habitats. This might suggest that the two entities are conspecific. Siphons of *R. crassa*, however, are much larger than those found in *R. nigrescens*. Moreover, specimens of both species were included in DNA phylogenetic analyses, the results of which clearly indicated that two taxa are present (Verbruggen, pers. comm. 2007).

Rhipilia nigrescens Coppejans & Prud'homme van Reine, 1990: 261. (Figure 3)

Type Locality: Tukang Besi Is., W coast of Binongko, Indonesia. *Illustrations*: Coppejans & Prud'homme van Reine, 1989: 128, plate 5. *Distribution*: Indonesia; Papua New Guinea; Scott Reef. *Specimens*: Scott Reef (South), south side outer edge (NWA Stn 17), 18 Sept. 2006, *J.M. Huisman* (PERTH). *Remarks*: Both this species and *Rhipilia crassa* represent new records for Western Australia, the former also a new record for Australia.

RHIPILIOPSIS A.Gepp & E.Gepp, 1911: 45.

Rhipiliopsis echinocaulos (Cribb) Farghaly, *in* Kraft, 1986: 54.

Geppella echinocaulos Cribb, 1960: 6. *Type Locality:* Caloundra, near Brisbane, Queensland, Australia. *Illustrations:* Kraft, 1986: Figures 12–16. Kraft, 2007: Plate 10C, figure 87. *Distribution:* Known from tropical Australia and southern Japan, possibly also China; epilithic in the subtidal. *Specimens:* Scott Reef (NWA Stn 25), 21 Sept. 2006, *J.M. Huisman* (PERTH 07816464). *Remarks*: *Rhipiliopsis echinocaulos* is known from only a single collection of several plants, but it is probably widespread in the region. Plants grow to only a few millimetres in height and are easily missed in the field.

UDOTEA Lamouroux, 1812: 186.

Udotea glaucescens Harvey ex J.Agardh, 1887: 70. (Figure 14)

Type Locality: Tonga, on shaded rocks in lagoon. *Illustrations:* Gepp & Gepp, 1911: figures 3, 5, 7, 8, 43. Coppejans & Prud'homme van Reine, 1989: plate 10, figures 1, 2. *Distribution*: Tropical Indo-Pacific; generally in sand. *Specimens*: Imperieuse Reef, Rowley Shoals, 2 Dec. 2007, *J.M. Huisman* (PERTH 07789335). Clerke Reef, Rowley Shoals, lagoon, 11 Dec. 2007, *J.M. Huisman* (PERTH 07729219). Mermaid Reef, Rowley Shoals, south end of inner lagoon at 11.9 m depth (NWA Stn 14), 16 Sept. 2006, *J.M. Huisman* (PERTH 07725094). *Remarks*: *Udotea glaucescens* is generally easily recognized due to its blades being borne in clusters and with filaments visible from the surface. The individual filaments often disassociate and result in the thallus having a frayed appearance. Living specimens are a green colour, but when dried they become grey-green, as suggested by the specific epithet.

Order DASYCLADALES

NEOMERIS Lamouroux, 1816: 241.

Neomeris bilimbata Koster, 1937: 221, plate 15, figures 1, 4, 5.

Type Locality: Itu Aba Island, Tizard Bank, South China Sea. *Illustrations*: Kraft 2007: Figure 108.

McCarthy & Orchard, 2007: Plate 36. *Distribution*: Recorded from numerous locations in the tropical Indo-Pacific. In Australia from Lord Howe Island (Kraft, 2007). Epilithic. *Specimens*: Scott Reef, intertidal (URS Tr. 2), 16 Feb. 2006, *J.M. Huisman* (PERTH). Clerke Reef, Rowley Shoals, from 5 m depth, 9 Dec. 2007, *J.M. Huisman* (PERTH 07789351). *Remarks*: These specimens are identical to those described by Kraft (2007) from Lord Howe Island, including producing distinctively stalked gametophores and deltoid secondary laterals. This represents a new record for Western Australia.

Heterokontophyta: Phaeophyceae

(Brown Algae)

Order DICTYOTALES

Family DICTYOTACEAE

DICTYOPTERIS Lamouroux, 1809: 332.

Dictyopteris repens (Okamura) Børgesen, 1924: 265, figure 13.

Haliseris repens Okamura, 1916: 8. *Type Locality*: Truk Islands, Caroline Islands. *Illustrations*: Allender & Kraft, 1983: Figures 19A, B. Phillips, 2000: Figures 10g-h. *Distribution*: Widespread in tropical and subtropical seas. *Specimens*: Clerke Reef, west side. 8 Dec. 2007, *J.M. Huisman* (PERTH 07789424). NWA Stn 5, *J.M. Huisman* (PERTH). Scott Reef, lagoon bommie (NWA Stn 39), 25 Sept. 2006, *J.M. Huisman* (PERTH). *Remarks*: *D. repens* is closely related to *D. delicatula*, differing in the absence of a thickened marginal rib. This represents a new record for Western Australia.

DICTYOTA Lamouroux, 1809a: 38.

Dictyota friabilis Setchell, 1926: 12: 91–92, plate 13, figures 4–7; plate 20, figure 1.

Type Locality: Tafaa Point, Tahiti. *Illustrations*: De Clerck, 2003: pls 22, 23. *Distribution*: Warmer waters of the Indo-Pacific; forms mats on hard substrate of the outer reef slope. *Specimens*: Clerke Reef, Rowley Shoals, lagoon, 7 Dec. 2007, *J.M. Huisman* (PERTH 07729111). Scott Reef (South), entrance to false lagoon (NWA Stn 25), 21 Sept. 2006, *J.M. Huisman* (PERTH 07725507).

LOBOPHORA J. Agardh, 1894: 21

Lobophora variegata (Lamouroux) Womersley ex Oliviera, 1977: 217. (Figure 12)

Dictyota variegata Lamouroux, 1809a: 40. *Type Locality:* Antilles. *Illustrations:* Huisman, 2000: 193. *Distribution:* Known from tropical to warm temperate coasts in most seas. Generally epilithic in the subtidal. *Specimens*: Imperieuse Reef, Rowley Shoals, lagoon, 4 Dec. 2007, *J.M. Huisman* (PERTH 07789270). Mermaid Reef, Rowley Shoals, inner lagoon, east side at 10.5 m depth (NWA Stn 1), 12 Sept. 2006, *J.M. Huisman* (PERTH 07719086). *Remarks*: *Lobophora variegata* is extremely common at the atolls, often forming dense imbricating mats on *Acropora* in lagoon habitats. On reef flats the crustose form of this species occurs.

PADINA Adanson, 1763: 13, 586.

Padina boryana Thivy in Taylor, 1966: 355, figure 2.

Type locality: 'Friendly Islands' = Tonga, Polynesia. *Illustrations*: Allender & Kraft, 1983: Figures 5D, E. *Distribution*: Widespread in the Indo-Pacific and eastern Atlantic. Epilithic or epiphytic. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH). Scott Reef (South), Intertidal. Reef flat near Guano wreck (URS Tr. 2), 16 Feb. 2006, *J.M. Huisman* (PERTH 07720262). Scott Reef (North), lagoon, 23 Sept. 2006, J.M. Huisman (PERTH 07720041)

STYPOPODIUM Kützing, 1843: 341

Stypopodium flabelliforme Weber-van Bosse, 1913: 176.

Type Locality: Rotti Island, Indonesia, and Pearl Bank, Tawitawi Province, Sulu Archipelago. *Illustrations*: Huisman, 2000: 198. Huisman *et al.*, 2006: 29. *Distribution:* Widespread in the warmer waters of the Indo-Pacific. In Australia from Busselton, W.A., around northern Australia to Lord Howe Island and Jervis Bay, N.S.W.; epilithic in the subtidal. *Specimens*: Clerke Reef, Rowley Shoals, lagoon, 7 Dec. 2007, *J.M. Huisman* (PERTH 07729138). Mermaid Reef, Rowley Shoals, inner lagoon east side at 10.5 m depth (NWA Stn 1), 12 Sept. 2006, *J.M. Huisman* (PERTH 07719043). Imperieuse Reef, Rowley Shoals, 6 Dec. 2007, *J.M.Huisman* (PERTH 07729359).

Order SPHACELARIALES

Family SPHACELARIACEAE

SPHACELARIA Lyngbye, 1819: 103.

Sphacelaria tribuloides Meneghini, 1840: 2.

Type Locality: Gulf of Spezia, northern Italy. *Distribution*: Widespread in tropical and temperate seas. *Illustrations*: Womersley 1987: 160, figures 45G, 52A-C. *Specimens*: Scott Reef (South), reef flat (URS Tr. 12), 18 Feb. 2006, *J.M. Huisman* (PERTH 07724632).

Order SCYTOSIPHONALES

Family SCYTOSIPHONACEAE

HYDROCLATHRUS Bory, 1825: 419

Hydroclathrus clathratus (C. Agardh) Howe, 1920: 590

Encoelium clathratum C. Agardh, 1822: 412. *Type Locality:* Uncertain. *Illustrations:* Womersley, 1987: 300, figures 109A, 110A, B. Huisman, 2000: 204. *Distribution*: Widely distributed in tropical to warm temperate seas. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef in shallows (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH).

ROSENVINGEA Børgesen, 1914*:* 22 (178)

Rosenvingea intricata (J. Agardh) Børgesen, 1914: 26.

Asperococcus intricatus J. Agardh, 1847: 7. *Type Locality:* Veracruz, Mexico. *Illustrations*: Oliveira *et al.,* 2005: 173. *Distribution*: Widespread in warmer seas. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef in shallows (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788843).

Order FUCALES

Family SARGASSACEAE

TURBINARIA Lamouroux, 1825: 71.

Turbinaria ornata (Turner) J.Agardh, 1848: 266. (Figure 1)

Fucus turbinatus L. var. *ornata* Turner, 1807–1808: 50–53, plate 24: Figures c, d. *Type Locality:* Not known. *Illustrations*: Huisman, 2000: 226. *Distribution*: Widespread in tropical seas. In Western Australia, from the tropics south to Coral Bay; generally on reef flats. *Specimens*: Mermaid reef, Rowley Shoals, intertidal on north-east corner, 13 Sept. 2006, *J.M Huisman* (PERTH 07626312). Scott Reef (South) east side (URS Tr. 17), 19 Feb. 2006, *J.M. Huisman* (PERTH 07788916).

Rhodophyceae (Red Algae)

Order NEMALIALES

Family GALAXAURACEAE

ACTINOTRICHIA Decaisne, 1842: 118.

Actinotrichia fragilis (Forsskål) Børgesen, 1932: 6, plate 1, figure 4

Fucus fragilis Forsskål, 1775: 190. *Type Locality:* Mokha, Yemen. *Illustrations*: Huisman, 2000: 37. Huisman, 2006: Figures 3A, 4A, plate 4. *Distribution*: Widespread in tropical seas; epilithic. *Specimens*: Clerke Reef, Rowley Shoals, lagoon near channel, 10 Dec. 2007, *J.M. Huisman* (PERTH 07789386). Mermaid Reef, Rowley Shoals, lagoon entrance channel (NWA Stn 13), 16 Sept. 2006, *J.M. Huisman* (PERTH 07718764). Seringapatam Reef, inner lagoon reef (NWA Stn 43), 26 Sept. 2006, *J.M. Huisman* (PERTH 07720335).

DICHOTOMARIA Lamarck, 1816: 143.

Dichotomaria marginata (Ellis & Solander) Lamarck, 1816: 146. (Figure 5)

Corallina marginata Ellis & Solander, 1786: 115, plate 22, figure 6. *Type Locality:* Bahama Islands, West Indies. *Illustrations*: (as *Galaxaura marginata*) Huisman & Borowitzka, 1990: 157–161, figures 14–27. Huisman, 2000: 38. *Distribution*: Widely distributed in warmer seas. Epilithic in the subtidal. *Specimens*: Mermaid Reef, Rowley Shoals, Sth end of inner lagoon at 11.9 m depth, 16 Sept. 2006, *J.M. Huisman* (PERTH 07725124). *Remarks*: More widely known as *Galaxaura marginata* (Ellis & Solander) Lamouroux, this species was recently restored to a resurrected *Dichotomaria* Lamarck by Huisman *et al.,* (2004) following DNA sequence analyses.

GALAXAURA Lamouroux, 1812: 185.

Galaxaura rugosa (Ellis & Solander) Lamouroux, 1816: 236.

Corallina rugosa Ellis & Solander, 1786: 115, plate 22, figure 3. *Type Locality:* Jamaica. *Illustrations*: Huisman & Borowitzka, 1990: 153–157, figures 1–13. Huisman, 2000: 39. *Distribution*: Widely distributed in warmer seas. Epilithic in the subtidal and lower intertidal. *Specimens*: Scott Reef (South), on reef flat (URS Tr. 12), 18 Feb. 2006, *J.M. Huisman* (PERTH 07788800). Scott Reef (North), intertidal (NWA Stn 33), 23 Sept. 2006, *J.M. Huisman* (PERTH 07720033). *Remarks*: In addition to typical *G. rugosa*, specimens referable to *Galaxaura filamentosa* were collected from some high energy sites. Australian records of the latter were regarded as representing *G. rugosa* by Huisman & Borowitzka (1990) and the Rowley Shoals specimens will be subjected to DNA sequence analyses to confirm this opinion.

TRICLEOCARPA Huisman & Borowitzka,, 1990: 164.

Tricleocarpa cylindrica (Ellis & Solander) Huisman & Borowitzka, 1990: 164.

Corallina cylindrica Ellis & Solander, 1786: 114, plate 22, figure 4. *Type Locality:* West Indies. *Illustrations*: Huisman & Borowitzka, 1990: Figures 40–45, 50–52. Huisman, 2000: 41. *Distribution*: Widespread in tropical seas. *Specimens*: Scott Reef (NWA Stn 30), 22 Sept. 2006, *J.M. Huisman* (PERTH 07720203).

Family LIAGORACEAE

GANONEMA Fan & Wang, 1974: 492.

Ganonema pinnatum (Harvey) Huisman, 2002: 828.

Liagora pinnata Harvey, 1853: 138. *Type Locality:* Sand Key, Florida, U.S.A. *Illustrations:* Huisman, 2002: Figures 125, 126, 128–130. *Distribution*: Widespread in tropical seas. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef in shallows (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788851). Mermaid Reef, Rowley Shoals, south outer, 14 Dec. 2007, *J.M. Huisman* (PERTH 07789408; PERTH 07789416). Scott Reef (South), west side of sandy islet (NWA Stn 24), 20 Sept. 2006, *J.M. Huisman* (PERTH 07720513).

Ganonema farinosum (Lamouroux) Fan & Wang 1974: 492.

Liagora farinosa Lamouroux, 1816: 240. *Type Locality:* Red Sea, near Suez. *Illustrations:* Huisman, 2000: 30. Huisman, 2002: Figures 118–123. *Distribution*: *Specimens*: Scott Reef, lagoon bommie, (NWA Stn 25), 21 Sept. 2006, *J.M. Huisman* (PERTH 07788789).

LIAGORA Lamouroux, 1812: 185.

Liagora ceranoides Lamouroux 1816: 239.

Type Locality: St Thomas, Virgin Islands. *Illustrations*: Huisman, 2006: Figures 1F, 25A-D, plate 15. *Distribution*: Widespread in tropical and warmer seas. Generally epilithic in the subtidal, often with the base covered with sand. *Specimens*: Scott Reef (South) west side of sandy islet (NWA Stn 24), 20 Sept. 2006, *J.M. Huisman* (PERTH 07720238).

TITANOPHYCUS Huisman, Saunders & Sherwood, 2006b: 119.

Titanophycus validus (Harvey) Huisman, Saunders & Sherwood, 2006b: 119.

Liagora valida Harvey, 1853: 138. *Type Locality*: Sand Key, Florida, U.S.A. *Illustrations*: Huisman *et al.*, 2006a: Figures 2B, 34, plate 17. *Specimens*: Scott Reef, intertidal reef adjacent to channel, (NWA Stn 33), 23 Sept. 2006, *J.M. Huisman* (PERTH 07816499).

Order CORALLINALES

Family CORALLINACEAE

AMPHIROA Lamouroux, 1812: 186.

Amphiroa fragilissima (Linnaeus) Lamouroux, 1816: 298.

Corallina fragilissima Linnaeus, 1758: 806. *Type Locality:* Jamaica. *Illustrations*: Huisman, 2000: 50. *Distribution*: Epilithic, generally in the shallow subtidal. Commonly found on reef flats.

HYDROLITHON (Foslie) Foslie, 1909: 55.

Hydrolithon farinosum (Lamouroux) Penrose & Chamberlain, 1993: 295.

Melobesia farinosa Lamouroux, 1816: 315. *Type Locality:* Mediterranean Sea. *Illustrations*: Penrose, 1996: 260–261, figure 118. Huisman *et al.,* 2007: 76. *Distribution*: Virtually cosmopolitan; epiphytic on a variety of other algae. *Specimens*: Scott Reef east of sand island, (URS Tr. 21), epiphytic on *Caulerpa cupressoides*, 19 Feb. 2006, *J.M. Huisman* (PERTH). *Remarks*: This small epiphyte occurs on a broad range of larger algae and is found throughout the atolls.

Hydrolithon gardineri (Foslie) Verheij & Prud'homme van Reine 1993: 451 *Lithophyllum gardineri* Foslie 1907: 30–31.

Type Locality: Coetivy Reef, Seychelles. *Distribution*: Widespread in tropical Indo-Pacific. *Illustrations*: Littler & Littler, 2003: 48–49 (as *Porolithon gardineri*). *Specimens*: Clerke Reef, Rowley Shoals, *J.M.Huisman* Clerke Reef, Rowley Shoals, southern lagoon, 11 Dec. 2007, *J.M. Huisman* (PERTH 07816685).

Hydrolithon onkodes (Heydrich) Penrose & Woelkerling, 1992: 83 (Figure 2)

Lithothamnion onkodes Heydrich, 1897: 6. *Type Locality:* Tami Island, north-west edge of Huon Gulf, New Guinea. *Illustrations*: Littler & Littler, 2003: 50–51 (as *Porolithon onkodes*). *Distribution*: Widespread in tropical seas. *Specimens*: Imperieuse Reef, Rowley Shoals, north-east slope, 2 Dec. 2007, *J.M. Huisman* (PERTH). Clerke Reef, Rowley Shoals, Mermaid Reef, 10 Dec. 2007, *J.M. Huisman* (PERTH 07816677). Scott Reef, southeast side, 18 Feb. 2006, *J.M. Huisman* (PERTH). *Remarks*: *Hydrolithon onkodes* is the common crustose coralline on reef crests in high energy zones.

Hydrolithon samoense (Foslie) Keats & Chamberlain, 1994: 15–19, figures 31–54. *Lithophyllum samoënse* Foslie, 1906: 20.

Type locality: Satana, Savaii Island, Western Samoa. *Illustrations*: Keats & Chamberlain, 1994: Figures 31–54. *Distribution*: Widespread in tropical to temperate seas. *Specimens*: Clerke Reef, Rowley Shoals, southern lagoon, 11 Dec. 2007, *J.M. Huisman* (PERTH 07816693).

JANIA Lamouroux, 1812: 186.

Jania adhaerens Lamouroux, 1816: 270.

Type Locality: "Méditerranée?" *Illustrations*: Price & Scott, 1992: 48–50, figure 12A-C. *Distribution*: Widespread in tropical and subtropical seas. *Specimens*: Seringapatam Reef (NWA Stn 42), 26 Sept. 2006, *J.M. Huisman* (PERTH).

LITHOPHYLLUM Philippi, 1837: 387.

Lithophyllum kotschyanum Unger, 1858: 22, plate 5: Figures 15, 16

Type Locality: Bahrain. *Illustrations*: Adey *et al.*, 1982: 37–40, figures 23–25. Huisman, 2000: 55. *Distribution*: Widespread in tropical waters of the Indian and Pacific Oceans. *Specimens*: Scott Reef (north), east side near channel (URS Tr. 27), 21 Feb. 2006, *J.M. Huisman* (PERTH).

Lithophyllum tamiense (Heydrich) Foslie, 1900a: 16.

Lithothamnion tamiense Heydrich, 1897: 1: Plate 1: Figures 4–7. *Type Locality*: Tami Island, Papua New Guinea. *Illustrations*: Ringeltaube & Harvey, 2000: Figures 7–11. *Distribution*: Widespread in tropical waters of the Indian and Pacific Oceans. *Specimens*: Imperieuse Reef, Rowley Shoals, shallow lagoon, 6 Dec. 2007, *J.M. Huisman* (PERTH). Clerke Reef, Rowley Shoals, southern lagoon, 11 Dec. 2007, *J.M. Huisman* (PERTH 07816707).

LITHOTHAMNION Heydrich, 1897: 412.

Lithothamnion proliferum Foslie, 1904: 18–19.

Type Locality: Lumu-Lumu shoal (Pulau Lumulumu), Borneo Bank, Indonesia. *Illustrations*: Keats *et al.,* 1996; Littler & Littler, 2003: 38–39. *Distribution*: Tropical Indian and Pacific Oceans. *Specimens*: Scott Reef (NWA Stn 31), 23 Sept. 2006, *J.M. Huisman* (PERTH). *Remarks*: This species inhabits darker crevices in the reef and can usually be recognized by its broad, horizontal protuberances and smooth surface.

RHIZOLAMELLIA Shevejko, 1982: 26

Rhizolamellia collum Shevejko, 1982: 26–28. (Figure 6)

Type Locality: Scott Reef, Western Australia, 17–27 m depth. *Illustrations*: Shevejko, 1982: Figures 1, 2. *Distribution*: Apparently known only from Scott Reef. *Specimens*: Scott Reef (NWA Stn 28), 22 Sept. 2006, *J.M. Huisman* (PERTH). Scott Reef (NWA Stn 36), south of channel, 24 Sept. 2006, *J.M. Huisman* (PERTH). *Remarks*: *Rhizolamellia* is a monospecific genus described from collections made by a Russian expedition to Scott Reef in 1978 (Shevejko, 1982) and the present specimens are the first record of the species since its description. The taxonomic placement of the genus is considered questionable by Woelkerling (1988) and the specimens collected during these surveys are being studied in detail (including DNA sequencing). These results will be presented elsewhere. *Rhizolamellia* inhabits darker crevices in the reef where is forms fragile, basally attached crusts.

Family SPOROLITHACEAE

SPOROLITHON Heydrich, 1897: 66.

Sporolithon ptychoides Heydrich, 1897: 67–69, figures. 2, 3, plate III: Figures. 20–23.

Type Locality: El Tor, Sinai Peninsula, Egypt. *Illustrations*: Verheij & Prud'homme van Reine, 1993; Littler & Littler, 2003: 52–53. *Distribution*: Widespread in warmer waters of the Indo-Pacific and the Mediterranean. *Specimens*: Clerke Reef, Rowley Shoals, lagoon near channel at 12m depth, 10 Dec. 2007, *J.M. Huisman* (PERTH).

Order GELIDIALES

Family GELIDIACEAE

GELIDIELLA Feldmann & Hamel, 1934: 529.

Gelidiella acerosa (Forsskål) Feldmann & Hamel, 1934: 533.

Fucus acerosus Forsskål, 1775: 190. *Type Locality:* Mocha, Yemen. *Illustrations:* Price & Scott, 1992: 25–27, figure 4. Huisman, 2000: *Specimens*: Scott Reef (URS Tr. 2), intertidal, 16 Feb. 06, *J.M. Huisman* (PERTH 07816367).

Family PTEROCLADIELLACEAE

PTEROCLADIELLA Santelices & Hommersand, 1997: 117.

Pterocladiella caerulescens (Kützing) Santelices & Hommersand, 1997: 118.

Gelidium caerulescens Kützing, 1868: 19, pl 56, figures c-d. *Type Locality*: Wagap, New Caledonia. *Illustrations*: Price & Scott, 1992: 21–24, figure 3A-F. Santelices, 1976: 173, figures 1–27 (as *Pterocladia caerulescens*). *Distribution*: Warmer waters of the Indo-Pacific. *Specimens*: Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH).

Order BONNEMAISONIALES

Family BONNEMAISONIACEAE

ASPARAGOPSIS Montagne, 1841: xv.

Asparagopsis taxiformis (Delile) Trevisan, 1845: 45.

Fucus taxiformis Delile, 1813[1813–1826]: 151, 295, plate 57, figure 2. *Type Locality*: Alexandria, Egypt. *Illustrations*: Cribb, 1983: 28, plate 4, figures 1–2. Huisman, 2000: 47. *Distribution*: Cosmopolitan in warmer seas. Epilithic in the subtidal. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef, in shallows, (NWA Stn 6) 14 Sept. 2006, *J.M. Huisman* (PERTH 07816545). *Remarks*: *Asparagopsis* has a markedly heteromorphic life history and the present record is of the diminutive tetrasporophyte only.

Order GIGARTINALES

Family CORYNOCYSTACEAE

CORYNOCYSTIS Kraft in Kraft *et al.*, 1999: 26.

Corynocystis prostrata Kraft in Kraft *et al.*, 1999: 26. (Figure 8)

Type Locality: Bulusan, Sorsogon Province, Philippines. *Illustrations*: Kraft *et al.*, 1999: Figure 20. *Distribution*: Known from the Rowley Shoals and Scott Reef; otherwise seemingly widespread in the Indo-West Pacific. Plants are almost invariably found in deep, shaded recesses in coral reefs. *Specimens*: Cod Hole, Mermaid Reef, 15 Dec. 2007, *J.M. Huisman* (PERTH 07729308). Mermaid Reef, Rowley Shoals, lagoon entrance channel. (NWA Stn 13), 16 Sept. 2006, *J.M. Huisman* (PERTH 07720122). *Remarks*: This represents a new record for Western Australia.

Family DUMONTIACEAE

GIBSMITHIA Doty, 1963: 458.

Gibsmithia hawaiiensis Doty, 1963: (Figure 9)

Type Locality: Waikiki, O'ahu, Hawaiian Islands. *Illustrations*: Doty, 1963: 458–465, figures 1–7. Kraft, 1986b: 425–433, figures 2–22. Huisman, 2000: 75. Huisman *et al.,* 2007: 85. *Distribution*: Widespread in tropical waters of the Indo-West Pacific. Epilithic in the subtidal. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie at 12 m depth, 16 Sept. 2006, *J.M. Huisman* (PERTH).

Family PEYSSONNELIACEAE

PEYSSONNELIA Decaisne, 1841: 168.

Peyssonnelia inamoena Pilger, 1911: 311. (Figure 7)

Type Locality: Gross-Batanga, Cameroon, West Africa. *Illustrations*: Kawaguchi *et al.,* 2002: Figures 23–29. *Distribution*: Tropical to warm temperate regions in the Atlantic, Pacific and Indian Oceans. *Specimens*: Imperieuse Reef, Rowley Shoals, 2 Dec. 2007, *J.M. Huisman* (PERTH 07789343). Scott Reef (NWA Stn 30) in cavities in reef, 22 Sept. 2006, *J.M. Huisman* (PERTH 07788819). *Remarks*: In addition to *P. inamoena*, several other species of *Peyssonnelia* were common at the atolls. These are presently being studied.

Family RHIZOPHYLLIDACEAE

PORTIERIA Zanardini, 1851: 33.

Portieria hornemannii (Lyngbye) Silva in Silva *et al.,* 1987: 129.

Desmia hornemanniii Lyngbye, 1819: 35, plate 7c. *Type Locality:* Probably Red Sea.

Illustrations: Cribb, 1983: 35–36, plate 8, figure 2 (as *Chondrococcus hornemannii*). Huisman, 2000: 92. *Distribution*: Tropical Indo-Pacific. Epilithic in the lower intertidal and shallow subtidal. *Specimens*: Scott Reef (NWA Stn 22), 20 Sept. 2006, *J.M. Huisman* (PERTH).

Family HYPNEACEAE

HYPNEA Lamouroux, 1813: 131.

Hypnea spp.

Remarks: Small, fragmentary specimens of *Hypnea* were collected during the surveys but these were inadequate for species deterimination.

Order NEMASTOMATALES

Family NEMASTOMATACEAE

PREDAEA De Toni f., 1936: [5]

Predaea laciniosa Kraft, 1984: 11–15.

Type locality: Coral Gardens, Heron Island, Great Barrier Reef, Australia. *Illustrations*: Kraft, 1984: Figures 25–35. *Distribution*: Warmer waters of the Indo-Pacific. *Specimens*: Scott Reef (NWA Stn 31), 23 Sept. 2006, *J.M. Huisman* (PERTH 07816391).

Predaea weldii Kraft & Abbott 1971: 194.

Type Locality: Kāne'ohe Bay, O'ahu, Hawaiian Islands. *Illustrations:* Kraft, 1984: 15–19, figures 36–42; Huisman, 2000: 85. *Distribution*: Widely distributed in tropical seas. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie at 12 m depth, 16 Sept. 2006, *J.M. Huisman* (PERTH).

Family SCHIZYMENIACEAE

PLATOMA Schousboe ex Schmitz, 1894: 627.

Platoma cyclocolpum (Montagne) Schmitz, 1894: 627 (footnote), 628.

Halymenia cyclocolpa Montagne, 1841: 163–164. *Type Locality:* Teneriffe, Canary Islands. *Illustrations*: Huisman, 1999: Figures 1–12; Huisman, 2000: 84. *Specimens*: Mermaid Reef, Rowley Shoals, south end of lagoon at 20 m depth (NWA Stn 26), 21 Sept. 2006, *J.M. Huisman* (PERTH 07720114).

TITANOPHORA (J.Agardh) J. Feldmann, 1942: 111.

Titanophora pikeana (Dickie) Feldmann, 1942: 111.

Galaxaura pikeana Dickie, 1874: 195–196. *Type Locality:* Mauritius. *Illustrations*: Børgesen, 1943: Figure 13. Huisman, 2000: 86; Schils & Coppejans, 2002: Figures 36–44. *Distribution*: Known from the Houtman Abrolhos, Western Australia, presumably around northern Australia to Queensland and Lord Howe I., N.S.W. Tropical Indo-Pacific. Epilithic in the subtidal, usually associated with coral reefs. *Specimens*: Seringapatam Reef (NWA Stn 43), 26 Sept. 2006, *J.M. Huisman* (PERTH 07719000). *Remarks*: Previously reported as *Titanophora weberae* Børgesen (type locality: Salee Strait, Irian Barat, Indonesia), a species now considered synonymous.

Order RHODYMENIALES

Family CHAMPIACEAE

CHAMPIA Desvaux, 1809: 245.

Champia parvula (C.Agardh) Harvey, 1853: 76.

Chondria parvula C.Agardh, 1824: 207. *Type Locality*: Cádiz, Spain. *Illustrations*: Price & Scott, 1992: 55–57, figure 14A-E. Huisman, 2000: 109. *Distribution*: Widespread in tropical and temperate seas. *Specimens*: Scott Reef (NWA Stn 31), 23 Sept. 2006, *J.M. Huisman* (PERTH)

Family RHODYMENIACEAE

ASTEROMENIA Huisman & Millar, 1996: 138.

Asteromenia sp.

Specimens: Mermaid reef, Rowley Shoals, outside slope middle east side, 13 Sept. 2006, *J.M. Huisman* (PERTH 07626339). *Remarks*: The genus *Asteromenia* was recently monographed by Saunders *et al.*, (2006), a study that included DNA sequencing and included specimens from Western Australia. The Rowley Shoals entity has been sequenced and compared with known species (see Saunders *et al.*), and these results, plus morphological observations, indicate it to be a new species (Saunders, pers. comm.) It will be described formally elsewhere.

CERATODICTYON Zanardini, 1878: 36.

Ceratodictyon spongiosum Zanardini, 1878: 37.

Type Locality: Wokam, Aru Islands, Indonesia. *Illustrations*: Price & Kraft, 1991: Figures 1–16. Huisman, 2000: 115. *Distribution*: Widespread in the tropical Indo-Pacific. In Western Australia, from the tropics south to the Houtman Abrolhos. Epilithic in the intertidal and shallow subtidal. *Specimens*: Scott Reef (South), intertidal reef flat, 19 Feb. 2006, *J.M. Huisman* (PERTH 07725523).

CHAMAEBOTRYS Huisman, 1996: 105.

Chamaebotrys boergesenii (Weber-van Bosse) Huisman, 1996: 105.

Coelarthrum boergesenii Weber-van Bosse, 1928:473, figures. 207, 208. *Type Locality*: Sailus-Besar, Isles Paternoster, from 27 m depth. *Illustrations*: Huisman, 1996: 105–109, figures 35–38, 40–42. Huisman, 2000: 116. *Distribution*: Widespread in warmer waters. Generally found in protected positions on and under rock and coral ledges. *Specimens*: Imperieuse Reef, Rowley Shoals, east side, 5 Dec. 2007, *J.M. Huisman* (PERTH).

COELOTHRIX Børgesen, 1920: 389.

Coelothrix irregularis (Harvey) Børgesen, 1920: 389, figures 373, 374.

Cordylecladia irregularis Harvey, 1853: 156. *Type Locality:* Key West, Florida, U.S.A. *Illustrations*: Price & Scott, 1992: Figure 17A-D. Huisman, 2000: 110. *Distribution*: Widespread in the tropical Indo-West Pacific region and tropical West Atlantic Ocean. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef in shallows (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788878). Scott Reef (South), reef flat (URS Tr. 12), 18 Feb. 2006, *J.M. Huisman* (PERTH 07724640).

GELIDIOPSIS Schmitz, 1895: 148.

Gelidiopsis intricata (C.Agardh) Vickers, 1905: 61.

Sphaerococcus intricatus C.Agardh, 1822: 333–334. *Type Locality:* Mauritius, Hawaiian Islands, and Ravak (Rauki I., near Waigeo I, Indonesia) (lectotype needs selecting). *Illustrations*: Price & Scott, 1992: Figure 13a-f. *Distribution*: Widespread in the tropical seas. *Specimens*: Imperieuse Reef, Rowley Shoals, 6 Dec. 2007, *J.M. Huisman* (PERTH 07729367). Mermaid Reef, Rowley Shoals, inner side of western reef, in shallows (NWA Stn 6), 14 Sept. 2006, *J.M. Huisman* (PERTH 07788886).

Order CERAMIALES

Family CERAMIACEAE

AGLAOTHAMNION Feldmann-Mazoyer, 1941: 17.

Aglaothamnion cordatum (Børgesen) Feldmann-Mazoyer, 1941: 459.

Callithamnion cordatum Børgesen, 1909: 10–11, figures. 5–6. *Type Locality*: Off Cruz bay, between St. Thomas and St. Jan, Virgin Islands. *Illustrations*: Price & Scott, 1992: 75–76, figure 22A, B. Huisman, 2000: 27. *Distribution*: Widespread in tropical seas. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie near south tip of reef (NWA Stn 14), epiphytic on *Dictyota* sp. 16 Sept. 2006, *J.M. Huisman* (PERTH 07816421).

ANOTRICHIUM Nägeli, 1862: 397

Anotrichium tenue (C.Agardh) Nägeli, 1862: 399.

Griffithsia tenuis C.Agardh, 1828: 131. *Type Locality:* Venezia, Italy. *Illustrations:* Baldock, 1976: Figures 59–64, 90. Huisman, 2000: 129. *Distribution*: Widely distributed in all tropical and subtropical oceans except for the eastern Atlantic. Epilithic and epiphytic on a variety of algae and seagrasses. *Specimens*: Mermaid Reef, Rowley Shoals (NWA Stn 14), on *Thalassia hemprichii*, 16 Sept 2006, *J.M. Huisman* (PERTH).

ANTITHAMNION Nägeli, 1847: 202.

Antithamnion antillanum Børgesen, 1917: 226, figures 213–216.

Type Locality: In the Harbour near Charlotte Amalia, St. Thomas, Virgin Is. *Illustrations*: Price & Scott, 1992: 69–72, figure 20A-C. *Distribution*: Widespread in tropical seas. *Specimens*: Scott Reef (South), north east outer slope (NWA Stn 30), 22 Sept. 2006, *J.M. Huisman* (PERTH 07816405).

ANTITHAMNIONELLA Lyle, 1922: 347.

Antithamnionella sp.

Specimens: Scott Reef (South), north east outer slope (NWA Stn 30), 22 Sept. 2006, *J.M. Huisman* (PERTH 07816626; also with PERTH 07816405). *Remarks*: These specimens do not fit any of the presently recognized species and appear to represent a new species. It will be described formally elsewhere.

BALLIELLA Itono & Tanaka, 1973: 249.

Balliella subcorticata (Itono) Itono & Tanaka, 1973: 250.

Antithamnion subcorticatum Itono, 1969: 40, figure 7. *Type Locality*: Yoronjima, Okinawa-gunto, Ruykyu-retto, Japan. *Illustrations*: Itono & Tanaka, 1973: Figures 1, 2, 18–22. *Distribution*: Probably widespread in the Indo-West Pacific; in Australia known only from the present collection and the Dampier Archipelago (Huisman & Borowitzka, 2003); epiltihic or epiphytic in the subtidal. *Specimens*: Cod Hole, Mermaid Reef, Rowley Shoals, epiphytic on *Corynocystis prostrata*, 15 Dec. 2007, *J.M. Huisman* (PERTH 07816618).

CENTROCERAS Kützing, 1841: 731.

Centroceras clavulatum (C.Agardh) Montagne, 1846: 140.

Ceramium clavulatum C. Agardh, 1822: 2. *Type Locality:* Callao, Peru. *Illustrations:* Price & Scott, 1992: 81–82, figure 25A-E; Huisman, 2000: 134. *Distribution:* Widespread in warmer waters; epilithic or epiphytic on a variety of substrata, very common. *Specimens*: Mermaid Reef, Rowley Shoals, lagoon (NWA Stn 1), on *Stypopodium flabelliforme*, 12 Sept. 2006, *J.M. Huisman* (PERTH 07816537). Scott Reef (South), entrance to false lagoon (NWA Stn 25), epiphytic on *Dictyota* sp., 21 Sept. 2006, *J.M. Huisman* (PERTH).

CERAMIUM Roth, 1797: 146

Ceramium codii (Richards) Mazoyer, 1938: 324.

Ceramothamnion codii Richards, 1901: 264, pls. 21–22. *Type Locality*: Bermuda, epiphytic on *Codium*. *Illustrations*: South & Skelton, 2000: Figures 11–14. *Distribution*: Widespread in warmer seas. *Specimens*: Mermaid Reef, Rowley Shoals, (NWA Stn 7), 16 Sept. 2006, *J.M. Huisman* (PERTH 07816480).

Ceramiun krameri South & Skelton, 2000: 69.

Type Locality: Sawa-I-lau, Fiji. *Illustrations*: South & Skelton, 2000: Figures 45–51. *Distribution*: Fiji, Samoa, north-western Australia. *Specimens*: Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (with PERTH 07816413).

Ceramium macilentum J.Agardh, 1894: 15.

Type Locality: Port Phillip, Victoria, Australia. *Illustrations*: South & Skelton, 2000: Figures 52–62. *Distribution*: Widespread in tropical and temperate seas. *Specimens*: Clerke Reef, Rowley Shoals, epiphytic on *Actinotrichia fragilis*, 11 Dec. 2007, *J.M. Huisman* (PERTH 07816596).

Ceramiun vagans Silva, in Silva *et al.*, 1987: 56.

Type Locality: Parry I., Eniwetok Atoll, Marshall Islands. *Illustrations*: South & Skelton, 2000: Figures 89–93. *Distribution*: Widespread in the tropics. *Specimens*: Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH 07816413). *Remarks*: This represents a new record for Western Australia

CORALLOPHILA Weber-van Bosse 1923: 339.

Corallophila apiculata (Yamada) R.Norris, 1993: 395.

Centroceras apiculatum Yamada, 1944: 42. Type Locality: Ant Atoll, Senyavin Is., East Caroline Is. *Illustrations*: Price & Scott, 1992: Figures 24A-D (as *Centroceras apiculatum*). *Distribution*: Tropical regions of the Indo-Pacific; in WA also known from Barrow Island and the Dampier Archipelago (Huisman & Borowitzka, 2003). *Specimens*: Mermaid Reef, Rowley Shoals, lagoon bommie near south tip of reef (NWA Stn 14), 16 Sept. 2006, *J.M. Huisman* (PERTH). Scott Reef (South), north east outer slope (NWA Stn 30), 22 Sept. 2006, *J.M. Huisman* (PERTH 07816456).

CROUANIA J.Agardh, 1842: 83.

Crouania attenuata (C.Agardh) J.Agardh, 1842: 83.

Mesogloia attenuata C.Agardh, 1824: 51. *Type Locality*: "In mari Atlantico" *Illustrations*: Price & Scott, 1992: 117–120, figure 38A-D, 39A-B. *Distribution*: Widespread in temperate and tropical seas. Epiphytic and epilithic in intertidal regions.

Specimens: Mermaid Reef, Rowley Shoals, inner side of western reef (NWA Stn 6), on *Codium* sp., 14 Sept. 2006, *J.M. Huisman* (PERTH 07816588).

GAYLIELLA Cho, McIvor & Boo, in Cho *et al.*, 2008: 723.

Gayliella flaccida (Harvey ex Kützing) Cho & McIvor in Cho *et al.*, 2008: 723

Hormoceras flaccidum Harvey ex Kützing, 1862: 21, plate 69a-d. *Type Locality:* Kilkee, County Clare, Eire. *Illustrations:* Womersley, 1978: 234, figures 4A-D, 14E-H; Huisman, 2000: 135 (as *Ceramium flaccidum*). *Distribution:* Widely distributed in cool-temperate to tropical oceans. Epiphytic on a variety of larger algae and seagrasses. *Specimens*: Mermaid Reef, Rowley Shoals, inner side of western reef (NWA Stn 6), on *Codium* sp., 14 Sept. 2006, *J.M. Huisman* (PERTH). *Remarks*: This species is more commonly known as *Ceramium flaccidum* (Harvey ex Kützing) Ardissone, but was recently transferred to the new genus *Gayliella* following a DNA sequence study (Cho *et al.*, 2008).

GRIFFITHSIA C.Agardh, 1817: xxviii.

Griffithsia heteromorpha Kützing, 1863: 2, plate 3: Figures. a, b.

Type Locality: New Caledonia. *Illustrations*: Price & Scott, 1992: 121–123, figure 40A-B. *Distribution*: Tropical Indo-West Pacific region and tropical western Atlantic Ocean. *Specimens*: Scott Reef (South), entrance to false lagoon (NWA Stn 25), 21 Sept. 2006, *J.M. Huisman* (PERTH 07816634). *Remarks*: The specimens are tetrasporangial and with non-involucrate sporangia, as is typical of this species.

HALOPLEGMA Montagne, 1842: 258.

Haloplegma duperreyi Montagne, 1842: 258–261, plate 7, figure 1.

Type Locality: Martinique, West Indies. *Illustrations:* Womersley, 1998: Figure 133. *Distribution*: Widespread in tropical seas; epilithic. *Specimens*: Seringapatam Reef, south side outer slope at 20 m depth (NWA Stn 41), 26 Sept. 2006, *J.M. Huisman* (PERTH 07720378).

SEIROSPORA Harvey, 1846: 1, t. XXI.1

Seirospora orientalis Kraft, 1988: 2.

Type Locality: One Tree Island, Capricorn Group, Great Barrier Reef, Queensland, Australia. *Illustrations*: Kraft, 1988: 1–11, figures 2–25. Huisman, 2000: 143. *Distribution*: Known from the Capricorn Group, Queensland, and the Houtman Abrolhos to Scott Reef, Western Australia. *Specimens*: Scott Reef (South), entrance to false lagoon (NWA Stn 25), epiphytic on *Padina* sp., 21 Sept. 2006, *J.M. Huisman* (PERTH 07816642).

SPYRIDIA Harvey, 1833: 259.

Spyridia filamentosa (Wulfen) Harvey, 1833: 337

Fucus filamentosus Wulfen, 1803: 64. *Type Locality:* Adriatic Sea. *Illustrations*: Womersley & Cartledge, 1975: 222, figures 1, 3A, B; Huisman, 2000: 145. *Distribution*: Widely distributed in tropical and warm temperate oceans; epilithic or epiphytic in the intertidal and subtidal. *Specimens*: Scott Reef, reef flat (NWA Stn 27), 21 Sept. 2006, *J.M. Huisman* (PERTH). Seringapatam Reef, on lagoon edge of reef flat at 10 m depth (NWA Stn 42), 26 Sept. 2006, *J.M. Huisman* (PERTH 07816529).

TIFFANIELLA Doty & Meñez, 1960: 135.

Tiffaniella cymodoceae (Børgesen) Gordon, 1972: 121.

Spermothamnion cymodoceae Børgesen, 1952: 54, figures 27, 28. *Type Locality*: Riambel, Mauritius. *Illustrations*: Gordon, 1972: Figures 39D-F, 40A-E. Womersley, 1998: Figure 100A-D. *Distribution*: Indian Ocean. *Specimens*: Scott Reef (NWA Stn 30), on *Galaxaura* sp., 22 Sept. 2006, *J.M. Huisman* (PERTH 07816561). *Remarks*: The present specimens were growing amongst the surface filaments of *Actinotrichia fragilis*. The only reproductive structures seen were tetrasporangia, so the identification is tentative.

Family DASYACEAE

HETEROSIPHONIA Montagne, 1842: 4.

Heterosiphonia crispella (C.Agardh) Wynne, 1985: 87.

Callithamnion crispella C.Agardh, 1828: 183. *Type Locality*: near Cádiz, Spain. *Illustrations*: Cribb, 1983: 105, plate 64, figure 1 (as *Heterosiphonia wurdemanni* var. *laxa*). *Distribution*: Most tropical oceans, previously recorded for Western Australia at the Dampier Archipelago (Huisman & Borowitzka, 2003). *Specimens*: Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH 07816472).

Family DELESSERIACEAE

ZELLERA Martens, 1866: 33.

Zellera tawallina Martens, 1866: 33, plate VIII: Figure 3.

Type Locality: 'Klein Tawalli" [Tawaliketjil] I., Halmahera, Indonesia. *Illustrations*: Verheij and Prud'homme van Reine, 1993: 443, plate 14, figure 8; Millar *et al.*, 1999: 570, figure 6A**.** *Distribution*: Widespread in tropical regions of the eastern

Indian and western Pacific Oceans, although seemingly never abundant. *Specimens*: Scott Reef (NWA Stn 31), 23 Sept. 2006, *J.M. Huisman* (PERTH 07788797). Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH 07718799).

Family RHODOMELACEAE

ACANTHOPHORA Lamouroux, 1813: 132.

Acanthophora spicifera (Vahl) Børgesen, 1910: 201.

Fucus spiciferus Vahl, 1802: 44. *Type Locality:* St. Croix, Virgin Islands. *Illustrations*: Cribb, 1983: 105–106, plate 32, figure 2. Huisman, 2000: 154. *Distribution*: Widespread in tropical and warmer seas; in Western Australia south to Dawesville. *Specimens*: Mermaid Reef, Rowley Shoals, inner platform, west side, 14 Sept. 2006, *J.M. Huisman*, (PERTH 07626533). Mermaid Reef, Rowley Shoals, inner lagoon, east side, 12 Sept. 2006, *J.M. Huisman* (PERTH 07719035). Mermaid Reef, Rowley Shoals, 16 Dec. 2007, *J.M. Huisman* (PERTH 07729081).

HERPOSIPHONIA Nägeli, 1846: 238.

Herposiphonia secunda (C.Agardh) Ambronn, 1880: 197.

Hutchinsia secunda C.Agardh, 1824: 149. *Type Locality:* Sicily, Mediterranean. *Illustrations*: Millar, 1990: 451–452, figures 68A-C. Huisman, 2000: 168. *Distribution*: Widespread in warmer waters. Epiphytic on a variety of larger algae and seagrasses. *Specimens*: Seringapatam Reef (NWA Stn 42), on *Hypnea*, 26 Sept. 2006, *J.M. Huisman* (PERTH).

LEVEILLEA Decaisne, 1839: 375.

Leveillea jungermannioides (Hering & G.Martens) Harvey, 1855: 539.

Amansia jungermannioides Hering & G.Martens in G.Martens & Hering, 1836: 485. *Type Locality*: Tor, Sinai Peninsula, Egypt. *Illustrations*: Price & Scott, 1992: 196–198, figure 71A, B. Huisman, 2000: 173. *Distribution*: Widely distributed in tropical and subtropical Indo-west Pacific. Epiphytic on a variety of larger algae and seagrasses. *Specimens*: Scott Reef (South) west side of sandy islet (NWA Stn 24), 20 Sept. 2006, *J.M. Huisman* (PERTH 07816448).

NEOSIPHONIA Kim & Lee, 1999: 271–281.

Neosiphonia poko (Hollenberg) Abbott in Abbott *et al.*, 2002: 312

Polysiphonia poko Hollenberg, 1968: 70, figures 3A, 15. *Type Locality*: Near reef margin, north of North Island, Johnston Atoll. *Illustration*: Hollenberg, 1968, figures 3A, 15. *Distribution*: Probably warmer waters of the Indo-Pacific. *Specimen*: Scott Reef, channel (NWA Stn 40), 25 Sept. 2006, *J.M. Huisman* (PERTH).

POLYSIPHONIA Greville, 1823: 90

Polysiphonia spp.

Remarks: Several species of *Polysiphonia* were collected during the surveys but these were mostly fragmentary and inadequate for species deterimination.

TOLYPIOCLADIA Schmitz in Engler & Prantl, 1897: 441.

Tolypiocladia glomerulata (C.Agardh) Schmitz, 1897: 442.

Hutchinsia glomerulata C.Agardh, 1824: 158. *Type Locality*: Shark Bay, Western Australia. *Illustrations*: Price & Scott, 1992: 219–221, figure 81A-D. Huisman, 2000: 179. *Distribution*: Widely distributed in tropical Indo-west Pacific. *Specimens*: Scott Reef (South), entrance to false lagoon (NWA Stn 25), associated with *Dictyota friabilis*, 21 Sept. 2006, *J.M. Huisman* (PERTH 07725507). Seringapatam Reef, on lagoon edge of reef flat at 10 m depth (NWA Stn 42), 26 Sept. 2006, *J.M. Huisman* (PERTH).

Family SARCOMENIACEAE

PLATYSIPHONIA Børgesen, 1931: 28.

Platysiphonia delicata (Clemente y Rubio) Cremades in Cremades & Perez-Cirera, 1990: 492. *Conferva delicata* Clemente y Rubio, 1807: 322. *Type Locality*: Sanlúcar de Barrameda, Cádiz, Spain. *Illustrations*: Børgesen, 1931: 21–29, figures 1–5; Ballantine & Wynne, 1985: 461–463, figures 7, 8 [as *Platysiphonia miniata* (C. Agardh) Børgesen]. *Distribution*: Widely distributed. *Specimens*: Scott Reef (South), entrance to false lagoon (NWA Stn 25), 21 Sept. 2006, *J.M. Huisman* (PERTH 07816553).

Order PIHIELLALES

Family PIHIELLACEAE

PIHIELLA Huisman, Sherwood & Abbott, 2003: 981.

Pihiella liagoraciphila Huisman, Sherwood & Abbott, 2003: 981.

Type Locality: Mokulēʻia, Oʻahu, Hawaiian Islands, on *Titanophycus validus* (Harvey) Huisman *et al., Illustrations*: Huisman *et al.*, 2003: Figures 1–3. *Distribution*: Widespread in tropical seas; epiphytic or endophytic in Liagoraceae. *Specimens*: Scott Reef (South) west side of sandy islet (NWA Stn 24), endophytic in *Liagora ceranoides*, 20 Sept. 2006, *J.M. Huisman* (PERTH 07720238). *Remarks*: *Pihiella liagoraciphila* is a minute (generally less than 500 µm in diameter) endophyte found in red algae of the family Liagoraceae. It is the only member of the order Pihiellales.

Cyanobacteria (Blue-green Algae)

Family OSCILLATORIACEAE

LYNGBYA C.Agardh ex Gomont, 1892: 95, 118.

Lyngbya majuscula (Dillwyn) Harvey, 1833: 370

Conferva majuscula Dillwyn, 1809: plate 20. *Type Locality*: England. *Illustrations*: Huisman *et al.*, 2007: *Distribution*: Widespread in most seas. *Specimens*: Scott Reef (URS Tr. 2), intertidal, 16 Feb. 06, *J.M. Huisman* (PERTH 07816375).

Family PHORMIDIACEAE

SYMPLOCA Kützing ex Gomont, 1892: 104.

Symploca hydnoides (Harvey) Kützing, 1849: 272.

Calothrix hydnoides Harvey, 1833: 368–369. *Type Locality*: Appin, Argyll, Scotland. *Illustrations*: Littler & Littler, 2000: 462, 463. *Distribution*: Cosmopolitan. *Specimens*: Scott Reef (South), intertidal near Guano wreck, 16 Feb. 2006, *J.M. Huisman* (PERTH 07720289).

LEPTOLYNGBYA Anagnostidis & Komárek, 1988: 390.

Leptolyngbya crosbyana (Tilden) Anagnostidis & Komárek, 1988: 391.

Phormidium crosbyanum Tilden, 1909: 645. *Type Locality*: Waianae, Oahu, Hawaiian Islands. *Illustrations*: Huisman *et al.,* 2007: 41. *Distribution*: Widespread in tropical seas. *Specimens*: Imperieuse Reef, Rowley Shoals, 4 Dec. 2007, *J.M. Huisman* (PERTH 07789238). Scott Reef (NWA Stn 30), 22 Sept. 2006, *J.M. Huisman* (PERTH 07719132). *Remarks*: This species forms distinctive cartilaginous hummocks on rock.

Magnoliophyta (Sea Grasses)

Order HYDROCHARITALES

Family HYDROCHARITACEAE

THALASSIA Banks ex König, 1805 ('1806'): 96.

Thalassia hemprichii (Ehrenberg) Ascherson, 1871: 242. (Figure 13)

Schizotheca hemprichii Ehrenberg, 1832: 429. *Type Locality*: Massawa, Eritrea. *Illustrations*: Hartog, 1970: Figure 61, pls 25–27. Phillips & Meñez, 1988: 68, figure 42. *Distribution*: Widespread in the Indo-West Pacific. *Specimens*: Mermaid Reef, Rowley Shoals, S end of inner lagoon at 11.9 m depth (NWA Stn 14) 16 September 2006, *J.M. Huisman* (PERTH 07725116). Mermaid Reef, Rowley Shoals, 16 Dec. 2007, *J.M. Huisman* (PERTH 07729103).

HALOPHILA Thouars, 1806: 2.

Halophila ovalis **(R.Brown) Hook. f., 1858: 45.**

Caulinia ovalis R.Brown, 1810: 339. *Type Locality*: Queensland, Australia.

Illustrations: Robertson, 1984: 61, figures 10B, C, 11D-G. Huisman, 2000: 283. *Distribution*: Widely distributed in tropical and warm temperate waters of the Indo-Pacific; growing in sand. *Specimens*: Imperieuse Reef, Rowley Shoals, lagoon, 4 Dec. 2007, *J.M. Huisman* (PERTH 07789289). Mermaid Reef, Rowley Shoals, inner lagoon bommie on west side at 11.3 m (NWA Stn 7), 14 Sept. 2006, *J.M. Huisman* (PERTH 07720386). Mermaid Reef, Rowley Shoals, lagoon near channel entrance, 14 Dec. 2007, *J.M. Huisman* (PERTH 07729146).

Halophila decipiens Ostenfeld, 1902: 260.

Type Locality: "Off Koh Kahdat, in 5 fathoms water (coral-sand)" [Gulf of Thailand]. *Illustrations*: Robertson, 1984: 61, figures 10A, 11A-C. Huisman, 2000: 283. *Distribution*: Widely distributed in tropical seas; growing in sand. *Specimens*: Scott Reef, lagoon bommie (NWA Stn 26), 21 Sept. 2006, *J.M. Huisman* (PERTH 07788908). Scott Reef (North), south-east corner at 20 m depth (NWA Stn 34), 24 Sept. 2006, *J.M. Huisman* (PERTH 07725221). *Remarks*: The local plants of *H. decipiens* tended to be smaller than *H. ovalis*, but positive identification can only be made by confirming the presence of marginal and surface spines. *H. ovalis* lacks spines.

Order POTAMOGETONALES

Family CYMODOCEACEAE

THALASSODENDRON Hartog, 1970: 186.

Thalassodendron ciliatum (Forsskål) Hartog, 1970: 186.

Zostera ciliata Forsskål, 1775: 157. *Type Locality*: Al Mukha, Yemen, southern Red Sea, leg. P. Forsskål, in BM (see den Hartog, 1970, p. 183). *Illustrations*: Hartog, 1970: Figure 52. Waycott *et al.,* 2004: unnumbered Figures on p. 34. *Distribution*: Warm waters of Indo-West Pacific. *Specimens*: Not collected in the present survey but recorded from Scott Reef and the Rowley Shoals by Walker & Prince (1987).

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Above: The barrel sponge, *Xestospongia testudinaria* (Lamarck, 1815). (Photo: John Huisman)

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Porifera (sponges) of Mermaid, Scott and Seringapatam Reefs, north Western Australia.

Jane Fromont[1] and Mathew A. Vanderklift[2]

[1]Department of Aquatic Zoology, Western Australian Museum, Locked Bag 49, Welshpool DC, WA6986, Australia.
Email: jane.fromont@museum.wa.gov.au

[2]CSIRO Marine and Atmospheric Research, PO Box 5, Wembley, WA 6913, Australia.

Abstract – A quantitative survey documenting the diversity and abundance of sponges at Mermaid, Scott and Seringapatam Reefs, north Western Australia, was conducted in September 2006. Four reef habitats (fore reef slope, channel, lagoon and intertidal reef flat) were surveyed by recording numbers of sponge individuals on replicate transects, providing baseline data of sponge species present and their abundance. In total 132 sponge species were recorded from these reefs. The majority of the species found (79) were unique to one of the reefs, with only 14 species found at all three reefs. A clear difference in the composition of the sponge assemblages between Mermaid and Scott Reefs was detected, which appears to be strongly influenced by the presence of infrequently recorded (rare) species. Intertidal reef flat habitats had lower species richness than subtidal habitats (<3 species at intertidal stations compared to between 6–21 species at subtidal stations). Channels were distinct from other subtidal habitats and were characterized by high abundances of a few common species. Over half of the species found in the study were rare with 56% having five or fewer individuals recorded from all locations in the study. This is the first documentation of the sponge fauna from these reefs and only the second study to date to examine the sponges found on the oceanic reefs off north Western Australia.

Keywords: Porifera, marine sponges, Australia, species richness, abundance, diversity.

INTRODUCTION.

Sponges were collected as part of a Western Australian Museum survey of Mermaid Reef (Rowley Shoals), North and South Scott Reefs, and Seringapatam Reef, north Western Australia, undertaken in September 2006. These oceanic atolls are situated on the edge of the continental shelf approximately 300 km off the coast of northwestern Australia. Their great distance from land means they are in oceanic waters not impacted by terrestrially derived sediments and water clarity is high. They can be subjected to cyclones, with Scott Reef severely impacted by Cyclone Fay in 2004. Scott Reef also experienced a massive bleaching event in 1998 (Heyward *et al.*, 1999).

No previous studies of sponges have been conducted in these reef systems. Hooper (1994) surveyed the coral reef sponges of the more northern oceanic reefs of Ashmore Reef, Cartier Island and Hibernia Reef, of which the southernmost, Cartier Island, is approximately 150 kms northeast of Seringapatam Reef. Prior to Hooper's study no work had been undertaken on the sponge fauna of the oceanic coral reefs on the northwestern continental margin of Australia.

Hooper (1994) found that although the three coral reef systems he examined were in close proximity to each other (less than approximately 50 km apart) they did not contain similar sponge species. Therefore in our study we were interested to determine if sponge species composition differed between Mermaid, Scott and Seringapatam Reefs.

The aims of this study were threefold, firstly to determine the sponge species present and their abundance at each of the atolls studied. Secondly, sponge species assemblages were compared between the habitats and atolls surveyed to determine if species composition differed significantly between atolls or between different habitats. Finally, non-parametric methods were used to estimate the possible number of species that may occur in the area.

METHODS.

Field sampling methods.

A total of 45 stations were surveyed (24 at Scott Reef, 16 at Mermaid Reef, and 5 at Seringapatam Reef).

Stations were chosen to represent four habitat types: intertidal reefs, fore reef slope, lagoon and channels. A list of stations, habitat descriptions and locality maps with the stations marked are presented in the Station and Transect Data section of this volume.

Subtidal station surveys were carried out on SCUBA or snorkel. Transect lines (5 x 1 m, n=3, total area 15 m^2) were laid over the dominant habitat parallel to the depth contour and all sponges were counted. At subtidal forereef slope and lagoon stations three transects were laid between nine and 15 m depth (12 m mean sea level (msl)) and a second set of three transects were laid at three to eight m depth (5 m msl). The exact depth sampled depended on the height of the tide at the time of diving. Only one depth was sampled at two stations where there was a reduced depth profile (eg. bommies in the lagoon). Transect lengths were estimated by eye in channels due to the difficulty of laying and retrieving tapes in strong currents. Counts of individual sponges were determined as per the methods used at stations where transect tapes were laid.

Intertidal station surveys were carried out by reef walking at low tide. Three transects were surveyed when the width of the reef flat was narrow ie. considered to comprise one habitat with all organisms exposed at low tide for a similar length of time. If the reef flat was wide three transects were surveyed near the low tide mark, and three transects were laid inshore where organisms are exposed to air for longer at low tide.

Specimen collection.

A voucher specimen of each sponge species was collected: voucher specimens were also collected if there were morphological or colour differences from previous vouchers. Specimens were separated immediately *in situ* to avoid contamination by mucous exudation from other sponges, or possible spicule loss. After collection, records were made of natural colour, changes in coloration on exposure to air, mucous exudation, and gross morphology for each specimen collected. Specimens were preserved individually in 75% ethanol, photographed on deck, and some species were photographed *in situ*.

Preliminary sponge identifications were undertaken at the end of each survey day by preparing bleach preparations of the skeletons and spicules of each species collected. These were examined with a Leitz DME compound microscope with a calibrated eyepiece graticule. Details and sizes of spicule and skeletal characters were recorded for comparison with other specimens.

Statistical analyses.

Multivariate patterns in the composition of sponge assemblages were assessed using nonmetric multidimensional scaling (NMDS) ordination. The significance of differences in composition between reefs and habitats were tested using two-way crossed analysis of similarities (ANOSIM). Both these sets of analyses were based on Bray-Curtis similarites calculated from untransformed

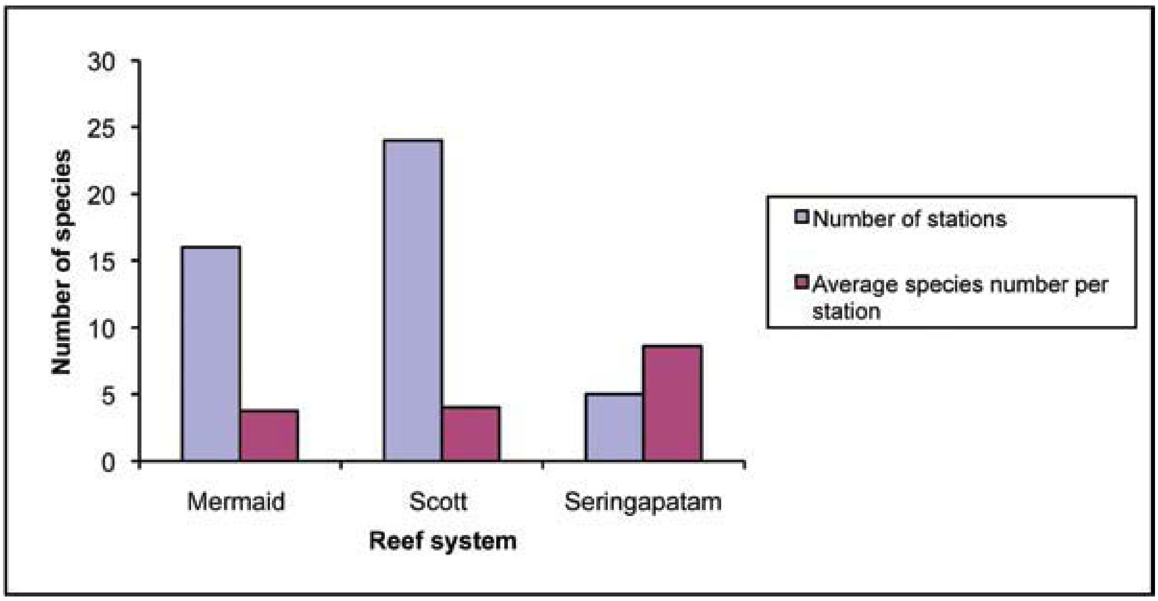

Figure 1 Number of stations per reef system and average number of species per station.

abundance data. In some analyses we also looked at patterns using presence/absence data (also based on Bray-Curtis similarities) to remove the effect of abundance. Stations that yielded no sponges (stations 6, 37 and one intertidal area at station 3) were excluded prior to analyses. SIMPER analyses were used to identify characteristic species. Multivariate analyses were conducted in the PRIMER statistical package.

Non-parametric methods were used to estimate the total number of species that might occur in the survey area. Three methods were examined to provide a range of diversity estimates: first- and second-order jackknife estimators and the bootstrap estimator (Colwell and Coddington 1994).

RESULTS.

General patterns.

One hundred and thirty two species of sponges were collected from the 45 stations examined. The greatest number of species at any reef system was 96 species found at Scott Reef, followed by 60 species at Mermaid and 43 at Seringapatam (Figure 1).

This study found a large proportion of the species reported were only found at one of the reef systems. Twenty four species were recorded only at Mermaid Reef, 48 at Scott Reef and 7 at Seringapatam. Therefore a total of 79 species were unique to one of the reefs examined. Only 14 species were widespread and common to all 3 reefs.

A full species list and the reefs where they occurred is provided in Table 1.

Sponges were not recorded from station 6 at Mermaid Reef, but this habitat was dominated by *Acropora* thickets which are difficult to sample visually for cryptic sponge species. Destructive sampling of the thickets was not undertaken so sponges could have been missed. Intertidal station 37 at Scott Reef did not have any sponges present and consisted predominantly of small boulders covered with algal turf.

Of the 132 species of sponges collected only 29 species (22%) could be fully identified with the basic laboratory techniques used (Table 1) and a further 22 species (17%) were assigned to a known species but require comparison with type material (signified as cf. in Table 1). The remaining 61% (81 species) were only able to be assigned to a genus

Above: *Haliclona koremella* de laubenfels 1954. Station 21 South Scott Reef. (Photo: Clay Bryce)

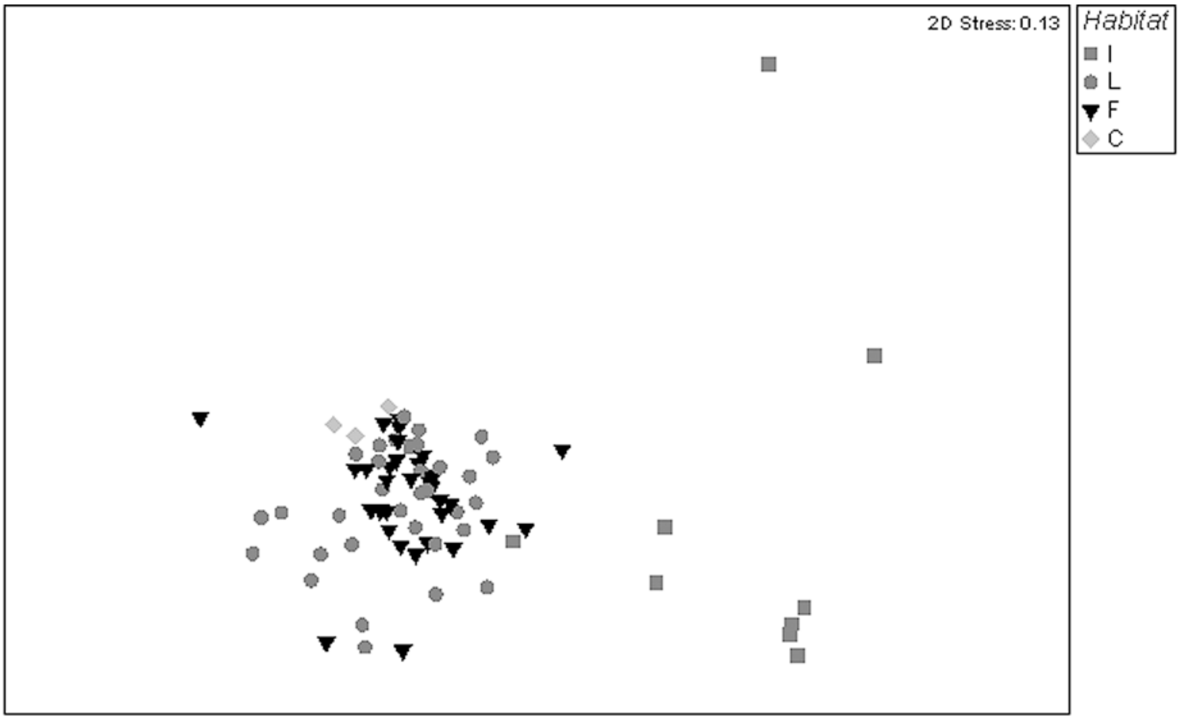

Figure 2 Non-metric multidimensional scaling ordination of all stations surveyed, based on Bray-Curtis similarities calculated from untransformed abundance data (I=intertidal, L=lagoon, F=fore reef slope, C=channels).

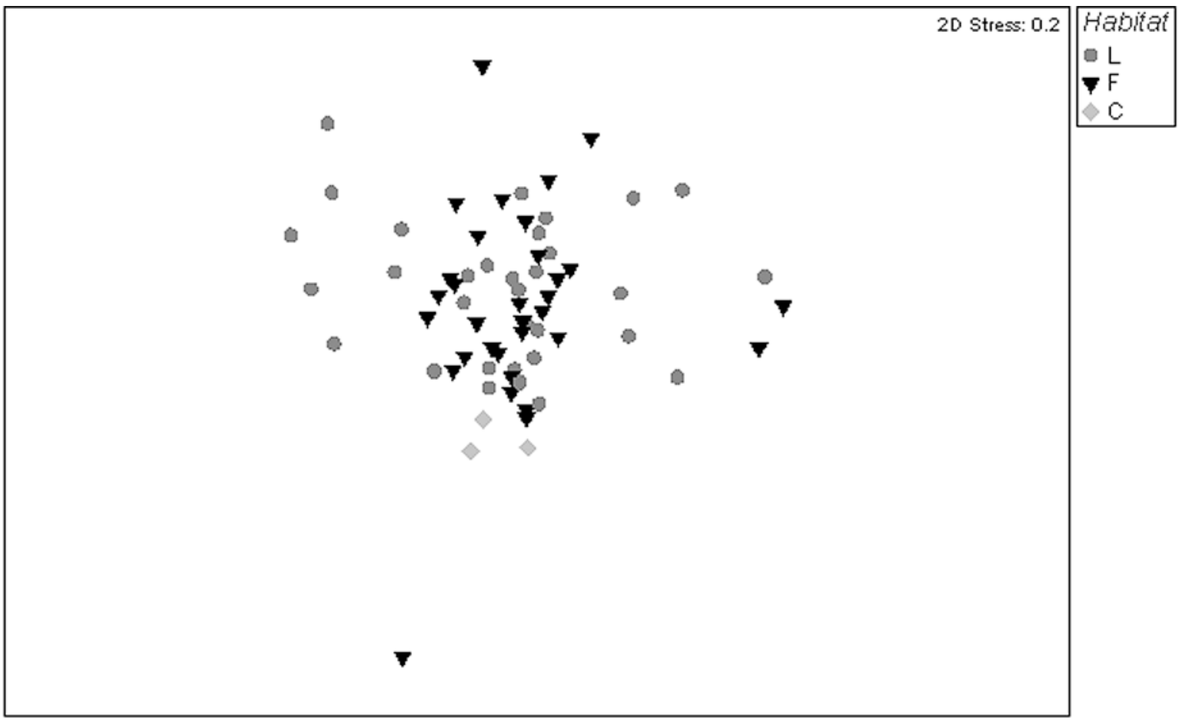

Figure 3 Non-metric multidimensional scaling ordination of subtidal stations surveyed, based on Bray-Curtis similarities calculated from untransformed abundance data, and classified by habitat (L=lagoon, F=fore reef slope, C=channels).

and given a species number. These are most likely poorly known species described in old taxonomic literature or are new to science. The 132 species recorded were assigned to 54 genera and 32 families (Table 1).

Patterns in abundance.

Most of the species reported were rare with 44 of the 132 species (33%) found at only one station out of the total 45 stations examined in the study. A further 19 species (14%) were only found at two of the stations surveyed. Furthermore, 74 species (56% of the total species found) had five or fewer individuals recorded in the total area examined in this study.

Of the 14 species reported at all three reefs, 11 are known to be widespread in the Indo-Pacific. These species are: *Plakortis nigra* Lévi, 1953, *Jaspis splendens* (de Laubenfels, 1954), *Cliona orientalis* Thiele, 1900, *Stylissa carteri* (Dendy, 1889), *Monanchora unguiculata* (Dendy, 1922), *Gelliodes fibulata* (Carter, 1881), *Xestospongia exigua* (Kirkpatrick, 1900), *Neopetrosia testudinaria* (Lamarck, 1815), *Hyrtios erecta* (Keller, 1889), *Lamellodysidea herbacea* (Keller, 1889) and *Pericharax heterorhaphis* (Polejaff, 1883).

Patterns in composition.

The results of the ANOSIM test indicated that the composition of the sponge assemblages across all reefs varied significantly among habitats ($R = 0.33$, $P<0.001$). However, most of the differences in composition were due to the differences between intertidal stations and subtidal stations, as can be seen in Figure 2. This difference in composition was primarily due to the much lower number of species found at intertidal stations.

When the analysis was repeated without the intertidal stations no clear separation of habitats was visible (Figure 3), although there was still a significant difference among habitats ($R = 0.11$, $P = 0.01$). Stations in channel habitats were most distinct (pairwise comparisons with lagoon and fore reef $R > 0.27$), and were characterised by high abundances of *Lamellodysidea herbacea*, *Cliona orientalis*, *Jaspis splendens*, *Haliclona* (*Reniera*) spNW2, *Monanchora unguiculata*, *Dysidea* cf. *granulosa* Bergquist, 1965 and *Stelletta clavosa* Ridley, 1884 relative to lagoon and fore reef slope habitats.

The composition of the sponge assemblages also varied significantly among reefs ($R = 0.17$, $P = 0.003$). When the analysis was performed on presence/ absence data, a clear separation of Scott Reef and Mermaid Reef stations was visible (Figure 4). However, no species were markedly characteristic of either reef.

In the species accumulation curve the number of species recorded did not reach an asymptote, indicating that additional stations would very likely yield more species of sponges (Figure 5). Non-parametric estimates of the total number of species ranged from 156 to 214 (Figure 5). However none of the methods had reached an asymptote, and so these figures should be considered estimates of the minimum number of species that could be present.

DISCUSSION.

This project has documented the sponge fauna of Mermaid, Scott and Seringapatam Reefs for the first time. The sponge fauna of the oceanic reefs on the northwestern margin of Australia was not known until a study by Hooper (1994), and this present study is the second in the region. This lack of knowledge of a major sessile fauna reflects the still poor state of knowledge of many marine taxa in the vast jurisdiction of Western Australia (12,500 km of coastline). Parts of Western Australia have been identified as biodiversity hotspots (Roberts *et al*., 2002) so the magnitude of the task of documenting the rich marine fauna of the State is massive at a time when the availability of taxonomists in Australia is at its lowest since the early 1900s (FASTS, 2007). Other sessile taxa never studied at these offshore atolls include the ascidians and bryozoa.

Hooper's study and the present study are not directly comparable as Hooper methods were qualitative and ours were quantitative. In addition, this study confined collection and reporting of sponge species from 0–15 m depth, whilst Hooper's study reported sponges to depths of 30 m. However, the total number of sponge species reported in this study, 132 species from 54 genera and 31 families is similar to the number of species reported by Hooper (1994) from Ashmore, Cartier and Hibernia: 138 species from 77 genera and 38 families. The greater number of genera reported from Hooper's study is now reduced due to recent changes in the taxonomy, for instance a number of the genera are now regarded as subgenera, eg. *Microciona, Thalysias, Strongylophora, Adocia,* and *Reniera*, and others have been synonymised, eg. *Pseudaxinella, Teichaxinella, Acervochalina, Pellina* and *Tethyopsilla*.

The species accumulation curves in this study indicate that additional species are likely to be found at these reefs. In particular, additional species are likely to occur in deeper waters not surveyed during this study, or at Seringapatam Reef where sampling intensity was lower.

This study found a high number of species unique to one of the three reef systems examined, and Hooper (1994) found that similarity between reefs was low: 13% similarity between Ashmore and Hibernia, 24% between Hibernia and Cartier,

Table 1 Sponge species recorded from Mermaid, Scott and Seringapatam Reefs, September 2006 (Total ind. = total number of individuals collected; cf. denotes species has close similarity to named species but requires comparison with the type specimen; NW prefix to species number denotes species collected in this study).

		Station numbers			
Family	**Species**	**Mermaid 1-16**	**Scott 17-40**	**Seringapatam 41-45**	**Total ind.**
Plakinidae	*Plakina* spNW1	1			1
	Plakortis nigra Lévi, 1953	1	1	1	276
	Plakortis spNW1		1	1	1
	Plakortis spNW2		1	1	6
Ancorinidae	*Jaspis* spNW1		1		1
	Melophlus sarassinorum Thiele, 1899		1		6
	Stelletta clavosa Ridley, 1884	1	1		69
	Jaspis splendens (deLaubenfels, 1954)	1	1	1	122
Geodiidae	*Erylus* cf. *lendenfeldi* Sollas, 1888	1			1
	Erylus cf. *amissus* Adams & Hooper, 2001			1	1
Tetillidae	*Cinachyra australiensis* Carter, 1881	1			13
	Paratetilla spNW1	1	1		10
	Craniella spNW1			1	1
Chondrillidae	*Chondrilla australiensis* Carter, 1873	1	1		11
Clioniadae	*Cliona orientalis* Thiele, 1900	1	1	1	65
	Cliona cf. *tinctoria* Schoenberg, 2000	1			1
	Cliona spNW1	1		1	2
	Spheciospongia vagabunda (Ridley, 1884)		1		6
Tethyidae	*Tethya* spNW1		1		1
Placospongiidae	*Placospongia* cf. *melobesioides* Gray, 1867		1		2
Theonellidae	*Theonella swinhoei* Gray, 1868		1	1	5
Axinellidae	*Axinella* spNW1		1	1	5
	Axinella spNW2	1			1
	Axinella spNW3		1		2
Desmoxyidae	*Higginsia* cf. *mixta* Hentschel, 1912		1		1
	Myrmekioderma granulatum (Esper, 1794)		1	1	8
Dictyonellidae	*Stylissa carteri* (Dendy, 1889)	1	1	1	17
	Stylissa massa (Carter, 1887)		1	1	18
Halichondriidae	*Hymeniacidon aurantium* (Kelly Borges & Bergquist, 1988)		1	1	18
	Hymeniacidon spNW1	1			15
	Hymeniacidon spNW2	1			5

	Halichondria spNW1	1	1		3
	Halichondria spNW2	1	1		51
	Halichondria spNW3		1	1	37
	Halichondria spNW4		1		2
	Halichondria spNW5			1	1
Agelasidae	*Agelas mauritiana* (Carter, 1883)	1	1	1	16
Desmacellidae	*Biemna* cf. *fortis* (Topsent, 1897)	1			2
	Biemna spNW1	1	1		2
	Biemna spNW2	1			20
Tedaniidae	*Tedania* cf. *anhelans* (Lieberkuhn, 1859)				1
Chondropsidae	*Chondropsis* spNW1	1	1		21
	Chondropsis spNW2	1			8
	Chondropsis spNW3	1		1	11
Myxillidae	*Iotrochota* cf. *coccinea* (Carter, 1886)		1	1	47
Acarnidae	*Zyzzya* cf. *criceta* Schoenberg, 2000		1		16
	Zyzzya cf. *fuliginosa* (Carter, 1879)		1		2
Microcionidae	*Clathria (Thalysias) reinwardti* Vosamer, 1880		1		1
	Clathria (Thalysias) cf. *cervicornis* (Thiele, 1903)		1		1
	Clathria spNW1	1			12
	Clathria spNW2		1		3
	Clathria spNW3		1		2
	Echinochalina (Echinochalina) cf. *intermedia* (Whitelegge, 1902)		1		2
	Echinochalina spNW1			1	13
	Echinoclathria spNW1		1		1
Rhabderemiidae	*Rhabderemia* cf. *indica* Dendy, 1905		1		2
Mycalidae	*Mycale* spNW1		1		35
Crambeidae	*Monanchora unguiculata* (Dendy, 1922)	1	1	1	254
Chalinidae	*Haliclona amboinensis* (Levi, 1961)		1	1	117
	Haliclona cymaeformis (Esper, 1794)		1	1	1
	Haliclona koremella deLaubenfels, 1954		1		2
	Haliclona cf. *viola* (deLaubenfels, 1954)	1			16
	Haliclona (Reniera) sp.		1		1
	Haliclona spNW1	1			2
	Haliclona (Reniera) spNW2	1	1		18
	Haliclona spNW3	1			2
	Haliclona spNW4	1	1		2
	Haliclona spNW5		1	1	55

Family	Species	Station numbers Mermaid 1-16	Scott 17-40	Seringapatam 41-45	Total ind.
	Haliclona (Reniera) spNW6		1		46
	Haliclona (Reniera) spNW7		1		1
	Haliclona (Reniera) spNW8		1		17
	Haliclona spNW9		1		122
	Haliclona spNW10		1		3
Niphatidae	*Amphimedon paraviridis* Fromont, 1993	1			2
	Amphimedon spNW1	1	1		5
	Gelliodes fibulata (Carter, 1881)	1	1	1	44
	Niphates cf. *nitida* Fromont, 1993	1			2
	Niphates spNW1	1	1	1	43
	Niphates spNW3	1			1
	Niphates spNW4		1		85
	Niphates spNW5		1		3
Callyspongiidae	*Callyspongia aerizusa* Desqueyroux-Faúndez, 1984		1	1	2
	Callyspongia spNW1		1		1
	Callyspongia spNW2		1		1
	Callyspongia spNW3		1		2
	Callyspongia spNW4		1		1
	Callyspongia spNW5		1		1
	Callyspongia spNW6			1	1
Petrosiidae	*Petrosia* spNW1	1	1		5
	Petrosia spNW2	1	1		7
	Petrosia spNW3	1	1		6
	Petrosia spNW4	1	1		5
	Petrosia spNW5	1	1		2
	Petrosia spNW6		1		1
	Petrosia (Strongylophora) cf. *durissima* (Dendy, 1905)	1	1	1	3
	Petrosia (Strongylophora) cf. *strongylata* (Thiele, 1903)		1	1	2
	Petrosia (Strongylophora) spNW1		1		1
	Petrosia (Strongylophora) spNW2		1		1
	Neopetrosia exigua (Kirkpatrick, 1900)	1	1	1	180
	Xestospongia bergquistia Fromont, 1991		1	1	5
	Xestospongia testudinaria (Lamarck, 1815)	1	1	1	16

	Xestospongia spNW1		1		1
	Xestospongia spNW2			1	1
Phloeodictyidae	*Aka* spNW1	1			8
	Aka cf. *paratypica* Fromont, 1993		1		22
	Aka spNW2		1		1
	Oceanapia macrotoxa (Hooper, 1984)	1			1
	Oceanapia spNW1	1			24
Spongiidae	*Spongia* spNW1		1		5
	Hippospongia spNW1		1		1
Thorectidae	*Hyrtios erecta* (Keller, 1889)	1	1	1	120
	Hyrtios spNW1	1			1
	Cacospongia spNW1		1		1
	Carteriospongia foliascens (Pallas, 1766)		1		16
	Dactylospongia cf. *elegans* (Thiele, 1899)		1	1	2
	Dactylospongia spNW1		1		7
Irciniidae	*Sarcotragus* spNW1	1		1	22
	Ircinia spNW1	1		1	6
	Ircinia spNW2		1		8
Dysideidae	*Lamellodysidea herbacea* (Keller, 1889)	1	1	1	1262
	Dysidea cf. *granulosa* Bergquist, 1965		1	1	96
	Dysidea spNW1	1			17
	Dysidea spNW3	1			11
	Dysidea spNW4	1	1		15
	Dysidea spNW5		1	1	2
	Euryspongia cf. *delicatula* Bergquist, 1995		1		3
Verongida	Verongid genus indet. spNW1	1			1
Aplysinellidae	*Suberea* spNW1	1	1		1
Class Calcarea	*Pericharax heterorhaphis* (Poléjaeff, 1883)	1	1	1	17
	Leucetta spNW1		1	1	7
	Calcarea spNW1		1		1
	Calcarea spNW2			1	3
	Calcarea spNW3	1		1	6
	Total number of species per reef	**60**	**96**	**43**	**3761**

Above: *Myrmekioderma granulatum* (Esper, 1794) at station 34, North Scott Reef. (Photo: John Huisman)

and 9% between Cartier and Ashmore. Similarity between reefs in this study were 12% between Seringapatam and Scott, 11% between Scott and Mermaid, and just 5% between reefs most distant from each other, Mermaid and Seringapatam. These results support the findings of Hooper (1994) that these oceanic reefs and atolls have different sponge faunas. We will be exploring explanations for this result in a separate publication (Fromont and Vanderklift, in prep.).

In this study the fauna at Mermaid Reef was distinct from that at Scott Reef and this is likely to be due to the large numbers of rare species found at each of the reefs: 48 species were found only at Scott Reef and 24 at Mermaid. The abundance data collected in this study allowed us to examine the uniqueness of sponge assemblages at a fine scale. Forty-four (33%) of the species reported were only found at one of the 45 stations examined suggesting that many species have very localized distributions. In addition, for a large number of the species found (74 of 132) very few individuals (≤5) were found in the 45 stations examined. This suggests that sponge communities of these reefs consist of a few abundant species, and many uncommon ones, and supports previous conclusions from other studies in both temperate and tropical regions that the majority of sponge species are rare (Fromont, 2003; McQuillan, 2006). The high number of species reported from only one station (33%) adds to the accumulating evidence that many sponge species are apparent endemics, i.e. found at a single locality (*sensu* Hooper and Kennedy, 2002; Fromont *et al.*, 2006).

These restricted distributions could be due to microhabitat requirements of sponge species (Zea, 2001). In addition, many sponges are now known to have relatively short-lived, and frequently demersal larvae unlikely to be capable of long range dispersal (Hooper, 1994; Maldonado and Bergquist, 2002). This is a life history characteristic that may contribute to the localized distribution patterns of most of the species in this study. Whatever the reasons for these restricted distributions and the

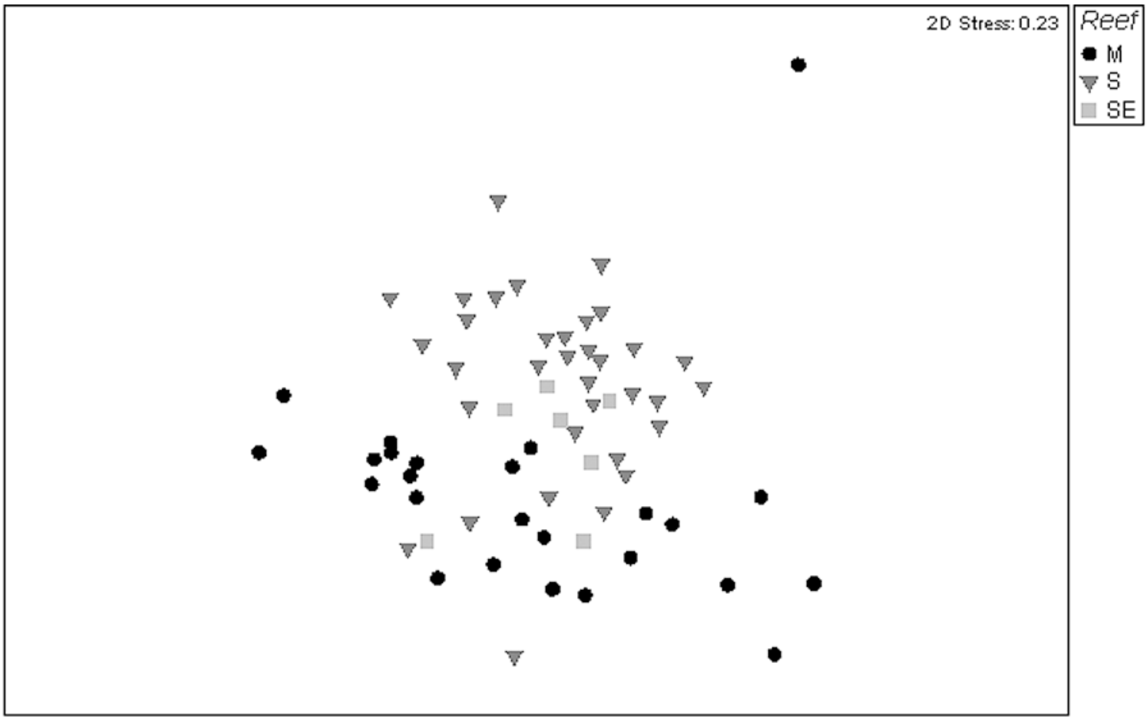

Figure 4 Non-metric multidimensional scaling ordination of subtidal stations surveyed, based on Bray-Curtis similarities calculated from presence/absence data, and classified by reef (M=Mermaid, S=Scott, SE=Seringapatam).

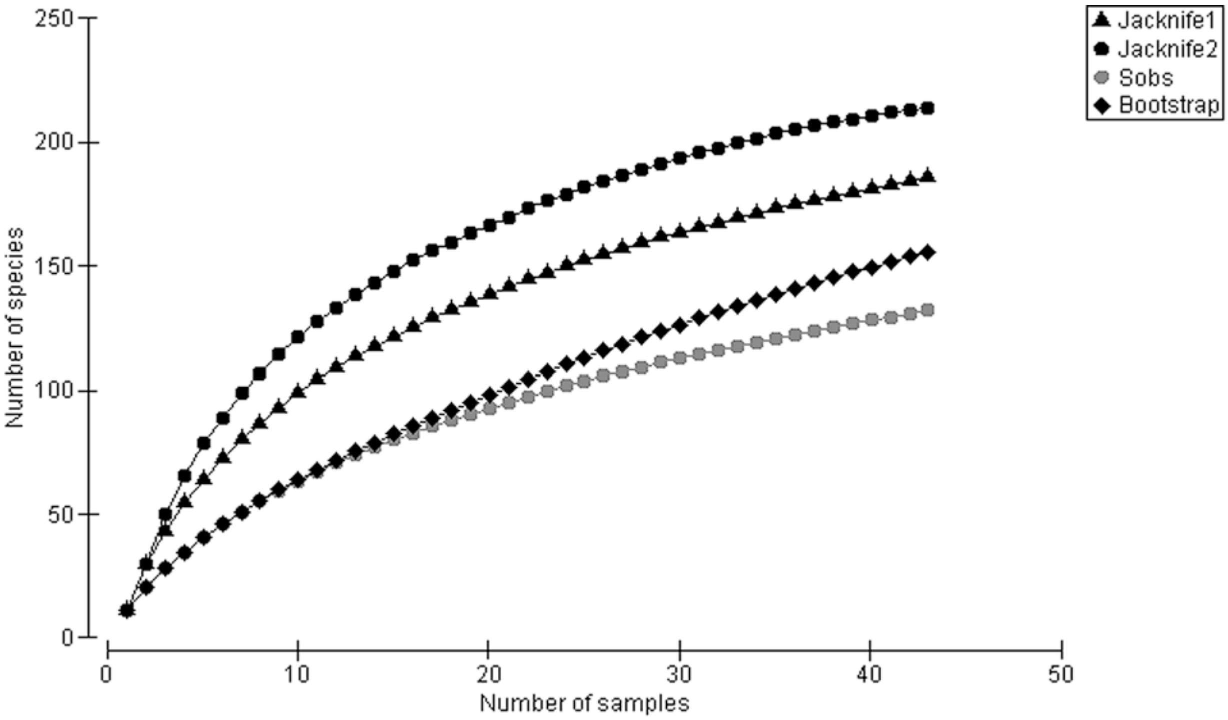

Figure 5 Species accumulation curve (Sobs) and estimated sponge diversity using three methods for estimating species richness. Jacknife1 = first-order jackknife; Jacknife2 = second-order jackknife.

Above: *Pericharax heterorhaphis* Poléjaeff, 1833: The most common calcareous sponge in the shallow subtidal at station 32, North Scott Reef. (Photo: John Huisman)

rarity of sponge species, it is likely to make these species vulnerable to environmental perturbations that may increase in occurrence with the impacts of climate change.

Some sponge species are capable of asexual modes of reproduction (Hooper, 1994), and this may, in part, explain the incidence of the few species (14 species) occurring at all three reefs.

Examination of sponge assemblages between habitats found that intertidal stations were distinctive, in large part due to the low sponge species richness in these habitats. Intertidal habitats at these reefs are extreme environments for sponges with low nutrient waters that get very warm in summer (up to 31°C, McKinney, pers. comm). Analysis of subtidal habitats found channels were distinctive from fore reef slope and lagoon habitats, due to high abundances of a few common species. These species tended to be encrusting or low-lying and thus able to withstand extreme flows that occur in high energy channel habitats (Bell *et al.*, 2006). Fore reef slope and lagoon habitats appeared to host similar species assemblages which included some of the more common species such as: *Plakortis nigra, Stelletta splendens, Monanchora unguiculata, Gelliodes fibulata, Xestospongia testudinaria* and *Hyrtios erecta*.

The preliminary nature of the species identifications does not allow for a detailed analysis of the species recorded and their biogeographic affinities. An enormous amount of detailed taxonomic work is required to determine if the species have been described in the historic tropical Indo-Pacific and Indian Ocean sponge literature, and to complete the identifications and describe the new species.

A large proportion of species from this and Hooper's study (81 and 77 species respectively) were not identified to known species making comparisons between the studies difficult. However, of the species that were fully identified (51 in this study and 61 in Hooper's study) only nine species were common to both studies. This finding supports the suggestion that the majority of sponge species are localized in their distributions.

A preliminary examination of the biogeography found that some of the common Indo-Pacific species that have been found at higher latitudes on the west coast (Dampier: Fromont, 2003) and during the collections undertaken at Ashmore, Cartier and Hibernia reefs (Hooper, 1994), were not found at the reefs examined in this study. No species of the genus *Ianthella* were found although the highest diversity of this genus is reported to be in tropical north-west Australia (Kelly Borges and Bergquist, 1995). Species of *Ianthella* were reported from Cartier and Hibernia by Hooper (1994) and Fromont (2003) in the Dampier Archipelago. A similar disjunction in species distributions is also apparent for other Indo-Pacific species such as: *Rhabdastrella globostellata* (Carter, 1883), *Reniochalina stalagmitis* Lendenfeld, 1888 , *Clathria (Microciona) aceratoobtusa* (Carter, 1887), and species of *Ectyoplasia* and *Echinodictyum.* Perhaps these species occur only in waters deeper than 15 m on these oceanic atolls, more shallow stations needed to be sampled to detect them, or they may not occur at these reefs. Only additional sampling at deeper depths and additional stations at shallow depths would determine if these species do occur at these atolls but were not found in this study.

Hooper (1994) also noted the presence of autotrophic sponges (capable of harnessing energy from symbiotic light requiring organisms resident in their tissues) at all three reefs he examined. These sponges were also found in this study with many of them being locally abundant. Autotrophic species reported from this study include *Lamellodysidea herbacea, Pericharax heterorhaphis, Chondrilla australiensis* Carter, 1886, *Haliclona cymaeformis* (Esper, 1794) and *Haliclona*

Above: *Gelliodes fibulata* (Carter, 1881) at station 31, North Scott Reef. (Photo: John Huisman)

Above: *Dysidea* in the shallow subtidal at station 26, South Scott Reef. (Photo: John Huisman)

koremella de Laubenfels, 1954. These symbioses are thought to enhance sponge growth rates and competitiveness in tropical shallow water environments (Wilkinson and Cheshire, 1989). Recently autotrophic sponges have been found to have an increased incidence in shallow tropical environments (Rutzler and Muzik, 1993) and may be competitive with other light requiring organisms (corals and clams) susceptible to bleaching. This study has documented abundance data for these sponges and may provide an important baseline for future monitoring of these coral reef sponges.

Other sponge species are known to infiltrate coral and these calcium carbonate bioeroders are thought to be increasing in incidence in some coral reef areas (Caribbean: Rutzler, 2002; Great Barrier Reef: Schoenberg, pers. comm). Four species of excavating sponges were reported in this study, and quantitative data on their distribution in these reefs is now available. The Indo-Pacific species, *Cliona orientalis*, is presently abundant (65 individuals found in this study), and the other three species are rare (between 1 to 6 specimens found in this study).

In conclusion, this study has documented the sponge fauna of three oceanic reefs in north Western Australia for the first time. Quantitative data are available to form a sound baseline for any future monitoring of these sponge species distributions and abundances.

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Above: Seringapatam Reef. An *Acropora* colony on a sand inundated reef probably caused from cyclonic activity. (Photo: Clay Bryce)

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A survey of the scleractinian corals at Mermaid, Scott, and Seringapatam Reefs, Western Australia.

David McKinney

Australian Institute of Marine Science Email: d.mckinney@aims.gov.au

Abstract – A diverse assemblage of scleractinian species was recorded during a rapid assessment of the shallow water coral taxa of Mermaid, Scott and Seringapatam Reefs. All taxa were predominately widespread Indo-Pacific species that present clear affinities with coral assemblages of Ashmore Reef and the Indonesian provinces to the north. A total of 269 scleractinian species from 57 genera in 14 families were recorded, comprised of 211 species at Mermaid Reef, 224 species at South Scott Reef, 201 species at North Scott, and 159 species at Seringapatam. The study yielded 22 new distribution records for Mermaid Reef, 18 new distribution records for Scott-Seringapatam, one new record for Western Australia (*Fungia moluccensis),* and one new record for the Rowley-Scott region *(Montipora digitata,* previously recorded from Ashmore Reef). Multivariate analyses indicated there were distinct communities within and among reefs associated with the reef front, lagoon, and intertidal reef flat habitats.

Keywords: Species richness, taxonomy, biogeography, disturbance.

INTRODUCTION

A considerable body of research has examined the ecology and distribution of the zooxanthellate scleractinia in coastal Western Australia. However, relatively few studies have investigated the coral biodiversity of the emergent shelf-edge atolls located in the oceanic region off the northwest continental mainland. Early taxonomic expeditions by the Western Australian Museum (WA Museum) documented the coral fauna of the Rowley Shoals, Scott Reef, and Seringapatam (Veron, 1986), and Ashmore Reef and Cartier Island (Veron, 1993; Veron and Marsh, 1988), while more recent taxonomic studies by Griffiths (1997) re-examined the corals of Ashmore Reef. Long-term monitoring of the region's coral resources by the Australian Institute of Marine Science (AIMS) including (Heyward *et al*., 1995, 1997; Heyward *et al*., 1999; Smith *et al*., 2004) and several predominately taxonomic-based surveys by Done *et al.,* (1994) and Wolstenholme and Smith (unpublished data), has resulted in a relatively deep understanding of the region's coral fauna and the accumulation of a considerable taxonomic inventory for the region.

The Rowley Shoals, Scott Reef and Seringapatam Reefs are influenced by a common suite of environmental variables, including large tidal regimes, warm sea surface temperatures, exposed aspects, and clear oceanic water inputs. However, differing geomorphological and physical characteristics between and within the major reef systems have resulted in heterogeneous physical habitats across exposed reef fronts, protected lagoons, and intertidal reef flats. These reef systems have also been impacted by several major disturbance events: in 1998, sustained elevated sea surface temperatures resulted in mass bleaching (Heyward *et al*., 1999; Smith *et al*., in review), and in 2004, category five Cyclone Fay resulted in widespread destruction of coral communities (Gilmour and Smith, 2006).

This study presents a preliminary rapid assessment of scleractinian species richness and abundance at Mermaid Reef (Rowley Shoals), South Scott, North Scott, and Seringapatam Reefs. The primary aims of this survey were to assess regional coral biodiversity, provide a quantitative assessment of abundance, execute a repeatable search effort that may afford future comparison between further surveys, and examine the taxonomic and biogeographical relationships of the complex mosaic of coral communities that exist in the region.

METHODS

Surveys were conducted at a series of stations that were selected using satellite imagery and historical records to maximize habitat diversity and to

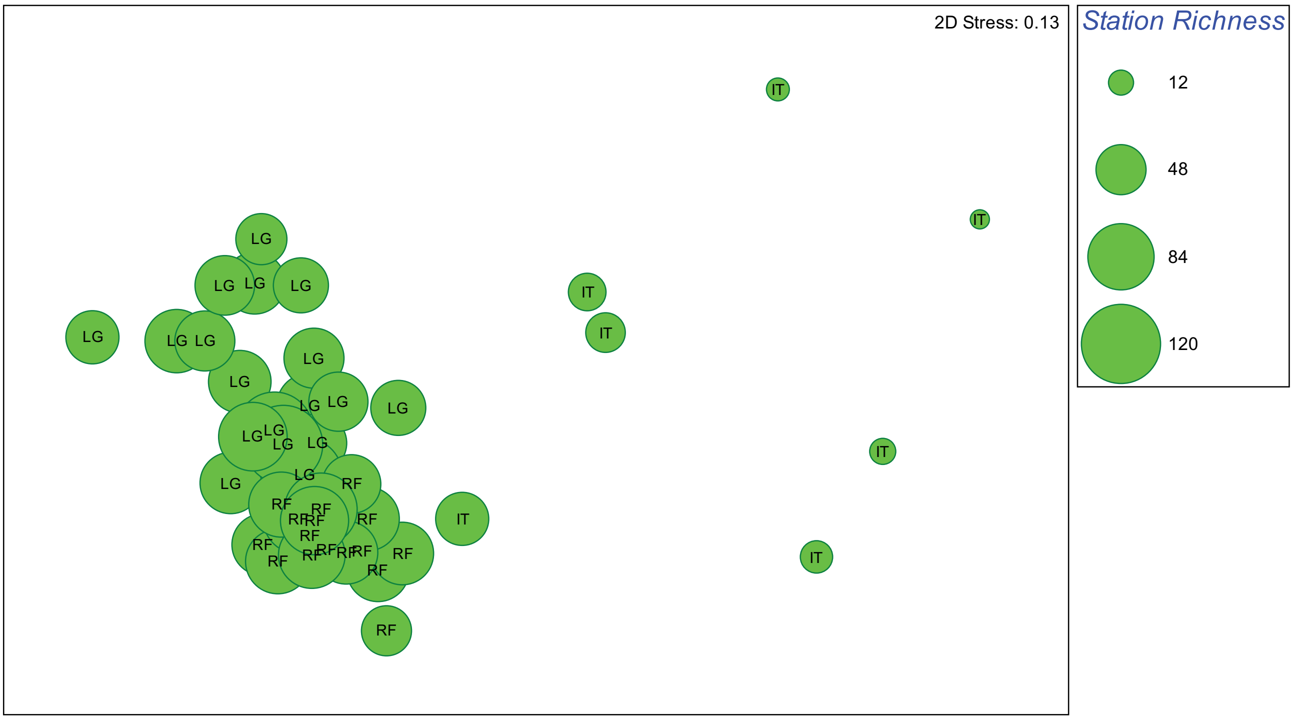

Figure 1 MDS ordination of 41 stations from Mermaid, South Scott, North Scott and Seringapatam, based on untransformed presence/absence and Bray-Curtis similarities. Station richness is superimposed over each station and the major habitat types are indicated: lagoon (LG), reef front (RF), intertidal reef flat (IT).

incorporate previous WA Museum and AIMS study sites. A total of 45 stations were surveyed by scuba, snorkelling and reef walking. A list of stations and habitat descriptions is presented in the Station and Transect Data section of this volume.

Surveys at each station were conducted along two 15 m x 1 m transects laid over the dominant habitat (typically parallel to the reef contour or reef crest) at approximately 5 m and 12 m depth, corrected to mean sea level. Transect depths were chosen to maximize species diversity and abundance by capturing the shallow reef slope between 3–6 m depth and the deeper reef slope at 10–14 m, as reported by Heyward for Scott Reef, (pers. comm.) and DeVantier *et al.*, in other locations (2006). Exceptions to the standard two transect method were stations 10, 13, 27, 40 (no transects were used, but surveyed for biodiversity), stations 29, 35, 42, 44 (one transect only used, plus 30 minutes additional search time), and stations 10, 13 (repeat survey at same location). Stations 10, 13, 27, 40 were excluded from all analyses due to non-standard search effort. Stations were scored against a series of habitat descriptors (refer Table 4), and a two-tiered survey approach was utilized at each station to assess biodiversity and abundance respectively.

Tier One: The presence of all species encountered along each transect was recorded during a visual survey. Additional search time to a maximum of 10 minutes per station was used to supplement sightings along the transects. Additional searches were conducted haphazardly, adjacent to, and between, transects. Opportunistic sightings, made outside the transect area or during additional search time, were recorded separately as extra sightings.

Station richness (defined as the total number of discrete species recorded at each station) was calculated by aggregating the number of species sighted along the transects, with those recorded during extra time or opportunistically off the transect.

Tier Two: Quantitative estimates of abundance at functional group levels were generated by video transect analysis, with estimates of percentage cover assigned to each group. Refer to, *The subtidal habitats of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia.* (this volume) for further discussion of these methods and analyses of these data.

Coral taxa on visual surveys were identified *in situ* to species level, or where identification could not be resolved, a voucher specimen was collected for further taxonomic analysis at WA Museum. Voucher specimens were bleached in calcium hypochlorite, then washed in seawater before being dried and packed for shipping.

Corals were identified using Veron (2000; 2002) and Veron and Stafford-Smith (2002), with the exception of the genus *Acropora* which follows

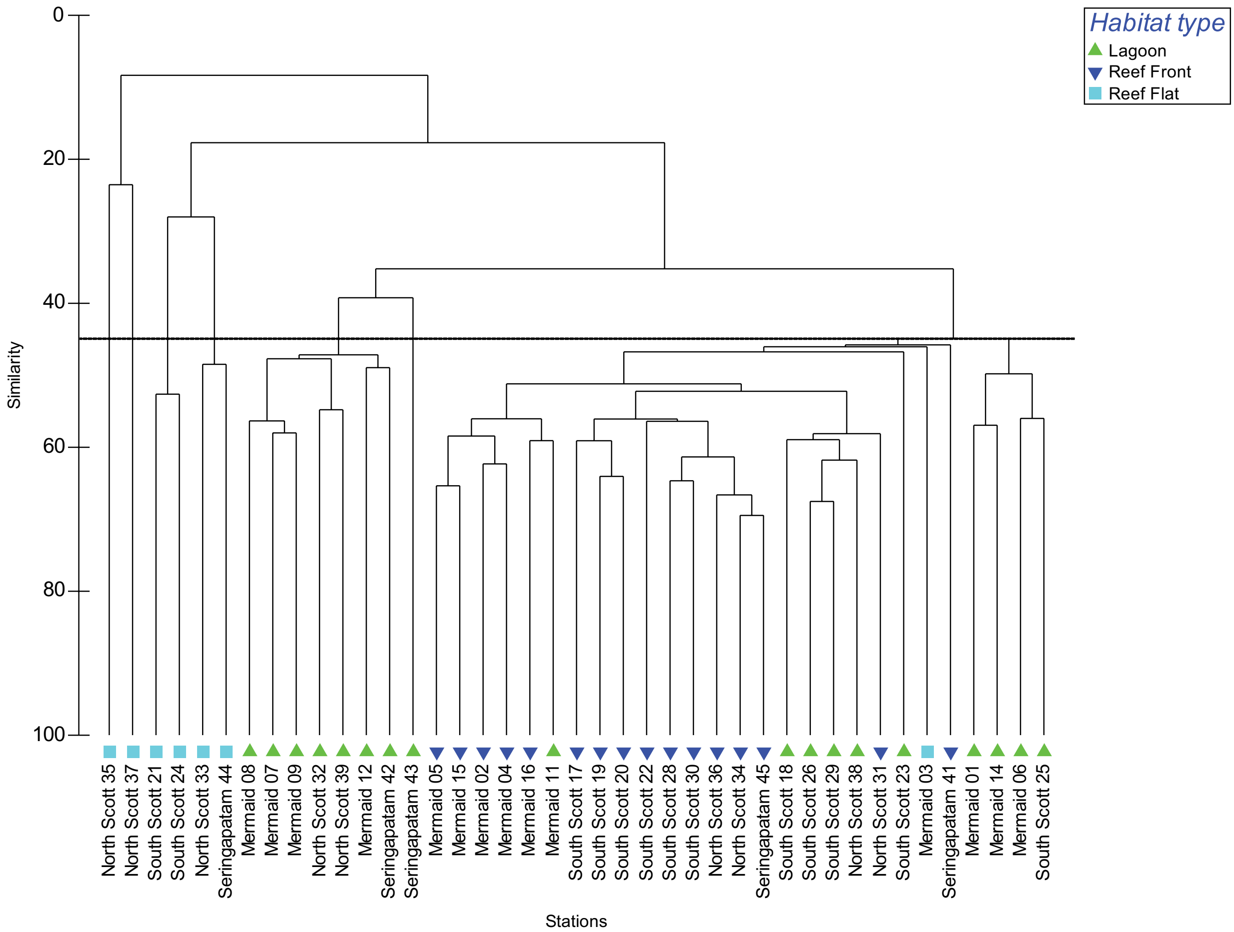

Figure 2 Dendrogram for hierarchical clustering of 41 stations at Mermaid, South Scott, North Scott and Seringapatam, using group-average linking of Bray-Curtis similarities, calculated on untransformed presence/absence data. A similarity level of 45% is indicated.

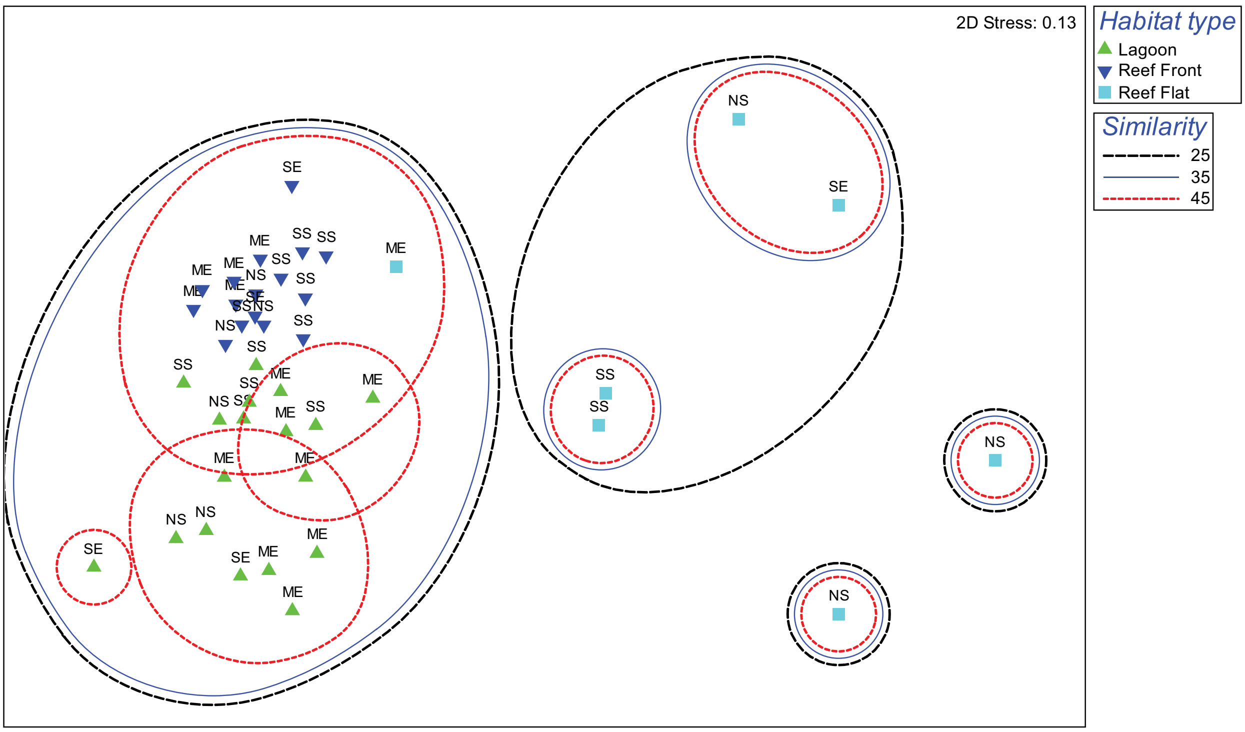

Figure 3 MDS ordination of 41 stations at Mermaid, South Scott, North Scott and Seringapatam, based on untransformed presence/absence data and Bray-Curtis similarities. Similarity contours from the cluster analysis at 25%, 35%, and 45% are indicated.

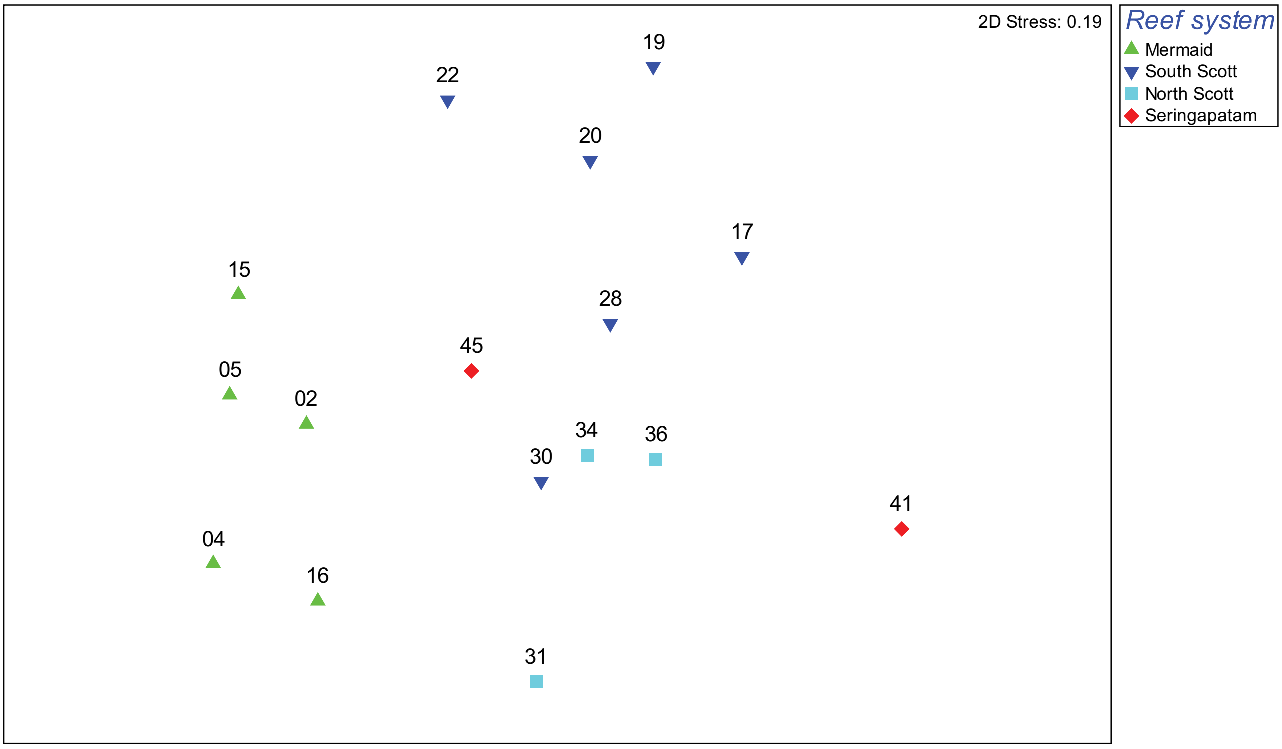

Figure 4 MDS ordination of 16 reef front stations at Mermaid, South Scott, North Scott and Seringapatam, based on untransformed presence/absence data and Bray-Curtis similarities.

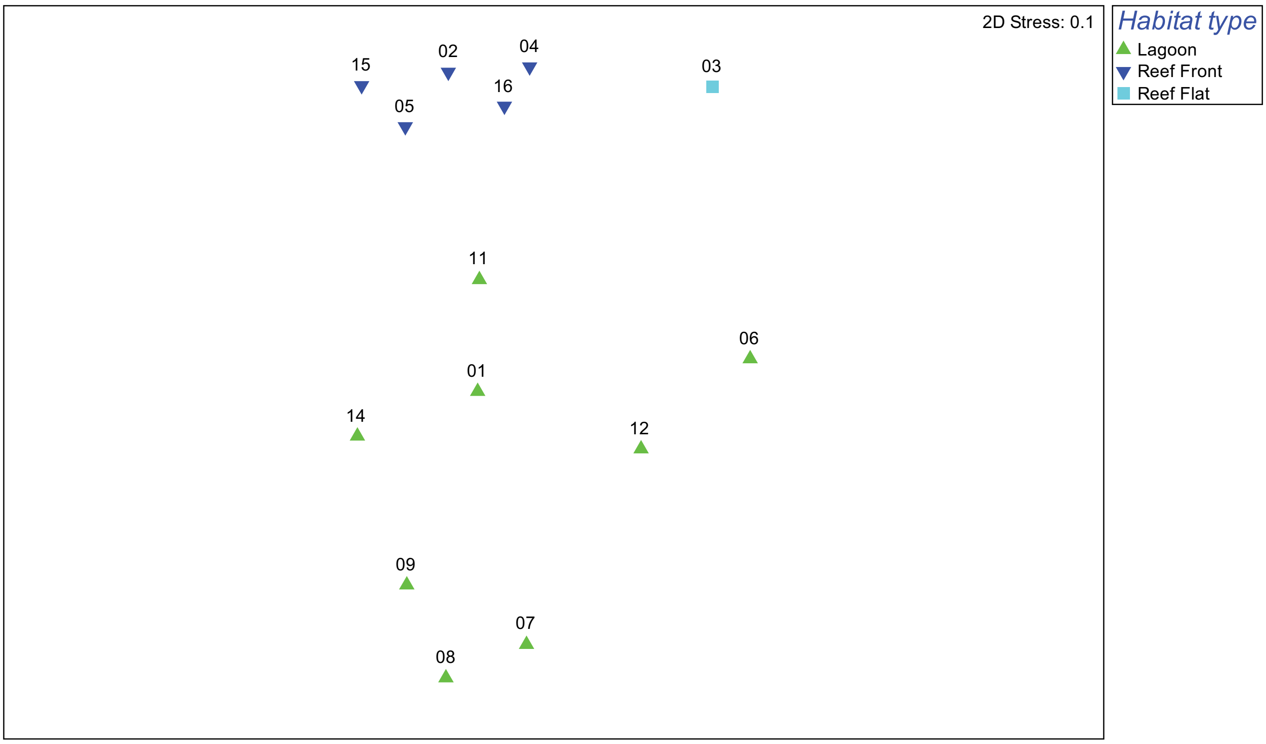

Figure 5 MDS ordination of 14 Mermaid stations, including reef front, lagoon, and intertidal reef flat habitats, based on untransformed presence/absence and Bray-Curtis similarities.

Left: Surveyed stations in Mermaid Reef lagoon displayed only minor cyclone damage; **Right:** The hard corals, *Seriatopora* (branching) and *Turbinaria* (encrusting) in the lagoon at Scott Reef. (Photos: Clay Bryce)

Wallace (1999) excluding *A. exquisita*, and the Fungiidae which follows Hoeksema (1989). Veron and Pichon (1975; 1980; 1982), Veron, Pichon and Wijsman-Best (1977), Veron and Wallace (1984) were also used to aid identification. The non-scleractinian species *Heliopora coerulea*, *Tubipora musica* and genus *Millepora* were also recorded during this survey.

Multivariate analyses of the two-way crossed survey design with replicates were performed using the software application PRIMER v6. A detailed discussion of these methods is provided in Clarke and Gorley (2006) and Clarke and Warwick (2001).

Deep and shallow transect data were aggregated in all analyses, as patterns of zonation with depth were relatively obscure within the higher-level patterns of habitat and reef system community similarity.

RESULTS

A total of 269 scleractinian species from 57 genera in 14 families were recorded during the present survey, comprised of 211 species at Mermaid, 224 species at South Scott, 201 species at North Scott, and 159 species at Seringapatam (Table 1).

The study yielded new distribution records for 22 species at Mermaid Reef and 18 species at Scott/Seringapatam. All new distribution records were small range extensions between individual reef systems in the Rowley-Scott complex, with the exception of *Fungia moluccensis*, a new record for Western Australia, and *Montipora digitata*, previously recorded from Ashmore Reef.

Station richness

Station richness recorded at all reef systems ranged from seven to 116 species per station (Table 1). Overall richness averaged 68 species per station, with mean values of 70 at Mermaid, 76 at South Scott, 60 at North Scott, and 55 at Seringapatam (Table 2). Intertidal stations were consistently depauperate (mean station richness = 23), while reef front and lagoon stations had relatively high station richness (mean richness = 77) (Figure 1). South Scott had four of the five highest station richness values recorded during the survey.

Nine of the 41 stations surveyed had high station richness (>80 species per site), 23 stations had medium station richness (>50 species), 6 stations had low richness (20–50 species), and three stations had very low richness (<20 species). Many of the species recorded were relatively rare, with 21 species recorded only once during the survey. A large proportion of species were uncommon, with 169 species recorded at less than 10 stations. 22 species were abundant and were recorded at more than 25 stations.

Left: Mermaid Reef. Branching *Acropora* and massive *Porites* corals; **Right:** Scott Reef. *Acropora* coral. (Photos: Clay Bryce)

Left: Mermaid Reef. *Fungia* mushroom corals surround the coral *Pectinia lactuca* (Pallas, 1766); **Right:** *Goniopora* sp., with tentacles extended, was common on all reefs. (Photos: Clay Bryce)

Community classification

Multivariate classification and non-metric multi-dimensional scaling (MDS) analyses showed strong clustering of stations based on similarities among and within reef systems and habitat types (Figure 2, 3).

Among reefs, strong clustering of stations occurred with habitat type. That is, habitat type was associated more strongly with community similarity than reef system location (Figure 3). Reef front stations were closely related between all reef systems, with Mermaid, South Scott, North Scott and Seringapatam reef front sites all strongly similar. Lagoon communities also clustered strongly, albeit it less than reef front stations, while intertidal reef flat stations clustered very weakly. Reef front and lagoon communities were more similar to each other than to intertidal communities.

Reef front stations at Mermaid were most closely related to reef front stations at North Scott. Reef front stations at South Scott were most closely related to reef stations at North Scott. Reef front stations at North Scott were intermediate between Mermaid and South Scott. Reef front stations at Seringapatam showed mixed affinities with Mermaid, South Scott, and North Scott.

Lagoon stations at Mermaid were most closely related to a mix of lagoon stations at South Scott, North Scott and Seringapatam. Some Mermaid lagoon stations tended towards reef front communities. Lagoon stations at South Scott presented mixed affinities with lagoon stations at Mermaid, and were closely related to all reef front stations. Lagoon stations at North Scott were most closely related to lagoon stations at Mermaid and South Scott. Lagoon stations at Seringapatam were closely related to lagoon stations at North Scott and Mermaid.

Intertidal reef flat communities were strongly dissimilar to both reef front and lagoon communities, with the exception of the Mermaid reef flat station, which was closely related to all reef front stations and South Scott in particular. Intertidal stations at South Scott, North Scott and Seringapatam were related only loosely.

Within each of the major habitat-associated communities, distinct reef system sub-communities were present. Each habitat community was typically comprised of several smaller clusters of stations belonging to each of the different reef systems. For example, within the major reef front

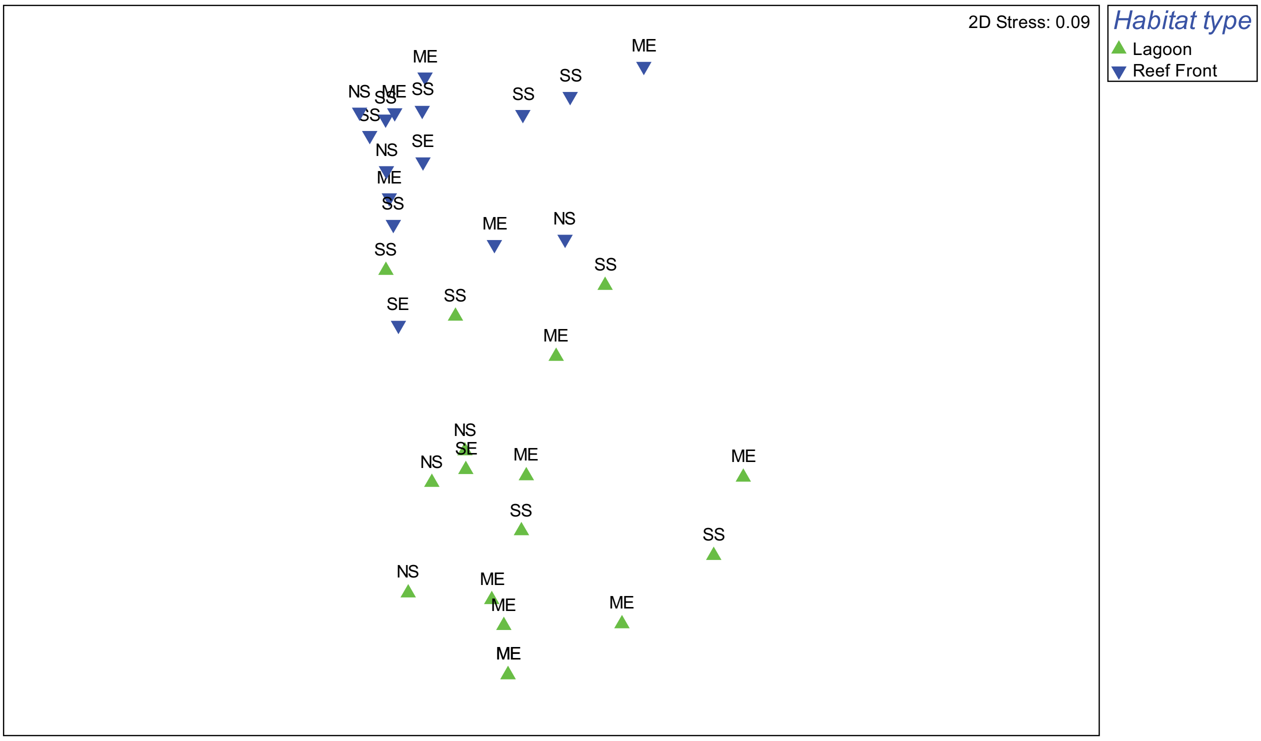

Figure 6 MDS ordination of 32 stations at Mermaid, South Scott, North Scott and Seringapatam, based on untransformed percent cover estimated from video transects, and Bray-Curtis similarities. Intertidal reef flat stations were not surveyed by video.

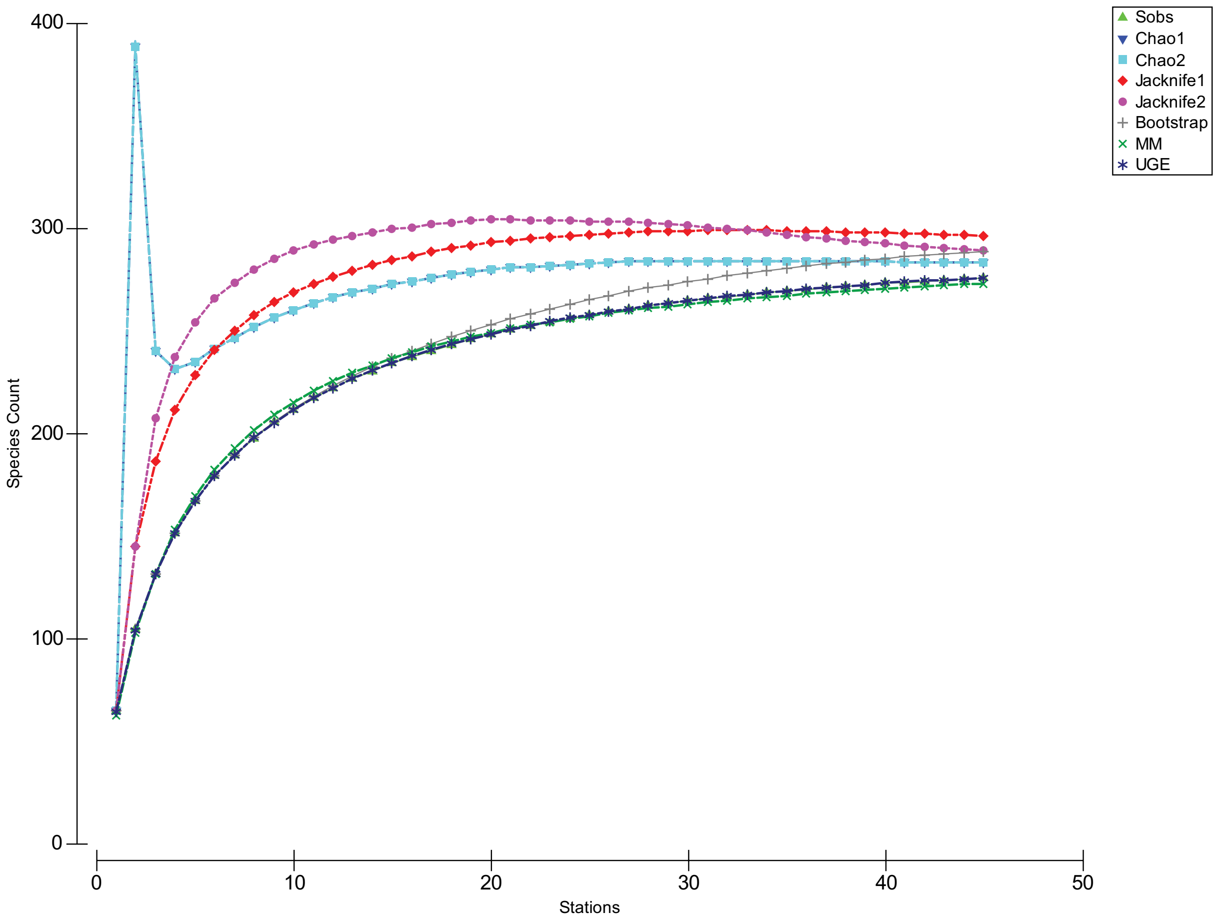

Figure 7 Combined species-area curve for all stations at Mermaid, South Scott, North Scott, and Seringapatam. Actual species counts are indicated (Sobs), as are projected values from Bootstrap, Jack-knife, Chao, and Michaelis-Menton models.

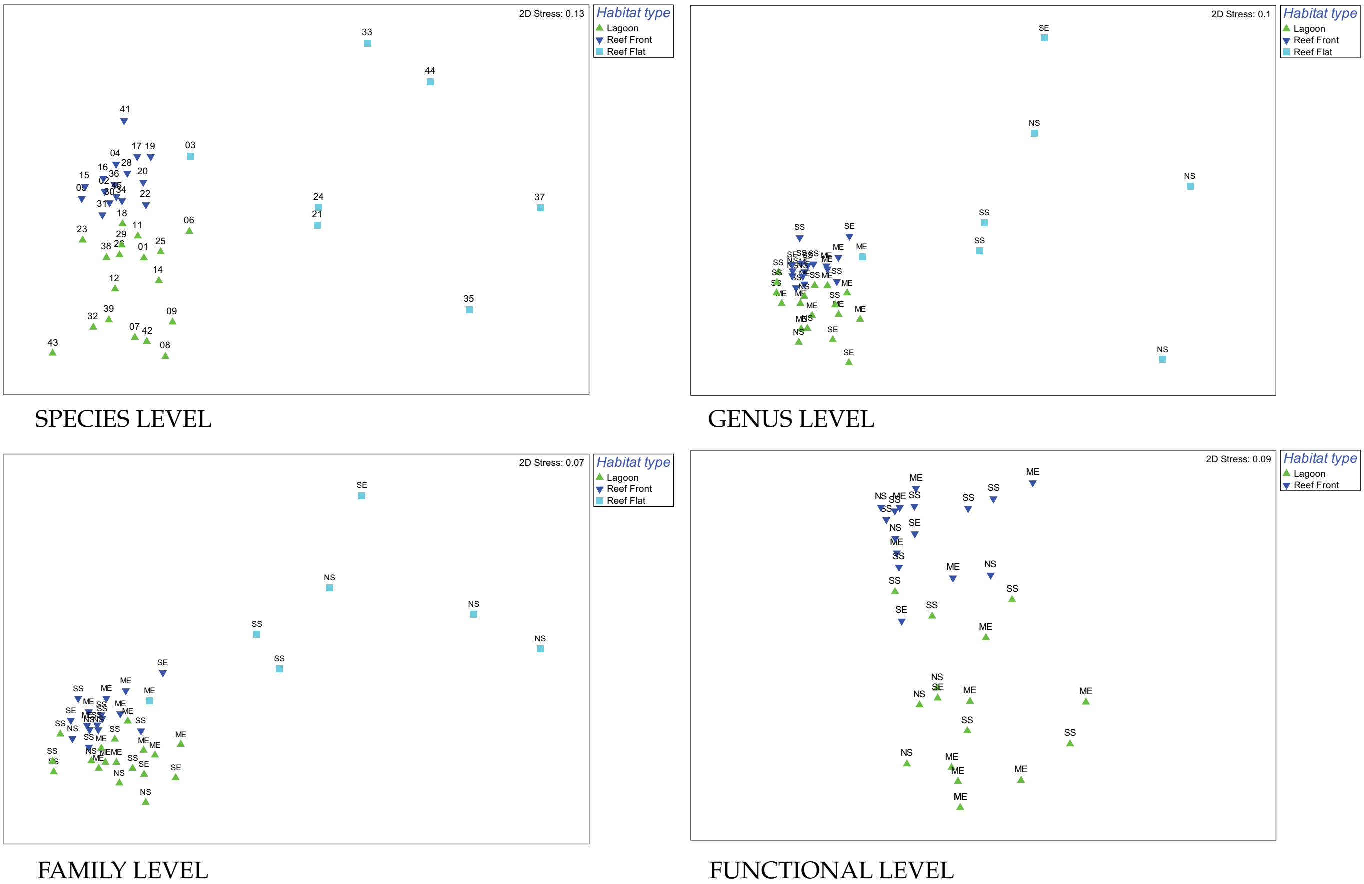

Figure 8 MDS ordinations of 41 stations at the species, genus, family, and functional group levels, based on untransformed presence/absence data and percent cover, with Bray-Curtis similarities. Intertidal reef flat stations were not surveyed by video and are therefore excluded from the functional group level MDS.

cluster, Mermaid communities were distinct from the South Scott and North Scott communities, which were in turn similar to each other, while Seringapatam showed mixed affinities with Mermaid, South Scott and North Scott (Figure 4). These patterns of intra-habitat reef system segregation were repeated in the lagoon-associated communities across the four major reef systems. Intertidal reef flat segregation relationships were unclear.

Patterns of similarity were also apparent within individual reef systems, with distinct habitat-associated communities occurring within each reef. Within the Mermaid reef system, lagoon sites were clearly distinct from reef sites (Figure 5). The intertidal station was also distinct from the reef front sites. These patterns of intra-reefal habitat segregation were repeated in lagoon- associated communities across the four major reef systems.

Pair-wise analysis of similarity tests for differences between all habitat types were statistically significant ($p<1\%$), with R scores ranging from 0.716 to 0.935. Pair-wise tests for differences between all reef systems were also statistically significant ($p<1\%$), with the exception of the North Scott-Seringapatam pair. R scores ranged from 0.344 to 0.657. Complete analysis of similarities (ANOSIM) test values are given in Table 3.

Benthic Cover

Analyses of video transect data also showed strong clustering of communities at the functional group level associated with the lagoon and reef front habitats (Figure 6). Within the lagoonal cluster, smaller sub-clusters were associated with the Mermaid and North Scott reef systems. Mermaid and North Scott were similar to each other, while South Scott and Seringapatam were loosely grouped, with no clear affinities to other reef systems. Within the reef front cluster, no clear patterns were associated with any single reef system. Rather, the four reef systems showed mixed affinities with each other while remaining distinct from the lagoon communities. Intertidal reef flat transects were not surveyed by video, therefore no analyses could be performed for this habitat.

Hard coral cover was highest at Mermaid (29%), followed by South Scott (21%), North Scott (17%), and Seringapatam (16%). Hard coral cover was highest in the reef front habitats (25%) followed by the lagoon habitats (22%).

Habitats

Habitat descriptor scores for each station are given in Table 4. The major species that typify the lagoon, reef front, and reef flat habitats are given in Table 5, as are the major species that discriminate between each habitat group. The major functional groups that typify the lagoon, reef front, and reef flat habitats are given in Table 6, as are the major functional groups that discriminate between each habitat group.

Lagoon stations were characterised by protected sandy floor or mixed reef and rubble habitats, interspersed with isolated outcrops and bommies, simple, regular structural features, low wave energy, low to medium water clarity, and flat or low slopes, to 10–20m deep. Key groups of taxa were the branching Acroporas, and massive non-Acroporas.

Reef front stations were characterised by exposed coral and coralline algae covered limestone platforms, complex, irregular structural features, medium to high wave energy, medium to high water clarity, and steep slopes to a terrace at 12–18m before an abrupt drop-off to very deep water. Key groups of taxa were the non-branching Acroporas and encrusting or massive non-Acroporas.

Intertidal reef flat stations were characterised by exposed combinations of reef crest zones, submerged elements of mixed reef, rubble, pavement and patch reefs, simple, regular structural features, medium to high wave energy, and extensive exposed reef flats at low tide. Key groups of taxa were the massive non-Acroporas, particularly *Porites* species.

Species-area curves

The cumulative species richness curve for the aggregated regional pool of the four major reef systems was close to reaching an asymptote, with few new discrete species encountered with additional station sampling in the region (Figure 7). However, examination of species-area curves for each separate reef system showed that individual

Above: An *Acropora* forest in the lagoon of Mermaid Reef. (Photo: Clay Bryce)

Above: The brooding coral, *Stylophora pistallata* Espar, 1797 (Photo: Clay Bryce)

reef species accumulations had not yet approached an asymptote, with new species continuing to be encountered with additional sampling. Estimates of the total number of species likely to be recorded in the Rowley-Scott region range from 273 to 296, based on a combination of Bootstrap, Jackknife, Chao, and Michaelis-Menton extrapolation models (Figure 7).

Aggregated taxonomic levels

MDS on aggregated taxonomic data at the levels of species, genus, family, and functional group showed similar community assemblages across multiple taxonomic levels, with the same overall patterns of community assemblages by site type and reef system (Figure 8). The species level data provide a detailed representation of community relatedness, with smaller sub-communities apparent at the species level, while genus and family level data display relatively similar, if less detailed, representations of relatedness. Functional group data provided a less clear picture of community relatedness.

Transect Ratio

The ratio of transect sightings to total sightings ranged very widely from 0% to 94%. Reef front and lagoon stations presented high ratios (79% and 74% respectively), while intertidal reef flat stations presented very low ratios (mean 32%), often with all records made off the transect (Table 2).

DISCUSSION

The total number of species recorded during this survey combined with historical survey records brings total species richness for the oceanic Rowley-Scott atolls to 291 species. Local biodiversity is therefore considerably less than the approximate 600 species found in the 'Coral Triangle' area of highest diversity centered around the Philippines, Indonesia, and Papua New Guinea (Donnelly *et*

Above: Corals from the family Acroporidae are dominant at Mermaid Reef. (Photo: Clay Bryce)

al., 2003; Erdmann and Pet-Soede, 2003; Green and Mous, 2004; Mous *et al*., 2005). Mermaid, Scott, and Seringapatam are therefore best described as a subset of Ashmore Reef (256 species), with neighbouring oceanic reef systems predominately sharing a complement of similar overlapping species.

South Scott had the highest mean station richness and included many of the highest station richness values recorded during the survey. South Scott also had the second highest percent cover of hard coral. Conservation values at South Scott, based on hard coral diversity and abundance, are therefore considerable. Seringapatam presented low levels of biodiversity, however this is most likely related to the very low levels of sampling employed (5 stations).

Aggregated distribution data for the northern reef group of Scott and Seringapatam, and southern Mermaid Reef support a net attenuation of species diversity across the latitudinal gradient from Indonesia towards Western Australia, consistent with the broad-scale latitudinal variability in scleractinian community assemblages documented by Veron (2000) and DeVantier *et al.,* (2006), and the larger global distribution themes presented by Mora and Robertson (2005). Cross-shelf gradients are strong in the northwest region, with the coral assemblages of the oceanic atolls being markedly different to those recorded from reefs in the inshore Kimberley region.

Multivariate analyses describe distinct communities associated with each of the reef front, lagoon, and reef flat habitats, as well as with the individual Mermaid, South Scott, North Scott, and Seringapatam reef systems. Communities were strongly dissimilar between habitats, and less distinct between reefs. Delineation of smaller community assemblages within the larger overall patterns of habitat and reef associated communities requires further analysis.

Coral communities in the region are clearly the product of response to a dynamic disturbance regime, that is compounded at varying spatial and temporal scales and intensities. Recent research in Western Australia suggests that disturbance regimes strongly influence site-scale species abundance and community assemblage structure, with severe disturbances resulting in the local reduction of coral abundance and shifts to alternate suites of coral assemblages (Smith *et al*., in press; Smith *et al*., in review; Smith *et al*., 2004).

The strong variability in scleractinian biodiversity recorded during this survey should be interpreted in the context of the complex suite of physical, biological, and anthropogenic forces that govern coral reef community structure. Isolation of the northwest oceanic atoll reefs, interdependencies with adjacent ecosystems, shelf-edge location and geomorphology, micro-habitat heterogeneity, larval transport and recruitment, gene flow, species interactions, and changing disturbance regimes,

Above: Scott Reef. Close up detail of the free living *Fungia* mushroom coral. (Photo: Clay Bryce)

are all likely to have shaped the faunal assemblages encountered in the region.

Thus, the nature of the strong association observed between habitat and community structure cannot be attributed to any single key driver. Rather, further investigation is required to determine the relative contributions of each of the above factors to the overall patterns of biodiversity and abundance recorded in the region. Recent studies by AIMS (Smith *et al*., 2004) suggest that recruitment and gene flow processes in the region may be largely driven at local, within-reef scales, rather than on a regional scale in which the atolls were suggested as stepping stones through a larger bio-geographic province. It is likely that other complex patterns of relatedness, biodiversity, and community structure will be revealed with further research.

The strong effect of search effort on species richness capture during a survey is well known (Clarke and Warwick, 2001) and search effort is therefore a critical variable between studies. Most previous studies have tended to utilize a haphazard timed swim over a non-defined area to capture coral species richness at a station. These techniques may represent unequal search effort, and interpretation of results between these studies may therefore be limited.

Analyses in the present survey also suggest that the efficacy of different search methods may be strongly affected by patterns of local-scale variability and microhabitat heterogeneity. Station richness during the survey was influenced strongly by the presence or absence of microhabitats within the sampled area, and the power associated with low transect replication was often insufficient to accurately capture community structure. Intertidal reef flat communities, which were typically characterised by low diversity and abundance, had very high proportions of species recorded off the transect. In contrast, the use of transects at reef front and lagoon stations, with a short period of additional search time, were relatively effective in capturing the major components of station biodiversity. These problems of scale and patchiness, and the adequacy of transect replication, are therefore critical to the successful design and development of future sampling regimes and monitoring programs. Further research is needed to determine appropriate sampling scales and levels of replication for the large and complex reef systems encountered in the northwest oceanic atolls. Future analysis of transect species-area curve data collected during this survey will be useful in this context.

Species-area curve analyses at the level of individual reef systems did not reach an accumulation asymptote, suggesting a restricted estimate of the within-reef species pools. This is supported by the large number of new distribution records for the Rowley Shoals and Scott Reef. On a larger scale, the combination of the Mermaid, South

Scott, North Scott, and Seringapatam richness data came close to reaching an asymptote, suggesting that total richness recorded during this survey may be close to total richness for the oceanic atolls. Further sampling, including examination of stations at Clerke and Imperieuse Reefs in the Rowley Shoals, would likely result in the upward revision of total biodiversity towards that predicted by the species-curve extrapolation models.

Non-metric MDS analyses on transect data aggregated to the higher taxonomic levels of genus and family presented strong similarities to that of data analysed at species level. Higher-level taxonomic analyses may therefore represent a useful tool to detect key patterns of change in local community assemblages (Olsgard *et al.*, 1998; Somerfield and Clarke, 1995). The power of such analyses remains to be determined, and while video transect analysis at the functional group level showed mixed results, Edinger and Risk (2000) reported successful prediction of coral reef conservation values based on morphological rather than taxonomic classification.

Further examination of voucher specimens collected during this survey is required and may result in additional records for the region. Ongoing review of the historical survey data is also required, as the major taxonomic revisions associated with the release of Veron (2000; 2002) resulted in the re-classification of several species recorded during historical surveys. Finally, recent methods in molecular phylogenetics suggest that the conventional taxonomic relationships used in this study may also undergo considerable revision in the future (Fukami *et al.*, 2004).

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Appendix

Table 1 Species recorded at Mermaid, South Scott, North Scott and Seringapatam Reefs, 2006. New records at Rowley Shoals are noted with [R]. New records at Scott Reef are noted with [S]. Species previously recorded in the region and not found during the present survey are noted with [P].

		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Acroporidae																	
Acropora abrolhosensis	Veron, 1985	1					1	1	1	1			1		1		
Acropora abrotanoides	(Lamarck, 1816)										1						
Acropora aculeus	(Dana, 1846)					1										1	
Acropora acuminata	(Verrill, 1864)																
Acropora anthocercis	(Brook, 1893)	1												1		1	
Acropora aspera	(Dana, 1846)														1		
Acropora austera	(Dana, 1846)													1			
Acropora carduus[R]	(Dana, 1846)	1						1	1	1					1		
Acropora caroliniana[S]	Nemenzo, 1976					1									1		
Acropora cerealis	(Dana, 1846)					1		1			1		1		1	1	
Acropora clathrata	(Brook, 1891)	1										1	1				
Acropora cytherea	(Dana, 1846)											1					
Acropora digitifera	(Dana, 1846)	1		1			1								1		
Acropora divaricata	(Dana, 1846)																
Acropora donei	Veron and Wallace, 1984													1			
Acropora echinata	(Dana, 1846)								1	1							
Acropora elseyi	(Brook, 1892)	1													1		
Acropora exquisita	Nemenzo, 1971	1						1	1				1				
Acropora florida	(Dana, 1846)	1					1	1	1	1		1	1		1		
Acropora gemmifera	(Brook, 1892)			1	1	1	1						1			1	
Acropora glauca	(Brook, 1893)										1						
Acropora grandis	(Brook, 1892)					1	1		1						1		
Acropora granulosa[R]	(Milne Edwards and Haime, 1860)		1			1								1			
Acropora horrida	(Dana, 1846)	1											1				
Acropora humilis	(Dana, 1846)	1	1	1		1	1	1		1	1	1	1		1	1	
Acropora hyacinthus	(Dana, 1846)	1		1		1	1				1		1	1	1	1	
Acropora indonesia	Wallace, 1997																
Acropora intermedia	(Brook, 1891)	1				1	1	1	1	1		1	1		1		
Acropora kimbeensis[P]	Wallace, 1999																
Acropora kirstyae[P]	Veron and Wallace, 1984																
Acropora latistella	(Brook, 1891)										1					1	
Acropora listeri	(Brook, 1893)			1	1						1						
Acropora loisetteae[R]	Wallace, 1994							1		1					1		
Acropora longicyathus	(Milne Edwards and Haime, 1860)	1															
Acropora loripes	(Brook, 1892)		1		1						1			1		1	1
Acropora lutkeni	Crossland, 1952										1						
Acropora microclados	(Ehrenberg, 1834)					1					1			1			1
Acropora microphthalma	(Verrill, 1859)	1					1	1	1	1		1			1		
Acropora millepora	(Ehrenberg, 1834)	1	1	1			1					1		1	1	1	
Acropora monticulosa	(Brueggemann, 1879)	1	1	1	1									1	1	1	1
Acropora muricata	(Linnaeus, 1758)	1	1					1		1		1			1		

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Acropora nana	(Studer, 1878)	1				1											
Acropora nasuta	(Dana, 1846)	1	1		1	1			1	1	1	1	1		1	1	1
Acropora paniculata	Verrill, 1902																
Acropora pichoni	Wallace, 1999																
Acropora polystoma	(Brook, 1891)		1		1	1					1					1	
Acropora pulchra	(Brook, 1891)							1	1	1					1		
Acropora robusta	(Dana, 1846)			1	1											1	1
Acropora samoensis	(Brook, 1892)	1									1				1		
Acropora secale	(Studer, 1878)																
Acropora selago	(Studer, 1878)				1	1											
Acropora spicifera	(Dana, 1846)	1	1	1	1	1	1				1	1	1			1	1
Acropora striata[P]	(Verrill, 1866)																
Acropora subglabra	(Brook, 1891)							1	1						1		
Acropora subulata	(Dana, 1846)																
Acropora tenuis	(Dana, 1846)	1	1		1	1	1	1		1	1	1	1		1	1	
Acropora valenciennesi	(Milne Edwards and Haime, 1860)																
Acropora valida	(Dana, 1846)	1		1		1								1	1		
Acropora vaughani	Wells, 1954														1		
Acropora yongei	Veron and Wallace, 1984														1		
Anacropora puertogalerae[P]	Nemenzo, 1964																
Astreopora cucullata[S]	Lamberts, 1980					1						1	1				
Astreopora expansa	Brueggemann, 1877				1	1								1		1	
Astreopora gracilis	Bernard, 1896																
Astreopora incrustans[R]	Bernard, 1896	1					1		1								
Astreopora listeri[S]	Bernard, 1896							1									
Astreopora myriophthalma	(Lamarck, 1816)	1					1	1	1	1			1		1	1	
Astreopora ocellata	Bernard, 1896																
Isopora brueggemanni	(Brook, 1891)	1			1	1	1	1	1	1		1	1		1	1	1
Isopora palifera	(Lamarck, 1816)			1	1	1					1	1			1	1	1
Montipora aequituberculata	Bernard, 1897							1			1				1		
Montipora angulata	(Lamarck, 1816)																
Montipora caliculata	(Dana, 1846)																
Montipora crassituberculata[R]	Bernard, 1897									1							
Montipora danae	(Milne Edwards and Haime, 1851)									1					1		
Montipora digitata[S]	(Dana, 1846)																
Montipora efflorescens	Bernard, 1897		1										1	1			
Montipora floweri	Wells, 1954												1				
Montipora foliosa	(Pallas, 1766)		1			1											
Montipora foveolata	(Dana, 1846)		1	1			1						1				
Montipora grisea	Bernard, 1897	1		1		1										1	1
Montipora hispida	(Dana, 1846)															1	
Montipora hoffmeisteri	Wells, 1954							1					1				
Montipora incrassata[R]	(Dana, 1846)			1	1		1						1			1	
Montipora informis	Bernard, 1897							1									
Montipora millepora[S]	Crossland, 1952	1															
Montipora mollis	Bernard, 1897								1	1							
Montipora monasteriata	(Forskal, 1775)	1	1		1								1				
Montipora nodosa	(Dana, 1846)												1				

South Scott														North Scott										Seringapatam				
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		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Montipora peltiformis[S]	Bernard, 1897															1	
Montipora spumosa[P]	(Lamarck, 1816)																
Montipora tuberculosa[R]	(Lamarck, 1816)	1	1	1	1					1			1			1	
Montipora turgescens	Bernard, 1897												1				
Montipora turtlensis[P]	Veron and Wallace, 1984																
Montipora undata	Bernard, 1897		1			1								1			
Montipora venosa[R]	(Ehrenberg, 1834)			1	1		1										
Montipora verrucosa	(Lamarck, 1816)																
Agariciidae																	
Coeloseris mayeri	Vaughan, 1918				1		1	1	1			1				1	1
Gardineroseris planulata	(Dana, 1846)		1		1	1					1						1
Leptoseris explanata	Yabe and Sugiyama, 1941																
Leptoseris foliosa	Dinesen, 1980																
Leptoseris hawaiiensis	Vaughan, 1907		1			1					1			1			
Leptoseris incrustans	(Quelch, 1886)		1			1					1			1		1	
Leptoseris mycetoseroides	Wells, 1954				1	1					1	1		1		1	1
Leptoseris papyracea	(Dana, 1846)																
Leptoseris scabra	Vaughan, 1907																
Leptoseris yabei	(Pillai and Scheer, 1976)																
Pachyseris rugosa	(Lamarck, 1801)		1			1					1		1			1	1
Pachyseris speciosa	(Dana, 1846)		1			1				1	1	1				1	
Pavona cactus	(Forskal, 1775)																
Pavona clavus[P]	(Dana, 1846)																
Pavona decussata	(Dana, 1846)	1						1	1	1					1		
Pavona duerdeni	Vaughan, 1907	1			1	1								1		1	1
Pavona explanulata	(Lamarck, 1816)		1			1		1		1	1	1		1		1	1
Pavona maldivensis	(Gardiner, 1905)				1	1								1		1	1
Pavona varians	Verrill, 1864	1	1	1	1	1	1	1	1	1	1	1			1	1	1
Pavona venosa	(Ehrenberg, 1834)												1				1
Astrocoeniidae																	
Stylocoeniella armata	(Ehrenberg, 1834)	1	1		1										1		
Stylocoeniella guentheri	Bassett-Smith, 1890					1		1					1				
Dendrophylliidae																	
Turbinaria frondens	(Dana, 1846)																
Turbinaria mesenterina[P]	(Lamarck, 1816)																
Turbinaria peltata[P]	(Esper, 1794)																
Turbinaria reniformis	Bernard, 1896																
Turbinaria stellulata	(Lamarck, 1816)							1		1	1	1	1				1
Euphyllidae																	
Euphyllia ancora	Veron and Pichon, 1980															1	
Euphyllia cristata[P]	Chevalier, 1971																
Euphyllia glabrescens	(Chamisso and Eysenhardt, 1821)																
Physogyra lichtensteini	(Milne Edwards and Haime,1851)	1	1			1		1		1	1	1	1		1	1	
Plerogyra sinuosa	(Dana, 1846)		1			1										1	
Faviidae																	
Caulastrea furcata	Dana, 1846																
Caulastrea tumida[P]	Matthai, 1928																
Cyphastrea agassizi[R]	(Vaughan, 1907)	1		1	1							1					

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Cyphastrea chalcidicum	(Forskal, 1775)	1	1					1							1		
Cyphastrea microphthalma	(Lamarck, 1816)	1	1	1	1	1	1		1	1	1	1	1			1	1
Cyphastrea serailia	(Forskal, 1775)				1			1	1	1			1		1	1	
Diploastrea heliopora	(Lamarck, 1816)		1			1					1					1	1
Echinopora ashmorensis	Veron, 1990							1	1								
Echinopora gemmacea[P]	Lamarck, 1816																
Echinopora hirsutissima[P]	Milne Edwards and Haime, 1849																
Echinopora horrida	Dana, 1846					1						1		1	1	1	1
Echinopora lamellosa	(Esper, 1795)	1	1		1	1	1	1	1	1		1	1		1	1	1
Echinopora mammiformis	(Nemenzo, 1959)																
Favia danae	Verrill, 1872																
Favia favus	(Forskal, 1775)	1	1		1			1	1				1				
Favia helianthoides	Wells, 1954							1	1				1				
Favia laxa	(Klunzinger, 1879)																
Favia lizardensis	Veron and Pichon, 1977							1		1		1	1				
Favia matthaii	Vaughan, 1918		1	1	1	1	1				1	1	1		1		1
Favia maxima	Veron and Pichon, 1977							1							1	1	
Favia pallida	(Dana, 1846)	1	1	1	1	1	1	1				1	1		1	1	1
Favia rotumana	(Gardiner, 1899)							1	1	1							
Favia rotundata	(Veron and Pichon, 1977)																
Favia speciosa	Dana, 1846		1	1	1	1	1	1			1	1	1		1		
Favia stelligera	(Dana, 1846)		1	1	1	1	1				1	1	1		1	1	1
Favia truncatus[R]	Veron, 2000			1	1							1			1		
Favites abdita	(Ellis and Solander, 1786)	1	1	1	1	1				1	1		1		1		1
Favites chinensis	(Verrill, 1866)																
Favites complanata[R]	(Ehrenberg, 1834)			1		1	1	1	1	1		1	1		1		
Favites flexuosa	(Dana, 1846)																
Favites halicora	(Ehrenberg, 1834)					1	1	1		1							
Favites pentagona	(Esper, 1794)		1	1	1	1		1						1		1	1
Favites russelli	(Wells, 1954)	1			1	1		1			1	1		1	1	1	
Favites stylifera[R]	(Yabe and Sugiyama, 1937)	1	1														
Goniastrea aspera	Verrill, 1905			1	1					1	1						1
Goniastrea australensis[P]	(Milne Edwards and Haime, 1857)																
Goniastrea edwardsi	Chevalier, 1971	1	1	1	1	1	1					1	1			1	1
Goniastrea favulus	(Dana, 1846)																
Goniastrea palauensis	(Yabe and Sugiyama, 1936)																
Goniastrea pectinata	(Ehrenberg, 1834)	1	1	1	1	1	1	1			1	1	1			1	1
Goniastrea retiformis	(Lamarck, 1816)	1	1	1		1	1	1	1	1	1	1	1		1	1	1
Leptastrea aequalis	Veron, 2000																
Leptastrea inaequalis	Klunzinger, 1879						1										
Leptastrea pruinosa	Crossland, 1952			1	1			1		1		1	1			1	1
Leptastrea purpurea	(Dana, 1846)	1	1	1	1	1	1								1	1	
Leptastrea transversa	Klunzinger, 1879	1	1	1	1		1					1		1		1	
Leptoria phrygia	(Ellis and Solander, 1786)		1		1	1					1	1				1	1
Montastrea annuligera[S]	(Milne Edwards and Haime, 1849)				1					1		1					
Montastrea curta	(Dana, 1846)		1	1	1	1	1				1					1	1
Montastrea magnistellata	Chevalier, 1971	1					1	1	1	1		1	1	1	1	1	
Montastrea valenciennesi	(Milne Edwards and Haime, 1848)				1												

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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1	1	1	1		1			1						1	1		1								1	1		1
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1	1	1	1			1		1	1		1	1	1	1			1		1				1	1				1
	1	1	1		1	1		1	1			1	1		1		1				1	1			1	1		
	1												1															

		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Oulophyllia bennettae	(Veron and Pichon, 1977)							1					1				
Oulophyllia crispa	(Lamarck, 1816)							1	1	1	1		1				
Oulophyllia levis[P]	(Nemenzo, 1959)																
Platygyra daedalea	(Ellis and Solander, 1786)																
Platygyra lamellina	(Ehrenberg, 1834)																
Platygyra pini	Chevalier, 1975	1	1	1	1	1					1	1		1	1	1	1
Platygyra ryukyuensis	Yabe and Sugiyama, 1936		1	1	1			1					1				
Platygyra sinensis	(Milne Edwards and Haime, 1849)										1						
Platygyra verweyi	Wijsman-Best, 1976			1		1	1						1		1		1
Plesiastrea versipora	(Lamarck, 1816)						1										
Fungiidae																	
Ctenactis crassa	(Dana, 1846)	1					1								1		
Ctenactis echinata	(Pallas, 1766)	1					1		1	1		1	1				1
Cycloseris costulata	(Ortmann, 1889)									1							
Cycloseris vaughani	(Boschma, 1923)																
Cantharellus noumeae[P]	Hoeksema and Best, 1984																
Fungia concinnaR	Verrill, 1864	1	1				1	1		1		1					1
Fungia fungites	(Linnaeus, 1758)	1						1	1	1					1		1
Fungia granulosa	Klunzinger, 1879	1					1										
Fungia horrida	Dana, 1846	1					1	1	1	1		1	1		1		1
Fungia moluccensis[S]	Horst, 1919																
Fungia paumotensis	Stutchbury, 1833	1							1								
Fungia repanda[S]	Dana, 1846							1									
Fungia scutaria	Lamarck, 1801			1									1				1
Fungia scruposa[R]	Klunzinger, 1879							1									
Heliofungia actiniformis	(Quoy and Gaimard, 1833)																
Herpolitha limax	(Houttuyn, 1772)	1					1	1	1				1				
Lithophyllon mokai	Hoeksema, 1989																
Lithophyllon undulatum	Rehberg, 1892																
Podabacia crustacea	(Pallas, 1766)		1								1					1	
Polyphyllia talpina	(Lamarck, 1801)	1						1	1	1							
Sandalolitha robusta	Quelch, 1886						1						1			1	
Merulinidae																	
Hydnophora exesa	(Pallas, 1766)					1				1	1		1			1	
Hydnophora microconos[S]	(Lamarck, 1816)																
Hydnophora pilosa	Veron, 1985															1	
Hydnophora rigida	(Dana, 1846)	1					1					1					
Merulina ampliata	(Ellis and Solander, 1786)	1	1		1	1		1			1		1				
Merulina scabricula	Dana, 1846	1	1		1	1			1			1	1		1	1	1
Scapophyllia cylindrica	Milne Edwards and Haime, 1848				1		1	1			1		1				1
Mussidae																	
Acanthastrea brevis	Milne Edwards and Haime, 1849																
Acanthastrea echinata	(Dana, 1846)													1			
Australomussa rowleyensis	Veron, 1985															1	
Lobophyllia hataii	Yabe and Sugiyama, 1936							1			1					1	
Lobophyllia hemprichii	(Ehrenberg, 1834)	1	1		1	1	1	1		1	1	1	1		1	1	1
Symphyllia agaricia	Milne Edwards and Haime, 1849	1									1	1					
Symphyllia radians[R]	Milne Edwards and Haime, 1849										1		1				1

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Symphyllia recta	(Dana, 1846)			1													1
Symphyllia valenciennesii	Milne Edwards and Haime, 1849																
Oculinidae																	
Galaxea astreata	(Lamarck, 1816)	1	1	1	1		1	1		1		1					1
Galaxea fascicularis	(Linnaeus, 1767)	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1
Galaxea horrescens	(Dana, 1846)																
Galaxea longisepta	Fenner and Veron, 2000																
Pectiniidae																	
Echinophyllia aspera[R]	(Ellis and Solander, 1788)								1							1	
Echinophyllia echinata	(Saville-Kent, 1871)																
Echinophyllia echinoporoides[P]	Veron and Pichon, 1980																
Echinophyllia orpheensis	Veron and Pichon, 1980												1				
Mycedium elephantotus	(Pallas, 1766)							1									
Mycedium mancaoi	Nemenzo, 1979																
Mycedium robokaki	Moll and Best, 1984																
Oxypora glabra	Nemenzo, 1959							1									
Oxypora lacera	(Verrill, 1864)														1		1
Pectinia alcicornis	(Saville-Kent, 1871)	1						1	1	1		1	1	1	1		
Pectinia lactuca	(Pallas, 1766)		1									1		1		1	
Pectinia paeonia	(Dana, 1846)									1			1				
Pectinia teres	Nemenzo and Montecillo, 1981							1									
Pocilloporidae																	
Pocillopora damicornis	(Linnaeus, 1758)	1	1	1			1		1				1				
Pocillopora danae	Verrill, 1864																
Pocillopora eydouxi	Milne Edwards and Haime, 1860										1			1			
Pocillopora meandrina[R]	Dana, 1846		1	1	1											1	
Pocillopora verrucosa	(Ellis and Solander, 1786)	1	1	1	1	1					1	1				1	1
Pocillopora woodjonesi	Vaughan, 1918																
Seriatopora hystrix	Dana, 1846	1	1	1		1		1	1	1		1			1	1	1
Stylophora mordax[R]	(Dana, 1846)		1	1	1												
Stylophora pistillata	Esper, 1797	1	1	1	1	1			1	1		1	1	1	1	1	1
Poritidae																	
Alveopora allingi	Hoffmeister, 1925																
Alveopora catalaiP	Wells, 1968																
Alveopora fenestrata	(Lamarck, 1816)			1			1										
Alveopora spongiosa	Dana, 1846																
Alveopora tizardi[P]	Bassett-Smith, 1890																
Alveopora verrilliana[P]	Dana, 1872																
Goniopora burgosi[R]	Nemenzo, 1955	1	1		1	1		1	1			1					1
Goniopora columna[P]	Dana, 1846																
Goniopora djiboutiensis	Vaughan, 1907							1									
Goniopora lobata	Milne Edwards and Haime, 1860																
Goniopora minor	Crossland, 1952												1				
Goniopora palmensis[S]	Veron and Pichon, 1982	1															
Goniopora pendulus	Veron, 1985							1	1							1	
Goniopora stutchburyi[S]	Wells, 1955																
Goniopora tenuidens	(Quelch, 1886)						1	1									
Porites annae[S]	Crossland, 1952															1	1

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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		Mermaid															
Species	**Authority**	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Porites cylindrica	Dana, 1846						1	1	1	1		1	1	1	1		1
Porites lichen	Dana, 1846																
Porites lobata	Dana, 1846	1			1				1			1	1		1		1
Porites lutea	Milne Edwards and Haime, 1851				1							1		1			
Porites monticulosa[R]	Dana, 1846		1		1	1								1	1	1	1
Porites murrayensis	Vaughan, 1918			1													
Porites nigrescens	Dana, 1846	1	1							1		1		1	1	1	
Porites rus	(Forskal, 1775)					1						1		1	1	1	1
Porites solida	(Forskal, 1775)		1														
Porites vaughani	Crossland, 1952		1		1	1					1	1		1		1	1
Siderastreidae																	
Coscinaraea columna[R]	(Dana, 1846)													1		1	1
Coscinaraea exesa[S]	(Dana, 1846)																
Coscinaraea wellsi	Veron and Pichon, 1980																
Psammocora contigua	(Esper, 1797)																
Psammocora digitata	Milne Edwards and Haime, 1851	1			1				1		1	1		1			1
Psammocora explanulata	Horst, 1922																
Psammocora haimeana	Milne Edwards and Haime, 1851		1		1	1					1						1
Psammocora nierstraszi	Horst, 1921																
Psammocora obtusangula	(Lamarck, 1816)																
Psammocora profundacella[R]	Gardiner, 1898	1	1	1	1	1				1	1	1			1	1	1
Psammocora superficialis	Gardiner, 1898										1						
Non-Scleractinian																	
Heliopora coerulea	(Pallas, 1766)			1			1				1						1
Tubipora musica	Linnaeus, 1758									1							
Millepora spp.	Linnaeus, 1758	1	1	1	1		1		1		1	1	1	1			1
Station Richness		**79**	**69**	**53**	**68**	**72**	**56**	**71**	**48**	**56**	**60**	**66**	**72**	**39**	**68**	**79**	**66**

South Scott														North Scott										Seringapatam				
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
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	1																											
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74	**105**	**74**	**78**	**30**	**66**	**71**	**27**	**65**	**109**	**0**	**74**	**116**	**86**	**79**	**74**	**20**	**100**	**10**	**83**	**7**	**89**	**68**	**29**	**47**	**67**	**54**	**13**	**88**

Table 2 Station richness and transect ratios for 41 stations at Mermaid, South Scott, North Scott, and Seringapatam Reefs.

Station Richness	Mermaid	South Scott	North Scott	Seringapatam	All Reefs
Mean	69.500	76.462	60.000	54.600	67.805
Standard Error	2.633	7.611	12.407	12.663	4.059
Standard Deviation	9.851	27.443	37.222	28.316	25.993
Range	34	91	95	77	112
Minimum	52	27	6	13	6
Maximum	86	118	101	90	118
Count	**14**	**13**	**9**	**5**	**41**

Station Richness	Reef Front	Lagoon	Reef Flat	All Habitats
Mean	77.188	76.833	23.143	67.805
Standard Error	3.028	4.505	6.501	4.059
Standard Deviation	12.112	19.113	17.199	25.993
Range	53	66	51	112
Minimum	48	52	6	6
Maximum	101	118	57	118
Count	**16**	**18**	**7**	**41**

Transect Ratio	Reef Front	Lagoon	Reef Flat	All Habitats
Mean	78.799	74.354	32.333	67.001
Standard Error	3.384	3.706	3.480	4.656
Standard Deviation	12.200	11.119	8.524	24.638
Range	47.994	29.517	23.000	93.827
Minimum	45.833	57.692	21.000	0.000
Maximum	93.827	87.209	44.000	93.827
Count	**13**	**9**	**6**	**28**

Table 3 Analysis of similarities (ANOSIM), two-way crossed, on species presence/absence data.

Tests for differences between reef system groups
(across all Habitat type groups)
Global Test
Sample statistic (Global R): 0.483
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Mermaid, South Scott	0.545	0.1	1783782	999	0
Mermaid, North Scott	0.495	0.1	36960	999	0
Mermaid, Seringapatam	0.657	0.3	945	945	3
South Scott, North Scott	0.344	0.7	47040	999	6
South Scott, Seringapatam	0.59	0.7	1764	999	6
North Scott, Seringapatam	0.181	15.8	400	400	63

Tests for differences between habitat type groups
(across all Reef system groups)
Global Test
Sample statistic (Global R): 0.739
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Lagoon, Reef Front	0.716	0.1	17837820	999	0
Lagoon, Reef Flat	0.865	0.1	5670	999	0
Reef Front, Reef Flat	0.935	0.1	5040	999	0

Table 4 Habitat descriptor scores for 45 stations at Mermaid, South Scott, North Scott, and Seringapatam Reefs.

	Station Number																																												
Habitat Descriptor	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Reef Type: Reef Front		1		1	1										1	1	1		1	1		1						1		1	1			1		1					1				1
Reef Type: Lagoon								1						1				1								1						1													
Reef Type: Lagoon Bombie	1						1		1		1	1											1		1				1			1						1	1				1		
Reef Type: LagoonPlatform						1																				1			1													1			
Reef Type: Reef Flat			1																		1			1			1						1		1		1							1	
Reef Type: Tidal Channel										1			1																											1					
Aspect: Protected	1					1	1	1	1		1	1		1							1		1		1	1			1			1						1	1			1	1		
Aspect: Exposed		1	1	1	1					1			1		1	1	1	1	1	1		1		1			1	1		1	1		1	1	1	1	1			1	1			1	1
Wave Energy: Low	1					1	1	1			1			1				1			1		1		1	1						1						1				1	1		1
Wave Energy: Medium			1		1										1			1						1			1			1	1		1		1	1	1							1	1
Wave Energy: High		1		1						1			1		1	1	1		1	1		1		1				1												1	1				
Substrate: Sand	1					1	1	1	1		1			1				1			1		1	1	1	1	1					1		1	1			1	1			1			
Substrate: Mixed	1					1	1	1	1	1	1	1	1	1				1			1	1	1	1	1	1	1		1	1		1		1	1	1		1	1		1	1	1		
Substrate: Reef	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1	1	1	1		1	1	1
Substrate: Rubble	1			1		1	1	1			1	1		1	1								1		1				1	1	1	1			1	1		1	1		1	1	1		
Slope: Flat	1		1	1		1	1	1	1	1	1	1	1	1					1		1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1
Slope: Sloped				1			1	1			1	1			1	1	1	1	1	1		1	1			1		1	1	1	1			1		1			1		1	1	1		
Slope: Wall		1		1	1																																								
Structure: Simple			1			1	1	1	1			1		1					1	1	1	1	1	1	1		1					1	1		1		1	1	1	1	1	1		1	
Structure: Medium	1										1																		1					1											
Structure: Complex		1		1	1					1	1		1		1	1	1	1								1		1		1	1					1							1		1
Surface: Regular	1		1			1	1	1	1					1					1	1	1	1	1	1	1		1		1			1	1	1	1		1	1	1		1			1	

Surface: Irregular		1		1	1					1	1	1	1	1	1	1	1	1					1			1		1		1	1			1		1				1		1	1		1
Features: Spur/Groove		1		1	1					1			1		1	1	1		1	1		1						1		1	1			1		1				1	1				1
Features: Outcrop/Bommies	1			1		1	1	1			1	1		1				1	1				1		1	1		1	1		1	1		1				1	1		1	1	1		
Features: Overhangs		1		1	1					1			1		1	1		1				1						1		1	1			1		1				1	1				1
Features: Reef Flat	1		1	1		1															1			1		1	1						1		1		1					1		1	
Water Clarity: Low								1			1	1		1											1							1						1	1				1		
Water Clarity: Medium	1							1	1			1							1				1		1			1	1					1	1	1				1	1	1			
Water Clarity: High	1	1		1	1	1	1			1			1		1	1	1	1		1		1				1		1	1	1	1			1	1	1						1			1
Coral Health: Low	1					1	1	1	1		1	1		1							1		1	1	1		1		1			1	1			1	1	1	1		1		1	1	
Coral Health: Medium	1					1	1		1		1	1		1					1	1		1						1	1	1	1	1	1	1	1	1					1		1		
Coral Health: High		1	1	1	1					1			1		1	1	1	1	1	1						1		1						1						1		1			1
Location: N									1																																				
Location: S				1				1						1			1								1	1	1						1								1				
Location: E	1				1										1								1														1		1						
Location: W						1	1									1		1	1	1	1			1																					
Location: NE		1	1							1	1		1																	1						1		1		1				1	1
Location: NW																						1																							
Location: SE																												1	1		1	1		1	1							1			
Location: SW																																													
Location: Central												1																															1		
Transects: 0 Transects										1			1														1													1					
Transects: 1 Transect only																													1						1							1		1	
Transects: 2 Transects	1	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1		1		1		1
Data reliablity: Good	1	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
Data reliability: Poor										1			1														1													1					

Table 5 Similarity Percentages of typifying and discriminating species (SIMPER).
Major species typifying and discriminating between lagoon, reef front, and reef flat habitats, listed in decreasing order. Two-way analysis examining habitat type groups (across all reef system groups).

Typifying: Group Lagoon					
Average similarity: 50.87					
	Av.Abund	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Galaxea fascicularis	1	1.4	5.69	2.75	2.75
Montastraea magnistellata	1	1.4	5.69	2.75	5.5
Goniastrea edwardsi	0.78	1.27	2.64	2.5	8
Acropora intermedia	0.89	1.25	2.41	2.46	10.46
Echinopora lamellosa	0.83	1.25	2.41	2.45	12.91
Acropora florida	0.83	1.15	1.79	2.26	15.17
Acropora brueggemanni	0.78	1.11	1.68	2.18	17.35
Acropora abrolhosensis	0.89	1.11	1.87	2.18	19.52
Lobophyllia hemprichii	0.89	1.08	1.91	2.12	21.64
Fungia horrida	0.72	1.07	1.53	2.1	23.75
Pavona varians	0.83	1.06	1.64	2.09	25.83
Astreopora myriophthalma	0.83	1.06	1.65	2.08	27.91
Acropora microphthalma	0.83	1.01	1.48	1.99	29.89
Acropora tenuis	0.67	0.99	1.58	1.94	31.83
Favites complanata	0.78	0.98	1.34	1.93	33.76
Pectinia alcicornis	0.83	0.98	1.42	1.92	35.68
Porites cylindrica	0.78	0.94	1.23	1.84	37.53
Acropora humilis	0.67	0.89	1.29	1.76	39.28
Acropora nasuta	0.78	0.83	1.2	1.63	40.91
Cyphastrea microphthalma	0.78	0.79	1.09	1.55	42.46
Seriatopora hystrix	0.72	0.78	1.1	1.53	43.99
Goniastrea pectinata	0.83	0.72	1.1	1.42	45.42
Millepora spp.	0.78	0.71	1.04	1.4	46.81
Stylophora pistillata	0.61	0.68	0.95	1.35	48.16
Favia pallida	0.67	0.67	0.97	1.31	49.47
Ctenactis echinata	0.67	0.66	0.87	1.3	50.77

Typifying: Group Reef Front
Average similarity: 58.51

	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Acropora spicifera	1	1.33	12.08	2.27	2.27
Echinopora lamellosa	1	1.33	12.08	2.27	4.54
Favia stelligera	1	1.33	12.08	2.27	6.81
Galaxea fascicularis	1	1.33	12.08	2.27	9.08
Goniastrea pectinata	1	1.33	12.08	2.27	11.35
Pavona varians	1	1.33	12.08	2.27	13.62
Pocillopora verrucosa	1	1.33	12.08	2.27	15.89
Psammocora profundacella	0.94	1.28	4.77	2.18	18.07
Favia pallida	0.94	1.25	3.47	2.13	20.2
Favia matthaii	0.94	1.14	2.39	1.95	22.16
Favites abdita	0.94	1.14	2.39	1.95	24.11
Acropora palifera	0.94	1.13	2.4	1.93	26.05
Goniastrea edwardsi	0.94	1.13	2.4	1.93	27.98
Montastraea curta	0.94	1.09	2.11	1.86	29.84
Porites vaughani	0.88	1.04	1.73	1.78	31.62
Acropora humilis	0.88	0.98	1.72	1.68	33.3
Platygyra pini	0.81	0.97	1.57	1.66	34.96
Acropora nasuta	0.88	0.92	1.45	1.58	36.54
Lobophyllia hemprichii	0.81	0.87	1.34	1.49	38.02
Millepora spp.	0.75	0.87	1.34	1.48	39.5
Favites stylifera	0.75	0.84	1.34	1.44	40.95
Pocillopora damicornis	0.75	0.84	1.34	1.44	42.39
Acropora gemmifera	0.69	0.82	1.25	1.4	43.79
Acropora millepora	0.75	0.81	1.25	1.39	45.17
Leptoria phrygia	0.75	0.8	1.16	1.38	46.55
Stylophora pistillata	0.75	0.8	1.16	1.38	47.92
Galaxea astreata	0.81	0.77	1.16	1.31	49.24
Heliopora coerula	0.69	0.76	1.16	1.31	50.54

Typifying: Group Reef Flat

Average similarity: 27.74

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Acropora digitifera	1	7.34	2.16	26.45	26.45
Porites lutea	0.29	2.94	0.5	10.6	37.05
Cyphastrea chalcidicum	0.71	2.54	0.79	9.17	46.22
Porites lobata	0.43	1.85	0.5	6.67	52.89

Discriminating: Groups Lagoon & Reef Front

Average dissimilarity = 57.84

	Group Lagoon	Group Reef Front			
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**
Acropora abrolhosensis	0.89	0.06	0.58	2.46	1.01
Acropora florida	0.83	0.06	0.54	1.91	0.94
Porites vaughani	0.17	0.88	0.54	1.8	0.93
Pectinia alcicornis	0.83	0.13	0.53	1.8	0.92
Acropora microphthalma	0.83	0.19	0.5	1.58	0.86
Porites monticulosa	0.28	0.69	0.49	1.55	0.86
Gardineroseris planulata	0.06	0.69	0.49	1.54	0.85
Acropora carduus	0.72	0	0.48	1.54	0.83
Leptoria phrygia	0.33	0.75	0.48	1.46	0.83
Acropora intermedia	0.89	0.31	0.47	1.45	0.81
Acropora palifera	0.22	0.94	0.47	1.43	0.81
Favites pentagona	0.33	0.63	0.47	1.43	0.81
Montastraea curta	0.33	0.94	0.45	1.29	0.77
Leptoseris mycetoseroides	0.28	0.75	0.45	1.32	0.77
Montastraea magnistellata	1	0.38	0.44	1.26	0.76
Acropora loripes	0.11	0.63	0.44	1.28	0.76
Acropora subglabra	0.67	0	0.43	1.37	0.75
Montipora grisea	0.11	0.75	0.43	1.34	0.75
Pavona maldivensis	0.11	0.63	0.43	1.26	0.74
Pavona duerdeni	0.22	0.69	0.43	1.26	0.74

Pachyseris rugosa	0.44	0.5	0.42	1.24	0.73
Porites cylindrica	0.78	0.31	0.42	1.22	0.73
Echinopora horrida	0.44	0.38	0.41	1.25	0.71
Psammocora haimeana	0.17	0.38	0.41	1.19	0.71
Fungia horrida	0.61	0.06	0.41	1.22	0.7
Acropora muricata	0.61	0.13	0.41	1.25	0.7
Herpolitha limax	0.67	0	0.4	1.22	0.7
Astreopora myriophthalma	0.83	0.56	0.4	1.11	0.68
Favites complanata	0.78	0.44	0.4	1.11	0.68
Pavona explanulata	0.5	0.44	0.39	1.19	0.68
Acropora millepora	0.33	0.75	0.39	1.14	0.68
Ctenactis echinata	0.67	0.31	0.39	1.13	0.67
Merulina ampliata	0.67	0.44	0.38	1.08	0.65
Acropora monticulosa	0.11	0.56	0.38	1.08	0.65

Discriminating: Groups Lagoon & Intertidal Reef Flat

Average dissimilarity = 79.60

	Group Lagoon	**Group Intertidal Reef Flat**			
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**
Montastraea magnistellata	1	0	0.96	4.52	1.2
Lobophyllia hemprichii	0.89	0	0.88	2.76	1.11
Acropora abrolhosensis	0.89	0	0.88	2.88	1.1
Porites cylindrica	0.78	0.29	0.83	1.95	1.05
Acropora digitifera	0.22	1	0.83	1.93	1.04
Acropora microphthalma	0.83	0	0.81	2.15	1.02
Echinopora lamellosa	0.83	0	0.79	2.16	1
Sandalolitha robusta	0.67	0	0.79	1.73	0.99
Acropora carduus	0.72	0	0.78	1.74	0.98
Pectinia alcicornis	0.83	0	0.77	1.72	0.97
Acropora subglabra	0.67	0	0.77	1.73	0.97
Acropora intermedia	0.89	0.14	0.77	1.74	0.97
Millepora spp.	0.78	0.14	0.76	1.76	0.96

Discriminating: Groups Lagoon & Intertidal Reef Flat
Average dissimilarity = 79.60

	Group Lagoon	Group Intertidal Reef Flat			
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**
Merulina ampliata	0.67	0	0.73	1.56	0.92
Favia matthaii	0.67	0.14	0.73	1.58	0.92
Acropora nasuta	0.78	0	0.73	1.76	0.92
Galaxea fascicularis	1	0.14	0.73	1.47	0.91
Herpolitha limax	0.67	0	0.72	1.47	0.91
Acropora florida	0.83	0	0.72	1.55	0.9
Fungia concinna	0.67	0.14	0.68	1.37	0.86
Merulina scabricula	0.67	0	0.68	1.47	0.85
Goniastrea pectinata	0.83	0.29	0.68	1.28	0.85
Favites abdita	0.67	0.14	0.68	1.48	0.85
Lithophyllon undulatum	0.5	0	0.68	1.27	0.85
Fungia horrida	0.61	0	0.66	1.38	0.83
Acropora brueggemanni	0.78	0	0.65	1.47	0.82
Favia favus	0.61	0	0.65	1.25	0.81
Goniastrea aspera	0.11	0.71	0.64	1.36	0.8
Fungia fungites	0.61	0.14	0.63	1.29	0.8
Favia stelligera	0.61	0.14	0.62	1.4	0.78
Pachyseris speciosa	0.5	0	0.62	1.28	0.78

Discriminating: Groups Reef Front & Intertidal Reef Flat
Average dissimilarity = 77.02

	Group Reef Front	Group Intertidal Reef Flat			
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**
Echinopora lamellosa	1	0	0.97	5.81	1.25
Acropora palifera	0.94	0.14	0.85	2.22	1.11
Favites stylifera	0.75	0	0.85	2.22	1.11
Favia matthaii	0.94	0.14	0.85	2.21	1.1
Favites abdita	0.94	0.14	0.85	2.21	1.1

Acropora nasuta	0.88	0	0.83	2.18	1.08
Favia stelligera	1	0.14	0.82	1.97	1.07
Galaxea fascicularis	1	0.14	0.82	1.97	1.07
Pocillopora verrucosa	1	0.14	0.82	1.97	1.07
Galaxea astreata	0.81	0.14	0.81	1.95	1.05
Acropora millepora	0.75	0.14	0.8	1.95	1.03
Porites vaughani	0.88	0	0.79	1.94	1.03
Montipora grisea	0.75	0.14	0.78	1.76	1.01
Lobophyllia hemprichii	0.81	0	0.77	2.03	1
Montastraea curta	0.94	0.14	0.75	1.62	0.97
Acropora tenuis	0.75	0	0.73	1.83	0.95
Leptoseris mycetoseroides	0.75	0	0.72	1.59	0.94
Pavona varians	1	0.29	0.71	1.48	0.93
Millepora spp.	0.75	0.14	0.71	1.67	0.92
Turbinaria reniformis	0.56	0	0.71	1.54	0.92
Heliopora coerula	0.69	0.43	0.7	1.67	0.91
Acropora digitifera	0.25	1	0.7	1.46	0.91
Lithophyllon undulatum	0.56	0	0.7	1.53	0.9
Acropora cerealis	0.63	0	0.68	1.53	0.89
Leptoria phrygia	0.75	0	0.67	1.52	0.87
Goniastrea retiformis	0.94	0.29	0.65	1.26	0.84
Stylocoeniella armata	0.56	0	0.64	1.26	0.83
Pavona duerdeni	0.69	0	0.63	1.4	0.82
Goniastrea pectinata	1	0.29	0.62	1.18	0.81
Pocillopora eydouxi	0.56	0.14	0.62	1.18	0.81
Goniastrea aspera	0.19	0.71	0.62	1.25	0.8
Leptastrea transversa	0.75	0.29	0.62	1.3	0.8
Acropora specifera	1	0.29	0.62	1.18	0.8
Acropora gemmifera	0.69	0.14	0.6	1.31	0.78

Table 6 Similarity Percentages of functional groups (SIMPER).
Major functional groups typifying and discriminating between lagoon and reef front habitats, listed in decreasing order. Two-way analysis examining habitat type groups (across all reef system groups).

Typifying: Group Lagoon
Average similarity: 62.50

	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Rubble	0.43	32.78	2.13	52.46	52.46
Branching Acropora	0.12	11.42	1.53	18.28	70.73
Sand	0.11	8.12	1.59	12.99	83.73
Rock	0.2	7.47	0.66	11.95	95.68
Tabulate Acropora	0.02	1.04	0.79	1.67	97.34
Massive Non-Acropora	0.04	0.71	0.44	1.13	98.48
Soft Coral	0.01	0.34	0.29	0.55	99.03
Digitate Acropora	0.02	0.31	0.54	0.5	99.53
Macroalgae	0	0.12	0.4	0.2	99.73
Mushroom coral	0.01	0.09	0.29	0.14	99.86
Sub-massive Non-Acropora	0.01	0.05	0.45	0.08	99.95
Foliaceous Non-Acropora	0	0.02	0.22	0.03	99.97
Encrusting Non-Acropora	0	0.02	0.16	0.03	100

Typifying: Group Reef Front
Average similarity: 68.66

	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Rock	0.61	50.79	3.53	73.97	73.97
Encrusting Non-Acropora	0.1	6.63	1.35	9.65	83.62
Massive Non-Acropora	0.06	3.7	1.47	5.39	89.02
Digitate Acropora	0.03	1.63	1.74	2.37	91.39
Soft Coral	0.04	1.5	0.6	2.18	93.57
Sand	0.03	1.21	0.7	1.77	95.34
Tabulate Acropora	0.03	0.97	0.59	1.41	96.74
Rubble	0.07	0.96	0.35	1.39	98.13
Sub-massive Non-Acropora	0.02	0.91	1	1.32	99.45
Branching Acropora	0.01	0.13	0.45	0.2	99.65
Macroalgae	0.01	0.12	0.33	0.17	99.82
Foliaceous Non-Acropora	0.01	0.09	0.24	0.13	99.95
Sponge	0	0.03	0.25	0.05	100
Gorgonian Coral	0	0	0	0	100
Mushroom coral	0	0	0	0	100

Descriminating: Groups Lagoon & Reef Front
Average dissimilarity = 67.35

	Group Lagoon	Group Reef Front				
	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Rock	0.2	0.61	21.27	1.82	31.58	31.58
Rubble	0.43	0.07	17.93	1.84	26.62	58.2
Branching Acropora	0.12	0.01	6.3	1.18	9.36	67.56
Encrusting Non-Acropora	0	0.1	6.29	1.18	9.33	76.9
Sand	0.11	0.03	5.46	1.38	8.11	85
Massive Non-Acropora	0.04	0.06	2.51	1.48	3.72	88.73
Digitate Acropora	0.02	0.03	1.97	0.84	2.93	91.66
Soft Coral	0.01	0.04	1.76	0.74	2.61	94.26
Tabulate Acropora	0.02	0.03	1.48	0.69	2.19	96.46
Sub-massive Non-Acropora	0.01	0.02	0.93	1.31	1.38	97.84
Foliaceous Non-Acropora	0	0.01	0.54	0.71	0.8	98.63
Macroalgae	0	0.01	0.43	0.65	0.64	99.28
Mushroom coral	0.01	0	0.26	0.61	0.38	99.66
Sponge	0	0	0.15	0.74	0.22	99.88
Gorgonian Coral	0	0	0.08	0.19	0.12	100

Above: South Scott Reef lagoon, back slope. (Photo: Clay Bryce)

Above: *Odontodactylus scyllarus* (Linnaeus, 1758). The harlequin mantis shrimp. Photo: Glenn Moore)

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Crustaceans of Mermaid (Rowley Shoals), Scott and Seringapatam Reefs, north Western Australia

M.A. Titelius, A. Sampey, and C.G. Hass

Abstract – The atolls on the north-western Australian continental shelf are recognised in having a diverse shallow-water fauna with many widely distributed Indo-West Pacific species. However, the crustaceans of these reefs are poorly known. A survey of the crustaceans of four of the reefs on these continental-shelf atolls (Mermaid, South and North Scott, and Seringapatam reefs) was conducted in 2006 by the Western Australian Museum, Perth. Identifications focused on the stomatopod and decapod crustaceans, although many species within these groups such as the galatheids, caridean shrimps, and stomatopods, are not yet fully identified. A total of 157 species were recorded, more than doubling the numbers of species previously recorded from these atolls. The number of species will increase with identification of the unidentified specimens. The Xanthidae (Brachyura) was the most diverse family at all reefs, which is typical of Australian coastal waters. Differences in the stomatopods and decapod assemblages among reefs and respective habitats are discussed.

INTRODUCTION

Along the edge of the continental shelf of north–western Australia are a series of emergent reefs, from north to south these are: Ashmore Reef (12°10′S 122°58′E), Cartier Island (12°31′S 123°33′E), Hibernia Reef (11°55′S 123°28′E), Seringapatam Reef (13°38′S 122°05′E), North and South Scott reefs (13°59′S 121°46′E) and the Rowley Shoals (Mermaid, 17°07′S 119°36′E; Clerke, 17°10′S 119°20′E; and Imperieuse, 17°35′S 118°56′E, reefs). These reefs have been recognised for their regional importance in providing habitat for shallow water coral reef fauna along the north-western Australian coast (Berry and Marsh, 1986). The stomatopod and decapod crustacean faunas of these reefs are poorly known as very few collections have been made.

A Western Australian Museum (WA Museum) expedition to Ashmore Reef and Cartier Island in 1986 recorded 93 decapod crustaceans (Morgan and Berry, 1993). The collections were dominated by xanthoids (39 species) and paguroids (25 species) (Morgan and Berry, 1993). The crustacean fauna of Scott and Seringapatam reefs, further to the north (see maps in Station and Transect data, this volume), has been somewhat better studied. Small collections were made in the 1970s by various workers and a Russian research ship stopped at Scott Reef in 1975. They recorded 55 species of decapods from 7 families and 31 genera (Tsareva, 1980). Berry and Morgan (1986) reported 56 species collected from Scott and Seringapatam reefs during the 1984 WA Museum expedition, but the sampling effort of the study was low. In 1982 a short survey of Mermaid and Clerke reefs (Rowley Shoals) produced a small collection of decapod crustacean species, 12 species from Mermaid Reef and 38 species from Clerke Reef (unpublished data, WA Museum Crustacean Collection). Until now these records have largely remained the basis of our knowledge of the crustaceans from the Rowley Shoals.

Collection during this 2006 survey was systematic and extensive, allowing for a comparison between the three reef systems (Rowley Shoals, Scott and Seringapatam). The results of this survey represent a significant increase to the known crustacean fauna of these atolls.

METHODS

Sample collection and processing

A total of 44 stations (7 intertidal and 37 subtidal stations) across Mermaid (15), South Scott (14), North Scott (10) and Seringapatam (5) reefs were surveyed.

Subtidal habitats (lagoon and outer reef) were surveyed using either SCUBA diving or snorkelling. At each SCUBA station a 30 minute survey was conducted at two depths, 5 m and 12 m mean sea level. A 25 m by 1 m transect line was laid at each of the chosen depth contours over the dominant habitat and visual records and collections of crustaceans were made from each transect and from the surrounding area. Only one depth was sampled at two stations: South Scott Reef station 29 (depth of 13 m) and Seringapatam Reef station 42

Above: The cryptic crab, *Huenia brevifrons* (Ward, 1941) on the algae, *Halimeda*. (Photo: Clay Bryce)

(depth of 7 m). Both these stations were in lagoons with reduced depth profiles (bommies over sand). Qualitative sampling of the crustacean diversity was conducted at four stations by snorkel (stn 6) and drift dives (10, 13 & 40).

No transect lines were laid at intertidal stations however, a 30 minute survey was conducted by shore collecting and visual records at each of the inner and outer platform zones. Sampling effort at these stations varied due to some platform stations having to be sampled at times other than low tide.

Emphasis was placed on recording species richness, which involved the examination and collection of various substrates such as live and dead coral heads, rocks, sand, sponges, echinoderms, and algae. Collected coral and rock were systematically broken down, while sponges, soft corals and ascidians were cut open to extract living crustaceans. The remaining debris was then sorted through to find all remaining crustaceans. Complex branching substrates, including algae and soft corals, were washed in a tray of sea water and clove oil to narcotise the crustaceans. Live material was euthanized by freezing and then preserved in 70% ethanol. Visual records were made only where a confident identification of species was possible.

Specimens were identified to species whenever possible using a dissecting microscope. All identifications were made where possible prior to placement into ethanol so the live colouration could be examined. Where species were not easily identified in the field they were treated at the order, infraorder or family level. The identifications of a small number of specimens were validated at the WA Museum but the majority of species have retained their field identifications. Current accepted names and systematic placement follow Davie (2002) and Ng *et al*., (2008). Specimens collected during the survey are housed at the WA Museum.

Given the complexity of recording very motile and cryptic crustaceans with time constraints (dive time at each station), this survey is based mainly on decapod and stomatopod crustaceans. Opportunistic collecting of isopods was undertaken but these were not included in this paper. Specimens were housed at the WA Museum and await further study.

Data analysis

Crustacean assemblages were compared among the sampled reefs (Mermaid, North Scott, South Scott, and Seringapatam reefs) and habitats (intertidal vs. subtidal, lagoon vs. outer reef slope). Data is thus arranged as a species matrix defining whole reef systems or parts of it. The degree of similarity between these chosen matrices can give insights into the relationships between reefs and the factors that may be influencing species distributions, such as particular microhabitats, depth and exposure at low tide.

Data was analysed using PRIMER v6.1.11 and PERMANOVA v1.0.1 based on the presence or absence of each species. Due to non-standard search effort at some stations these were omitted from subsequent data analyses. The first four stations (trialling sampling methods), drift dive stations of reef channels (10, 13 & 40), the snorkel stations (6), and any opportunistic collections of species were all omitted. The resulting data matrix consisted of 138 taxa from 36 stations.

The observed species richness (Sobs) of the four shelf atolls was calculated from the dataset. Projected values of species richness were calculated using two non-parametric methods to estimate the number of species that would be collected as the number of samples approaches infinity. The Bootstrap method examines the proportion of samples containing each species, while the Jacknife method is a function of the numbers of species present in one or two samples (Clarke and Gorley, 2006).

Non-metric multidimensional scaling (nMDS) and cluster analysis were used to explore the relationships among the reefs and habitats. Similarity profiles (SIMPROF) were used to test the significance of the clusters formed (Clarke and Gorley, 2006). Similarity percentages (SIMPER, Clarke and Warwick, 2001) were used to determine which species contributed to differences among habitats and reefs. Differences between reef system groups and habitat types were further analysed using PERMANOVA (Anderson *et al.*, 2008). All analyses used the untransformed presence/absence species data and a Bray-Curtis similarity matrix. Three main habitat types (platform, outer reef and lagoon) were examined. As not all habitats were sampled at every reef the PERMANOVA considered habitats to be nested in reef and both reef and habitat were fixed factors. As there was uneven replication of the habitats within each reef system PERMANOVA was run using a type III (partial) model and the permutation was done on the residuals under a reduced model. The p value was calculated by both permutation and Monte Carlo methods, if the number of permutations was > 25 then the permutation p values were reported, if the number of permutations was < 25, then the Monte Carlo p values were used.

Differences in the assemblages at different depths were examined only for subtidal habitats, lagoon and outer reef zones. The unidentified mixed species (stomatopods, galatheids and caridean shrimps) were removed prior to analysis. As all depths and these two habitats were sampled at all reefs the PERMANOVA model considered reef, habitat and depth to be fixed orthogonal factors and used a type III (partial) model, and the permutation was done on the residuals under a reduced model.

RESULTS

Species richness

Observed species richness.

A total of 157 species were recorded from the 2006 collections, of which 87 species are new for the region (Table 1). Species richness for the individual reefs was 79 species (Mermaid Reef), 105 species (South Scott Reef), 63 species (North Scott Reef) and 40 species (Seringapatam Reef).

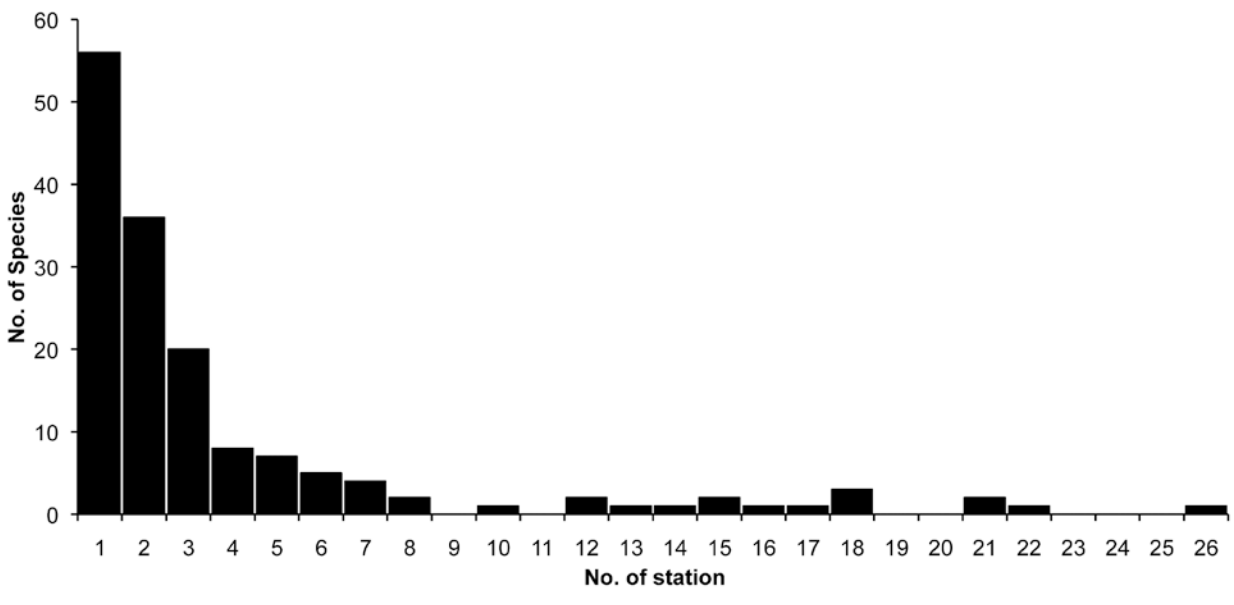


Figure 1 Frequency distribution of the number of stations at which species were recorded.

Table 1. List of crustaceans recorded from Mermaid, Scott and Seringapatam reefs in this study and also from previous studies. cf. = differences in characters from the published description; ? = uncertainty in the identification but likely to be the given genus or species. c = carapace only, v = visual record, BW = beach walk. Previous collections are based on records in reports or the Western Australian Museum crustacean collection. Location: RM = Mermaid Reef, Rowley Shoals, RC = Clerke Reef, Rowley Shoals, S = Scott Reef, Ser = Seringapatam Reef, A = Ashmore Reef, C = Cartier Island. Reference Source: [1] = Berry & Morgan 1986, [2] = Morgan & Berry 1993, [3] = Tsareva 1980, [4] = Unpublished Data, WAM Crustacean Collection. *Author listed as Herbst, 1897 - this is incorrect. NB. Likely misidentification as species does not occur in the area. #1 = species occurs in Western Atlantic, #2 = occurs in the Mediterranean.

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
STOMATOPODA					
GONODACTYLIDAE					
Gonodactylus chiragra (Fabricius, 1781)					RM[4]
Gonodactylus platysoma Wood-Mason, 1895		27	33		
Gonodactylus sp.					RC[4]
ODONTODACTYLIDAE					
Odontodactylus scyllarus (Linnaeus, 1758)			31		
Unidentified Stomatopods	1, 8	17, 21-22, 27	32, 34-35	41, 44-45	
DECAPODA					
Stenopodidea					
STENOPODIDAE					
Stenopus hispidus (Olivier, 1811)	1, 6, 9-10, 16		31		A[2]
Stenopus sp. 1	8				
Caridea					
ALPHEIDAE					
Alpheus acutofemoratus Dana, 1852					S[3]
Alpheus bouvieri A. Milne-Edwards, 1878#1					S[3]
Alpheus bucephalus Coutière, 1905					S[3]
Alpheus collumianus Stimpson, 1860					S[3]
Alpheus deuteropus Hilgendorf, 1879					S[3]
Alpheus dentipes Guérin Ménéville, 1832#2					S[3]
Alpheus frontalis H. Milne Edwards, 1837					A[2], C[2]
Alpheus leviusculus Dana, 1852					S[3]
Alpheus lottini Guérin-Méneville, 1829		21, 25	34	44	S[3],[4]

Alpheus pacificus Dana, 1852					A[2]
Alpheus strenuus strenuus Dana, 1852					S[3], A[2], C[2]
Synalpheus hastilicrassus Coutière, 1905					S[3]
Synalpheus sp.					S[4]
Synalpheus stimpsoni (de Man, 1888)	1	25, 26			
Synalpheus tumidomanus (Paul'son, 1875)					S[3]
Unidentified Alpheidae sp.					RM[4], RC[4]
HIPPOLYTIDAE					
Alope sp.					S[3]
Saron marmoratus (Oliver, 1811)		17	33	44	
Saron neglectus de Man, 1902	9-10, 14				A[4]
Saron sp.			32		S[3], A[2]
Thor amboinensis de Man, 1888		17			
PALAEMONIDAE					
PONTONIINAE					
Hamodactylus sp.					S[3]
Neopontonides sp.					S[3]
Periclimenes brevicarpalis Schenkel, 1902	10, 13				
Periclimenes sp. 1		29	35		
Periclimenes sp. 2		24, 25			
Vir philippinensis Bruce & Svoboda, 1984 **New species record WA**				45	
Unidentified Palaemonidae sp.					RM[4], RC[4]
Unidentified caridean shrimp	1-3, 6, 8, 12, 14, 15	17-22, 24-26, 28-29	31-36, 38-40	41-42, 45	RC[4]
Palinura					
PALINURIDAE					
Panulirus femoristriga (Von Martens, 1872)					A[2]
Panulirus ornatus (Fabricius, 1798)					A[2]
Panulirus versicolor (Latreille, 1804)	16	23, 26, 28	33, 39		S[1], A[2]
SCYLLARIDAE					
Parribacus antarcticus (Lund, 1793)					S[1]
Anomura					
GALATHEIDAE					

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
Allogalathea elegans (Adams and White, 1848)		22			
Galathea sp.					A[2]
Unidentified galatheids	1-4, 6-9, 11, 13, 15	17-19, 25, 28, 30	31-32, 34-36, 38-39	41	RC[4]
PORCELLANIDAE					
? *Lissoporcellana* sp. 1				41	
Neopetrolisthes maculatus (H. Milne Edwards, 1837)	3	21	33		A[2]
Petrolisthes asiaticus (Leach, 1820)					A[2]
Petrolisthes haswelli Miers, 1884					C[2]
Petrolisthes lamarckii (Leach, 1820)		24	37		A[4]
Petrolisthes sp. 1	6	17, 20			
Petrolisthes sp. 2		18, 22, 25	32, 39-40		
Petrolisthes sp. 3			24		
Polyonyx sp. 1		25, 29			
Porcellanid sp. 1	4				
HIPPIDAE					
Hippa pacifica (Dana, 1852)					A[2]
DIOGENIDAE					
Aniculus sp.					RC[4], RM[4], S[4], Ser[4]
Aniculus ursus (Olivier, 1811)					A[2]
Calcinus elegans (H. Milne Edwards, 1836)					S[3]
Calcinus gaimardii (H. Milne Edwards, 1848)	3-4, 10, 13	18, 21	31, 33-34, 40	44-45	S[1], Ser[4], A[2], C[2]
Calcinus ? gaumensis Wooster, 1984	4, 16				S[2], A[2]
Calcinus laevimanus (Randall, 1839)					RC[4], S[1], Ser[1], A[2], C[2]
Calcinus latens (Randall, 1840)	3, 6, 8-9, 11, 13-14	21, 24, 26-27	32, 35, 37	42	S[1], Ser[1], A[2], C[2]
Calcinus lineapropodus Morgan and Forest, 1991	4, 7, 8-10, 12-14	17-18, 22, 25-26	31-32, 34, 36, 38-39	42, 45	A[4]
Calcinus minutus Buitendijk, 1937	4, 6, 12-13, 15-16	17-20, 22-23, 25-26, 28-30	31-32, 34, 36, 39-40	41-42, 45	A[2], C[2]
Calcinus pulcher Forest, 1958					A[2]
Calcinus seurati Forest, 1951					S[1], Ser[1]
Calcinus ? vachoni Forest, 1958	9		33		
Calcinus sp. A					A[2], C[2]

Calcinus sp. B					A[2]
Ciliopagurus strigatus (Herbst, 1804)		20, 22			A[2]
Clibanarius corallinus (H. Milne Edwards, 1848)					S[1], Ser[1], A[2], C[2]
Clibanarius cf. *eurysternus* (Hilgendorf, 1878)					Ser[1]
Clibanarius striolatus Dana, 1852					A[2]
Clibanarius virescens (Krauss, 1843)					A[2]
Clibanarius sp. 1		24			
Clibanarius sp. 2		27			
Clibanarius ? sp.					S[1]
Dardanus crassimanus (H. Milne Edwards, 1836)					S[1], Ser[1], A[2]
Dardanus deformis (H. Milne Edwards, 1836)					S[1], A[2], C[2]
Dardanus gemmatus (H. Milne Edwards, 1848)					A[2]
Dardanus guttatus (Olivier, 1811)	3, 10	21	31		RM[4], S[1], Ser[1], A[2]
Dardanus lagopodes (Forskål, 1775)	1, 3, 12, 14-16	17-18, 21-22, 24-25, 27-28	31, 34-36, 38-39	41	RM[4], RC[4], S[1], A[2], C[2]
Dardanus megistos (Herbst, 1804)		27	33		RM[4], S[1], A[2]
Dardanus ? pedunculatus (Herbst, 1804)		24, 27			S[3*]
Dardanus scutellatus (H. Milne Edwards, 1848)					S[1], Ser[1], A[2]
Dardanus sp.				44	RC[4], S[4], A[2]
Paguristes brevirostris Baker, 1905					S[3]
Unidentified Diogenidae sp.					RC[4]
PAGURIDAE					
Pagurid sp. 1	2				
Pagurid sp. 2	9		35		
Pagurid sp. 3		21, 26			
Pagurid sp. 4	1, 7, 11	26			
Paguritta sp. 1	9-10, 13-16	18			
Pagurus hirtimanus Miers, 1880	2, 3		33		A[2]
Pagurus sp.					S[1], C[2]
Unidentified Paguridae sp.					RM[4], RC[4]
COENOBITIDAE					
Coenobita perlatus H. Milne Edwards, 1837					C[2]
Coenobita rugosus H. Milne Edwards, 1837					A[2], C[2]

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
Brachyura					
DROMIIDAE					
Dromiid spp. (likely to be two different species)	1			44	
Dromiid sp.					RC[4]
Dromidiopsis australiensis (Haswell, 1882)					S1
? *Petalomera* sp.					S[1]
Stimdromia lateralis (Gray, 1831)					A[2]
AETHRIDAE New family record for WA					
Aethra ? scruposa (Linnaeus, 1764) New species record WA	14c				
CALAPPIDAE					
Calappa calappa (Linnaeus, 1758)		21c			A[2]
Calappa gallus (Herbst, 1803)					A[2]
Calappa hepatica (Linnaeus, 1758)		27			RC[4], S[1,3], A[2], C[2]
CARPILIIDAE					
Carpilius convexus (Forskål, 1775)		22c			RC[4], S[1,3]
DACRYOPILUMNIDAE					
Dacryopilumnus rathbunae Balss, 1932					S[1]
DAIRIDAE					
Daira perlata (Herbst, 1790)	3		33	44	S[1,3], A[2]
ERIPHIIDAE					
Eriphia sebana (Shaw & Nodder, 1803)					S[3], A[2], C[2]
Eriphia scabricula Dana, 1852		24, 27	33	44	RM[4], S[1], A[2]
GONEPLACIDAE					
Goneplacid sp. 1		27			
Unidentified Goneplacidae sp.					RC[4]
GONEPLACINAE					
Carcinoplax sp.					RC[4]
LEUCOSIIDAE					
Heteronucia venusta Nobili, 1906					S[3]

Leucosiid sp. 1		23			
Unidentified Leucosiidae sp.					RC[4]
EPIALTIDAE					
EPIALTINAE					
Huenia brevifrons Ward, 1941 New Australia record	16		31		
Huenia cf. *heraldica* (De Haan, 1837)			33		Ser[4]
Menaethius orientalis (Sakai, 1969)	1	22			A[2]
Menaethius ? monoceros (Latreille, 1825)	3	24, 30	31-32, 34	44	A[2]
Menaethius sp.					S[4]
Perinea tumida Dana, 1852 New Australia record	2-4, 16	17, 19, 30			
PISINAE					
Hoplophrys oatesii Henderson, 1893	13, 16				A[2]
Tylocarcinus styx (Herbst, 1803)					A[2]
HYMENOSOMATIDAE					
Unidentified Hymenosomatidae sp.					RC[4]
INACHIDAE					
Camposcia retusa Latreille, 1829		27			S[3], A[2]
MAJIDAE					
Majid sp. 1		22			
Unidentified Majidae sp.					RC[4]
MAJINAE					
Cyclax suborbicularis (Stimpson, 1858)	3	24, 27	33		A2
Cyclax sp.					S[1]
Schizophrys aspera (H. Milne Edwards, 1834)	13		31, 33		S[1], A[2]
Schizophrys sp.					RC[4]
? *Pseudomicippe* sp. 1			33	44	
MITHRACINAE					
Micippa sp. 1		18			
Micippa cristata (Linnaeus, 1758)					A[2]
Tiarinia angusta Dana, 1852					S[3], A[2], C[2]
Tiarinia ? cornigera (Latreille, 1825)	1, 3, 4, 6, 12, 14-15	18, 20, 25-26, 29			
Tiarinia sp. 1	7, 12, 14, 16	17, 29			

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
Tiarinia sp.					S[4]
PARTHENOPIDAE					
Daldorfia horrida (Linnaeus, 1758)		24			S[1]
PILUMNIDAE					
EUMEDONINAE					
Echinoecus pentagonus (A. Milne Edwards, 1879)					RC[4]
Harrovia sp.					S[4]
Tiaramedon spinosum (Miers, 1879)					RC[4], S[4]
PILUMNINAE					
Heteropilumnus longipes (Stimpson, 1858)					S[1]
Heteropilumnus sp.					S[1]
Pilumnus cf. minutus (De Haan, 1835)					S[4]
Pilumnus vespertilio (Fabricius, 1793)					S[3]
Pilumnus vermiculatus A. Milne Edwards, 1873					S[3]
Viaderiana quadrispinosa (Zehntner, 1894)					A[2]
Pilumnid sp. 1	2	17		44	
Pilumnid sp. 2		29			
Pilumnid sp. 3			34	43	
Pilumnid sp.					S[1]
PORTUNIDAE					
Portunid sp. 1	11				
Portunid sp. 2		22			
Portunid sp. 3		30			
CAPHYRINAE					
Caphyra laevis (A. Milne Edwards, 1869)					A[2]
Lissocarcinus orbicularis Dana, 1852	4				
PORTUNINAE					
Portunus (Achelous) granulatus (H. Milne Edwards, 1834)					S[3], A[2]
Portunus sp.					RC[4]

THALAMITINAE					
Charybdis sp.					RC[4]
Thalamita admete (Herbst, 1803)		24, 27, 30	31, 32		S[3], A[2]
Thalamita coeruleipes Hombron & Jacquinot, 1846		24			S[1]
Thalamita cooperi Borradaile, 1903					C[2]
Thalamita picta Stimpson, 1858			37		
Thalamita ? prymna (Herbst, 1803)	12				
Thalamita sima H. Milne Edwards, 1834	6				
Thalamita sp. 1	14, 16				
Thalamita sp. 2		21, 29	32	41	
Thalamita sp. 3		22			
Thalamita sp. 4		24			
Thalamita sp. 5			37		
Thalamita sp.					RC[4], S[4], A[4]
PSEUDOZIIDAE					
Pseudozius caystrus (Adams & White, 1849)					A[2], C[2]
DOMECIIDAE					
Domecia glabra Alcock, 1899	6	17, 29			S[3]
Domecia hispida Eydoux & Souleyet, 1842	4, 6	19-20			S[1,3]
TETRALIDAE					
Tetralia ? cinctipes Paul'son, 1875	2, 7, 10				RC[4]
Tetralia glaberrima (Herbst, 1790)	11-13, 15	17-18, 23, 25-27, 29-30	31-32, 36	41-42, 45	S[1,3]
Tetralia nigrolineata Serène & Pham, 1957	6-9, 16	25-26	31-32, 38-39	41-43	
Tetralia sp. 1	1v, 3-4, 12v	17, 19, 20v, 23-24, 25-26v, 28-29v, 30	31-32v, 34v, 36v, 38-39	41, 45	
Tetralia sp. 2	6	17, 23			
Tetralia sp. 3		17, 19-20, 27		45	
Tetraloides heterodactylus (Heller, 1861)	4v				S[1,3]
TRAPEZIIDAE					
Trapezia areolata Dana, 1852					S[3]
Trapezia cymodoce (Herbst, 1801)	1, 4v, 12v, 16v	26v	31v, 34		S[1,3]
Trapezia cf. *bidentata* (Forskål, 1775)					S[1,3]

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
Trapezia digitalis Latreille, 1828		25	34		S[3]
Trapezia guttata Rüppell, 1830	14	17-18, 25-26,	31-32, 34, 36, 38-39	41-43, 45	S[1,3], Ser[4], A[2]
Trapezia lutea Castro, 1997		17-20, 22, 25-26, 28	31, 34	41-42, 44	
Trapezia rufopunctata (Herbst, 1799)		18, 20, 22	31, 34		S[3]
Trapezia septata Dana, 1852	2, 8, 10, 16	18-19, 21-22, 24-26, 29-30	31, 34, 36	42, 44	S[1]
Trapezia tigrina Eydoux & Souleyet, 1842	2, 4, 12-13, 15-16	18	34		S[3]
XANTHIDAE					
ACTAEINAE					
Actaea sp.					RC[4], S[4]
Actaea polyacantha (Heller, 1861)		24			
Actaeodes sp. 1		20			
Actaeodes sp. 2	3	20			
Actaeodes consobrinus (A. Milne Edwards, 1873)					A[2]
Actaeodes hirsutissimus (Rüppell, 1830)					A[2]
Actaeodes tomentosus (H. Milne Edwards, 1834)		24			S[1,3]
Gaillardiellus sp. 1			39	43	
Gaillardiellus orientalis (Odhner, 1925)					S[3]
Paractaea sp. 1		24			
Psaumis ? cavipes (Dana, 1852)	8-9, 11, 14				
Pseudoliomera sp. 1		19, 25			
CHLORODIELINAE					
Chlorodiella ? cytherea (Dana, 1852)	1-3, 6-9, 11-12, 14, 16	17-18, 20, 22, 25-26			
C*hlorodiella ? laevissima* (Dana, 1852)	1	17, 19, 22, 28-30	32-34, 39	41-45	S[3], A[2], Ser[4]
Chlorodiella barbata (Borradaile, 1900)					S[3]
Cyclodius granulatus (Targioni-Tozzetti, 1877)					S[1]
Cyclodius ? granulosus (De Man, 1888)	6, 12, 14-15	20, 21			C[2]
Cyclodius nitidus (Dana, 1852)					S[3]
Cyclodius obscurus (Hombron & Jacquinot, 1846)					S[3]
Cyclodius ungulatus (H. Milne Edwards, 1834)	3, 6	21			S[1], A[2], C[2]
Pilodius areolatus (H. Milne Edwards, 1834)		21, 27	33, 37	44	S[1,3]

Pilodius ? flavus Rathbun, 1894	6, 14				A[2]
Pilodius pilumnoides (White, 1848)		29		43	RC[4]
Pilodius sp. 1	3-4, 6	18-23, 25-28, 30	33-34	41, 45	
Pilodius sp. 2	1, 6, 8	18-19, 21, 29		43	
Tweedieia sp. 1	4	17, 19			
CYMOINAE					
Cymo deplanatus A. Milne Edwards, 1873		17, 19, 23			S[3]
Cymo melanodactylus Dana, 1852		26	34		S[3]
Cymo quadrilobatus Miers, 1884					S[3]
Cymo sp. 1	3, 10, 12, 14	20			
Cymo cf. *andreossyi* (Audouin, 1826)					S[1, 3]
ETISINAE					
Etisus cf. *demani* Odhner, 1925					S[1]
Etisus dentatus (Herbst, 1785)	10c	21c, 24			S[1]
Etisus electra (Herbst, 1801)	11, 14, 15c				
Etisus ? utilus Jacquinot, in Jacquinot & Lucas, 1853 New Australia record	14c, 15c		38c		
EUXANTHINAE					
Euxanthus exsculptus (Herbst, 1790)		24			S1[,3], A[2]
Euxanthus huonii (Hombron & Jacquinot, 1846)					S[1]
Hypocolpus abbotti (Rathbun, 1894)					A[2]
Paramedaeus sp. 1	2				
KRAUSSIINAE					
Palapedia ? integra (De Haan, 1835)		26juv			A[2]
Palapedia ? marquesa (Serène, 1972) New Australia record			35		
LIOMERINAE					
Liomera cinctimana (White, 1847)					RC[4]
Liomera edwardsi Kossmann, 1877				41	
Liomera laevis (A. Milne Edwards, 1873)					A[2]
Liomera monticulosa (A. Milne Edwards, 1873)		17		44	A[2]
Liomera rubra (A. Milne Edwards, 1865)			35, 37		S[1], A[2]

Taxa	STATIONS				Previous Collections
	Mermaid Reef	South Scott Reef	North Scott Reef	Seringapatam	
Liomera rugata (H. Milne Edwards, 1834)					C[2]
Liomera stimpsoni (A. Milne Edwards, 1865)	3, 6, 13	21, 24			
Liomera tristis (Dana, 1852)	1, 14				S[1], A[2], C[2]
Liomera sp.					RC[4]
POLYDECTINAE					
Lybia tessellata (Latreille, in Milbert, 1812)		20, 23			S[1]
XANTHINAE					
Lachnopodus subacutus (Stimpson, 1858)					A[2]
Leptodius exaratus (H. Milne Edwards, 1834)			35, 37		A[2], C[2]
Leptodius sanguineus (H. Milne Edwards, 1834)					S[1,3]
Neoxanthias impressus (Latreille, in Milbert, 1812)					S[1], A[2]
Paraxanthias notatus (Dana, 1852)					A[2]
Paraxanthias pachydactylus (A. Milne Edwards, 1867)					A[2]
Xanthias sp. 1			34, 40		
Xanthias sp.					A[2]
Xanthias lamarcki (H. Milne Edwards, 1834)					S[3]
ZALASIINAE					
Banareia sp. 1		20			
ZOSIMINAE					
Atergatis floridus (Linnaeus, 1767)	6	24, 27			A[2]
Atergatopsis sp. 1	13	19			
Lophozozymus sp. 1	4				
Lophozozymus cf. *anaglypta* (Heller, 1861)		23			
Platypodia eydouxi (A. Milne Edwards, 1873)					A[2]
Platypodia granulosa (Rüppell, 1830)					A[2]
Platypodia cf. *semigranosa* (Heller, 1861)	13				
Platypodia sp. 1	8, 9				
Platypodia sp. 2	9				
Zozymodes cavipes (Dana, 1852)					A[2]
Zosimus aeneus (Linnaeus, 1758)		27, BW	33	44	RC[4], S[1,3], A[2]

Unidentified Xanthidae spp.					RM[4], RC[4], S[1]
CRYPTOCHIRIDAE					
Hapalocarcinus marsupialis Stimpson, 1859		25-26	31-32, 34, 38-39	41, 43, 45	S[1], A[2]
GRAPSIDAE					
Grapsid sp. 1		24			
GRAPSINAE					
Grapsus albolineatus Latreille, in Milbert, 1812		BWc			
Grapsus tenuicrustatus (Herbst, 1783)					A[2]
Pachygrapsus sp. 1	3	21, 27	37	44	
Pachygrapsus minutus A. Milne Edwards, 1873					RC[4], A[2]
Planes major (Macleay, 1838)					RC[4]
PLAGUSIIDAE					
PLAGUSINAE					
Plagusia sp. 1			40		
PERCNINAE					
Percnon abbreviatum (Dana, 1851)					A[2]
Percnon guinotae Crosnier, 1965				41	A[2]
Percnon planissimum (Herbst, 1804)			33, 37		RC[4], S[1]
Percnon sp.					RM[4], RC[4]
MACROPHTHALMIDAE					
Macrophthalmus (Chaenostoma) boscii Audouin, 1826		21, 24, 27			
OCYPODIDAE					
Ocypode ceratophthalmus (Pallas, 1772)		BWc			RM[4], A[2]
Uca tetragonon (Herbst, 1790)					A[2]
PINNOTHERIDAE					
Pinnixa sp.					RC[4]
Xanthasia murigera White, 1846					S[1]
Unidentified Pinnotheridae sp.					RC[4]

Above: *Calcinus elegans* (H. Milne-Edwards, 1836) - Elegant hermit crab. (Photo: Clay Bryce)

Above: A juvenile specimen of the rock lobster, *Panulirus versicolor* (Latreille, 1804) at Station 28, South Scott Reef. (Photo: Glenn Moore)

Table 2 Number of crustacean species recorded from the 2006 survey compared with the cumulative number of species recorded from previous collections. Recollected Species: number of species recorded at each reef visited during the 2006 survey that were also collected by previous surveys in the region. The numbers of new records of crustaceans for each reef visited in 2006 are provided.

	Reef		
Source	Mermaid	Scott	Seringapatam
Previous Collections	12	106	13
2006 Survey	79	128	40
Recollected Species	34	61	22
New Records	45	67	18

These figures represent a more than doubling of species previously recorded from Mermaid and Seringapatam reefs and an increase in the number of species from Scott Reef (Table 2). Furthermore, the number of species will increase with identification of galatheids, caridean shrimp, stomatopods and other species that require further identification.

Two species from Mermaid Reef, 40 from Scott Reef and four from Seringapatam Reef were previously collected from each location (Table 1). These values are based on those species only having full species-level identifications. It is expected that the number of repeat collections will increase with further study of the material as several specimens in both the current and previous collections were not fully identified.

The majority of the species collected (112 species, or 73%) were rare, only being recorded from three or less stations (Figure 1). Twenty-six species (17%) were common, occurring at four to nine stations and 16 species (10%) were considered widespread (10+ stations).

Unique species are defined as those that were recorded only from one reef, and are not shared with the other reefs examined. Mermaid Reef recorded the highest proportion, 31% (24 species), of unique crustacean species, with South Scott Reef recording 29% (29 species) (Figure 2). Proportions of unique species at North Scott and Seringapatam Reefs were 19% (11 species) and 18% (6 species) respectively.

Estimated species richness

The species accumulation curve of observed species (Sobs) did not reach an asymptote indicating that the sampling had not fully sampled the study area and further sampling would likely reveal more species of crustaceans (Figure 3). Projected estimates of diversity for the area, as provided by non-parametric analyses, ranged from 157 (Bootstrap) to 197 species (Jacknife 1). Neither estimator reached an asymptote. They therefore represent minimum estimates of species richness using these methods.

Species richness within families

Twenty eight decapod families are represented in

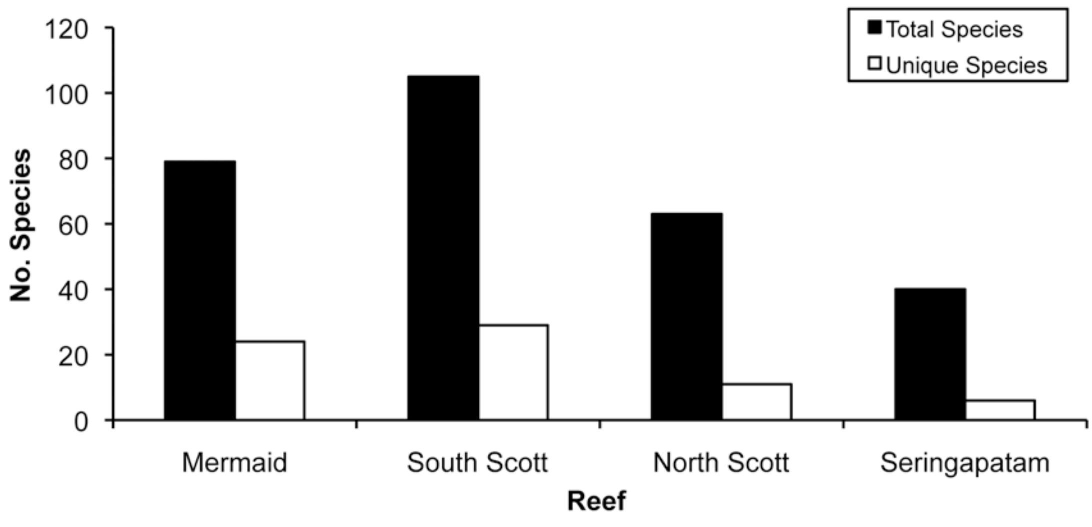


Figure 2 Total number of species and the number of unique species (not shared with other reefs) recorded at Mermaid, South Scott, North Scott and Seringapatam reefs during the September 2006 survey.

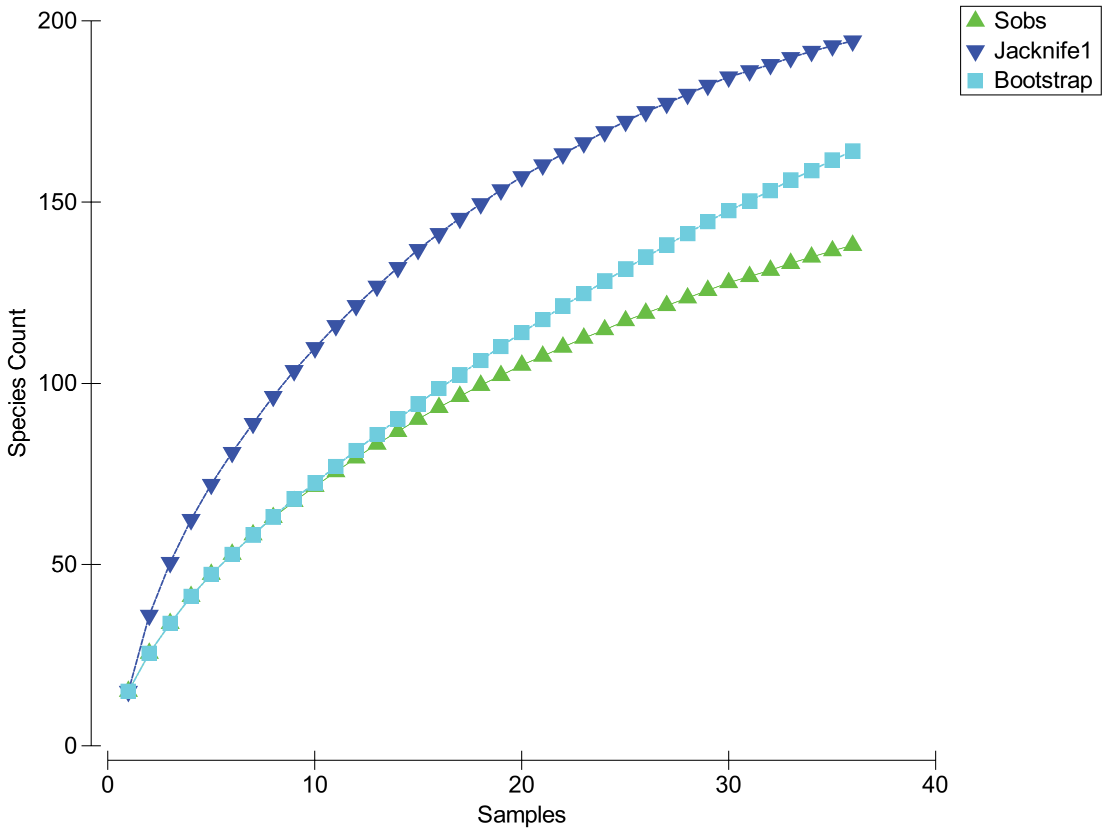


Figure 3 Species accumulation curve of the species observed (Sobs) for 36 stations at Mermaid, Scott and Seringapatam reefs, and projected estimates of diversity based on Bootstrap and Jacknife non-parametric methods.

the 2006 collections. Caridean shrimp families and the family Galatheidae have been omitted due to their identifications being incomplete.

Species richness within families across the reefs ranged from one species (Palinuridae, Dromiidae, Leucosiidae, Aethridae, Dairidae, Daldorphiidae, Carpiliidae, Eriphiidae, Goneplacidae, Cryptochiridae) to a maximum of 45 species (Xanthidae) (Table 3). Seventeen families were represented by three or fewer species. Four families had between four and ten species Paguridae (6), Porcellanidae (8), Trapeziidae (8) and Tetralidae (7). Four families had more than 10 species each, Xanthidae (45 species), Majidae (14), Diogenidae (14) and Portunidae (14), (Table 3).

The Xanthidae was the most diverse family at all reefs and had the greatest observed change in species richness across reefs: Mermaid (23 species), South Scott (29), North Scott (11) and Seringapatam (9). Diversity of the coral inhabiting crabs (Trapeziidae and Tetralidae) was relatively consistent across the reefs with a maximum of 12 species being recorded at South Scott and a minimum of seven species at Seringapatam Reef, and 10 species at both Mermaid and North Scott reefs. A similar pattern was observed in the anomuran family Diogenidae: South Scott Reef (max. 11), Seringapatam Reef (min. 6), Mermaid and North Scott Reefs (8 each). Diversity of the Majidae across the reefs is highest at Mermaid and South Scott reefs (9), and lowest at Seringapatam Reef (2).

The ordering of families based on species richness should not be treated as conclusive because the identifications of galatheids and caridean shrimps has yet to be completed. Both of these decapod groups were observed to be significant components of the faunas at all reefs, in particular galatheids. Despite the unavailability of this data it is unlikely either family would surpass the observed diversity of the Xanthidae at any of the reefs.

Site diversity

Species richness at sites ranged from a minimum of six species (Mermaid stn 7) to a maximum of 25 species (South Scott stn 24). Mean site richness within reef systems was highest at South Scott Reef (16.5 species), followed in decreasing order of richness by Mermaid (12.4), Seringapatam (11.8) and North Scott reefs (10.7) (Table 4). The reef platform stations showed the highest species richness (average of 17.2 species), and lagoon stations had the lowest (11.8). Outer reef stations had an average number of 13.7 species. The average across habitats was 13.5 species.

Above: The cleaner shrimp, *Stenopus hispidus* (Olivier, 1811) was common under ledges. (Photo: Sue Morrison)

Table 3 Species richness within decapod families across all reefs and within each reef. Caridean shrimps and galatheids have been omitted due to the incomplete identifications among these groups. The four most species rich families are highlighted, the highest ranked in orange and the others in grey.

Family	Number of Species				
	All Reefs	Mermaid	Sth Scott	Nth Scott	Seringapatam
Stenopodidea					
STENOPODIDAE	2	2	0	1	0
Palinura					
PALINURIDAE	1	1	1	1	0
Anomura					
DIOGENIDAE	14	8	11	8	6
PAGURIDAE	6	5	3	2	0
PORCELLANIDAE	8	3	6	3	1
Brachyura					
DROMIIDAE	1	1	0	0	1
CALAPPIDAE	2	0	2	0	0
LEUCOSIIDAE	1	0	1	0	0
MAJIDAE	14	9	9	6	2
AETHRIDAE	1	1	0	0	0
DAIRIDAE	1	1		1	1
DALDORPHIIDAE	1	0	1	0	0
PORTUNIDAE	14	5	7	4	1
XANTHIDAE	45	23	29	11	9
TETRALIDAE	7	6	5	3	4
TRAPEZIIDAE	8	4	7	7	3
DOMECIIDAE	2	2	2	0	0
CARPILIIDAE	1	0	1	0	0
PILUMNIDAE	3	1	2	1	1
ERIPHIIDAE	1	0	1	1	0
GONEPLACIDAE	1	0	1	0	0
OCYPODIDAE	2	0	2	0	0
GRAPSIDAE	3	1	3	1	1
PLAGUSIIDAE	3	0	0	2	1
CRYPTOCHIRIDAE	1		1	1	1

Table 4 Average species richness within each reef, across reefs, and for each habitat type within and across reefs. Calculations do not include channel stations.

Mermaid Reef	Mean	Std Dev
Station Richness (all collections)	12.4	4.03
Station Richness (transect only)	10.6	3.58
Lagoon	11.9	4.52
Outer Reef	12	3.46
Platforms	19	
South Scott Reef		
Station Richness (all collections)	16.5	4.99
Station Richness (transect only)	15.8	4.39
Lagoon	16.2	4.27
Outer Reef	14.3	5.12
Platforms	21.3	3.21
North Scott Reef		
Station Richness (all collections)	10.7	6.07
Station Richness (transect only)	11.6	5.13
Lagoon	10.6	3.51
Outer Reef	16	7.81
Platforms	11.7	6.43
Seringapatam Reef		
Station Richness (all collections)	11.8	3.7
Station Richness (transect only)	11.6	3.97
Lagoon	8.5	1.41
Outer Reef	12.5	2.12
Platforms	17	
Species Richness Across Reefs		
All Habitats	13.5	5.1
Lagoon	11.8	4.57
Outer Reef	13.7	4.83
Platforms	17.25	5.96

Above: The trapeziid crab, *Trapezia cymodoce* (Herbst, 1801). (Photo: Clay Bryce)

Species distributions and comparisons among reefs

The stations are clearly different due to differences in habitats, with the intertidal platform habitat being very different from the subtidal habitats of the lagoon and outer reef (Figure 4a). These differences are greater than differences between reefs, although reef location influenced the clustering of Mermaid Reef subtidal stations. Strong clustering was observed in the closely situated northern reefs of South Scott, North Scott and Seringapatam but there was little separation of reef systems within this cluster. A gradient separation of lagoon and outer reef habitats is evident. It is apparent that the same habitats need to be compared across reef systems.

Habitats across reef systems

The crustacean assemblages at the platform stations were very different from lagoon or outer reef communities. Separation occurred at 15% similarity and was significant (SIMPROF, $p < 0.05$, Figure 4a). The lagoon and outer reef communities also showed some separation. There is a gradient in the communities among reef systems from Mermaid to the more northerly reefs, Scott and Seringapatam reefs. The average dissimilarity between the platform habitat and the two subtidal habitats combined (lagoon and outer reefs) was 86%.

Ten species were the main discriminators (SD/Diss > 1) of the differences between platform habitats and the other two habitats combined (Figure 4b). *Eriphia scabricula*, *Pilodius areolatus* and

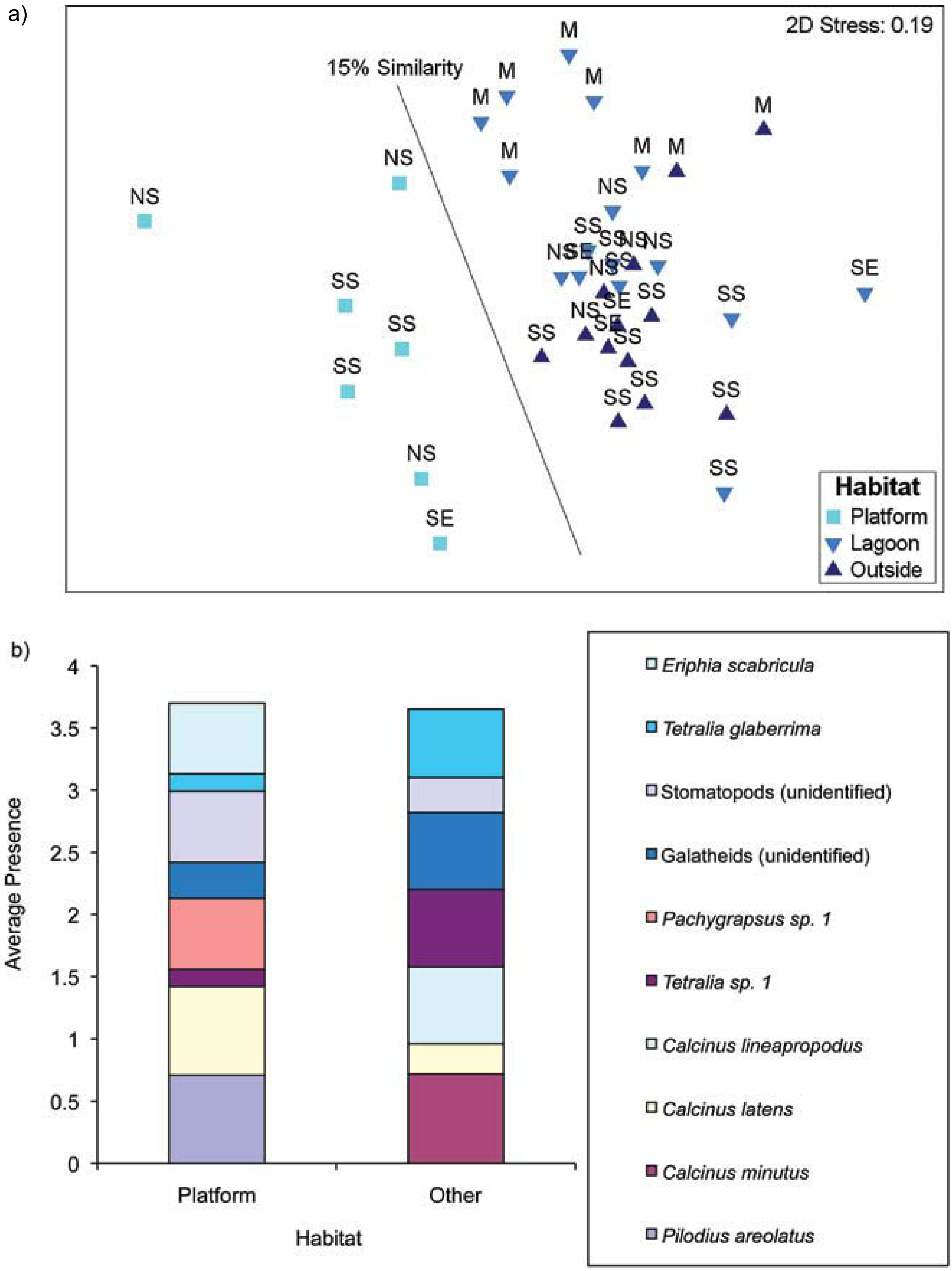


Figure 4 Crustacean taxa from north-west Australian reefs, a) two-dimensional ordination, showing the main habitat types for each reef system, b) discriminating taxa based on average presence or absence across stations within each habitat grouping (SIMPER, Diss/SD >1). M: Mermaid, SS: South Scott, NS: North Scott, and SE: Seringapatam. The main groupings are significant at 15% similarity (SIMPROF, $p < 0.05$), Other includes the two subtidal habitats (lagoon and outer reef).

Table 5 PERMANOVA results for the three main habitats (platform, outer reef, lagoon), a) main test, b) pairwise tests, Mermaid and South Scott reefs, p value derived from the permutation method, North Scott and Seringapatam reefs, p value from the Monte Carlo method.

a) main test

Source	df	SS	MS	Pseudo-F	P(perm)
Reef	3	16575	5525.1	2.975	0.001
Habitat(Reef)	7	32424	4632	2.494	0.001
Res	25	46438	1857.5		
Total	**35**	**98488**			

b) pairwise tests

Groups	t	P
Mermaid Reef		
Lagoon, Outside	1.465	0.034
South Scott Reef		
Lagoon, Outside	1.185	0.119
Lagoon, Platform	1.784	0.017
Outside, Platform	1.917	0.015
North Scott Reef		
Lagoon, Outside	1.368	0.199
Lagoon, Platform	1.879	0.054
Outside, Platform	1.824	0.046
Seringapatam		
Lagoon, Outside	1.188	0.328
Lagoon, Platform	1.403	0.334
Outside, Platform	2.458	0.167

Pachygrapsus sp. 1 only occurred in the platform habitats and were absent from lagoons and outer reef habitats. This is expected, as the former two species, and members of the genus *Pachygrapsus,* are known inhabitants of the intertidal zone, and only *P. areolatus* is also reported from the shallow subtidal. Coral associated species were either absent (*Calcinus minutes* and *Calcinus lineapropodus*, Diogenidae), or of decreased influence (*Tetralia glaberrima* and *Tetralia* sp. 1), on station similarity of platform stations. Other species, stomatopods (unidentified), and *Calcinus latens*, were more common in this habitat than either lagoon or outer reef habitats. Stomatopods and galatheids were not identified to species and it is likely that different species occur in the different habitats.

The PERMANOVA results support the above results with habitats nested in reefs being significantly different from each other (Table 5, $p < 0.05$). Pairwise comparisons clearly indicate separation of the platform communities from the other two habitats at South Scott Reef. Differences between lagoon and outer reef habitats were only significant within Mermaid Reef, a separation also evident in the two-dimensional ordination. No significant difference ($p > 0.05$) was observed between habitats at North Scott and Seringapatam reefs, a result of the low number of stations sampled at these reefs. The highest p values are recorded for pairwise tests for Seringapatam, which had the lowest number of stations sampled (5 stations).

There is some indication that that there are differences in the platform crustacean assemblages across the three reefs where these were sampled, with the South Scott stations grouping together and one of the North Scott stations closer to the Seringapatam station. The North Scott stations were all widely separated from each other, possibly due to the low number of species collected at each station. However, there were no significant groupings of the platform stations below 15% similarity.

Depths differences for the outer reef and lagoon habitats

There were no major differences in crustacean assemblages as a result of the depth sampled at the subtidal stations, encompassing the lagoon and outer reef habitats (Figure 5a). In general, crustaceans from the shallow and deep sampling at the same station were very close on the MDS plot, and species that occurred at 5 m were just as likely to be collected at the 12 m depth. There was some evidence of the grouping of stations due to habitat and reef location (Figure 5b and c). The reef

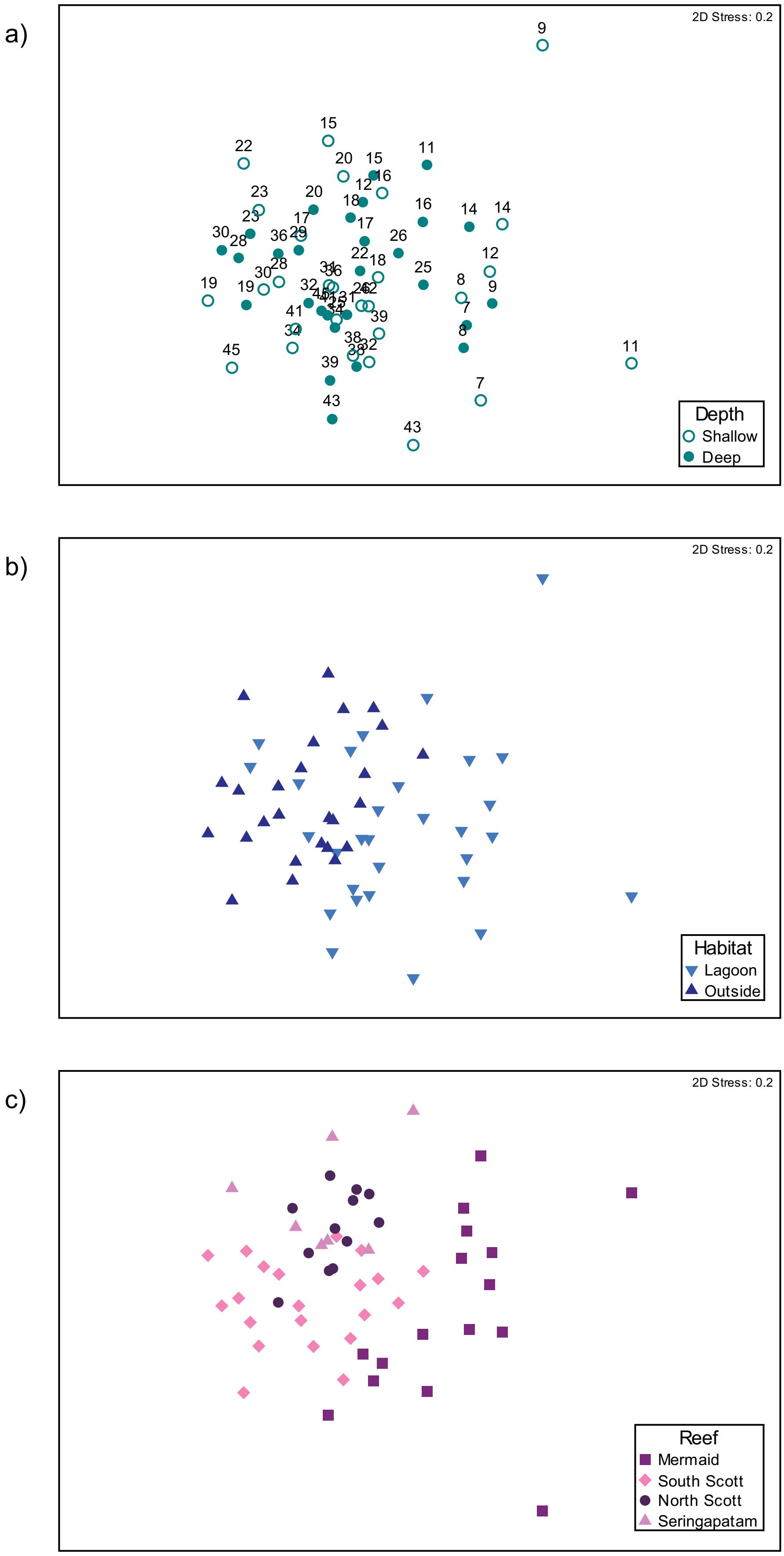


Figure 5 Two-dimensional ordination of crustacean taxa from subtidal stations on north-west Australian reefs, a) depth and station number, b) habitat and c) reef.

Table 6 PERMANOVA results for lagoon and outer reef habitats only. a) main test, b) pairwise tests

a) main test

Source	df	SS	MS	Pseudo-F	P(perm)
Reef	3	31569	10523	4.083	0.001
Habitat	1	8094.5	8094.5	3.140	0.002
Depth	1	4170.5	4170.5	1.618	0.074
Reef x Habitat	3	16011	5337	2.071	0.001
Reef x Depth	3	6357.9	2119.3	0.822	0.776
Habitat x Depth	1	2551.5	2551.5	0.990	0.445
Reef x Habitat x Depth	3	5272.8	1757.6	0.682	0.925
Residual	40	1.03E+5	2577.5		
Total	**55**	**1.85E+5**			

b) pairwise tests

Groups	t	P(perm)
Lagoon		
Mermaid, South Scott	2.171	0.001
Mermaid, North Scott	2.226	0.001
Mermaid, Seringapatam	1.544	0.005
South Scott, North Scott	1.963	0.002
South Scott, Seringapatam	1.507	0.014
North Scott, Seringapatam	1.356	0.08
Outer Reef		
Mermaid, South Scott	1.727	0.003
Mermaid, North Scott	2.074	0.003
Mermaid, Seringapatam	1.969	0.029
South Scott, North Scott	1.607	0.009
South Scott, Seringapatam	1.393	0.025
North Scott, Seringapatam	1.502	0.045

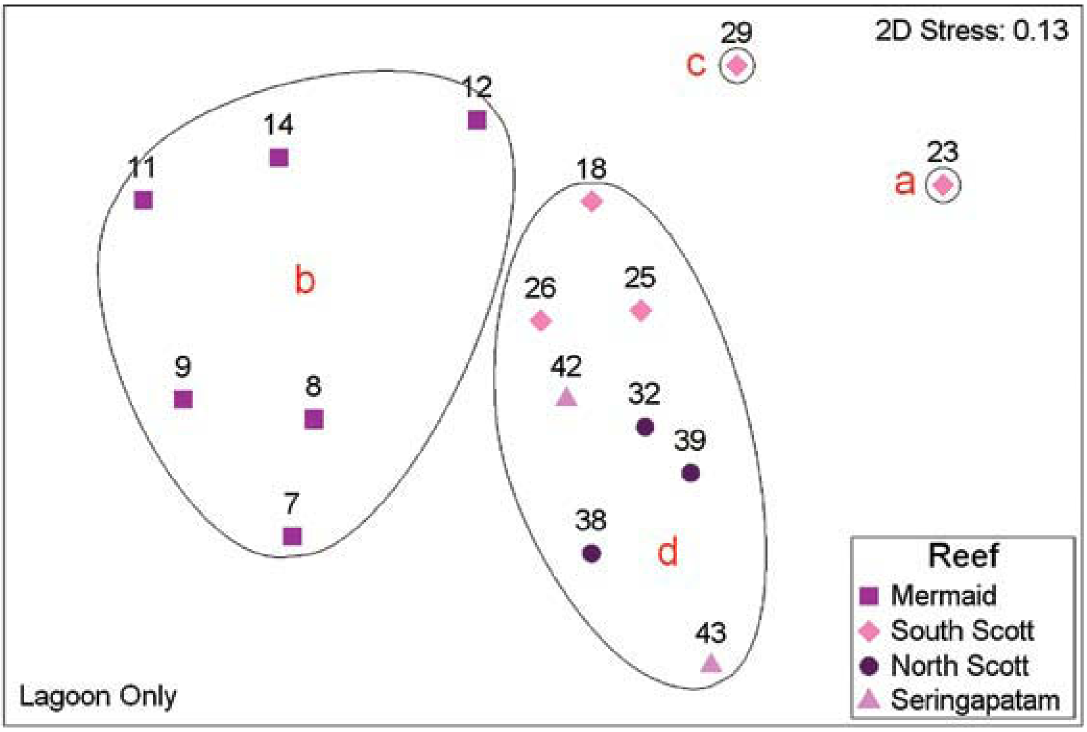
by habitat by depth, habitat by depth, and reef by depth interactions were all not significant (Table 6a).

A clearer picture of the differences among reefs was obtained by pooling the two depths sampled at each station and examining the reef dissimilarities for each habitat. The crustacean assemblages in lagoons were very different at Mermaid Reef compared to those from the other atolls (Figure 6a). Three of the stations at South Scott grouped with lagoon stations from North Scott and Seringapatam reefs, and there is a north/south gradient evident on the plot. Two of the South Scott stations (stn 23, group a and stn 29, group c) formed their own groups.

Six of the top ten species contributing to the similarities within the groups are obligate coral associates (*Trapezia guttata*, *Tetralia* sp.1, *T. nigrolineata*, *T. glaberrima*, *Haplocarcinus marsupialis* and *Calcinus minutus*) (Figure 6b). Mermaid Reef lagoon stations (Group b) were the least influenced by these coral associates and separated out largely due to the dominance of the xanthid *Chlorodiella* ? *cytherea* (>25%) and the occurrence of the xanthid *Psaumis* ? *cavipes,* the latter species not being present at any of the other reefs. Overall, the percentage composition of species driving similarity within Group b is markedly different from the other three groups. Station similarity in Group d, the northern reefs collective group, was strongly influenced by coral associates with five of the nine discriminating species being coral associates and comprising greater than 50% of the group's composition. Two of the species, *Trapezia guttata* and *Haplocarcinus marsupialis*, were not dominant within the other groups. Separation of the two single station groups at South Scott (stn 23, group a, and stn 29, group c) was driven by the strong influence of rare species (80% and > 80% respectively). The three discriminating species for both groups are the same and are also common with Group d. Only one of the species is shared with the Mermaid Reef group.

The crustacean assemblages at outer reefs were very similar across atolls and no significant groupings were formed (Figure 7a). However, some difference is evident in the Mermaid Reef stations, which are well separated from the other reef stations, and evidence of a north/south change in communities in the more northern reefs.

Examination of the top ten species contributing to similarity within each reef supports the observed separation of the Mermaid outer reef stations (Figure 7b). The coral associated hermit crab *Calcinus minutus* was common to all reefs. Only three species, *Trapezia tigrina*, *Dardanus lagopodes* and *Calcinus minutus*, contributed to similarities at Mermaid Reef and comprised 75% of the species composition of the outer stations. Similarity of outer reef assemblages of South Scott, North Scott and Seringapatam reefs was determined by eight, seven and six species respectively. Two species, *Tetralia* sp. 1 and *T. glaberrima*, were common drivers to all three northern reefs. Three species, *Trapezia lutea*, *Calcinus lineapropodus* and *Dardanus lagopodes*, were a)



b)

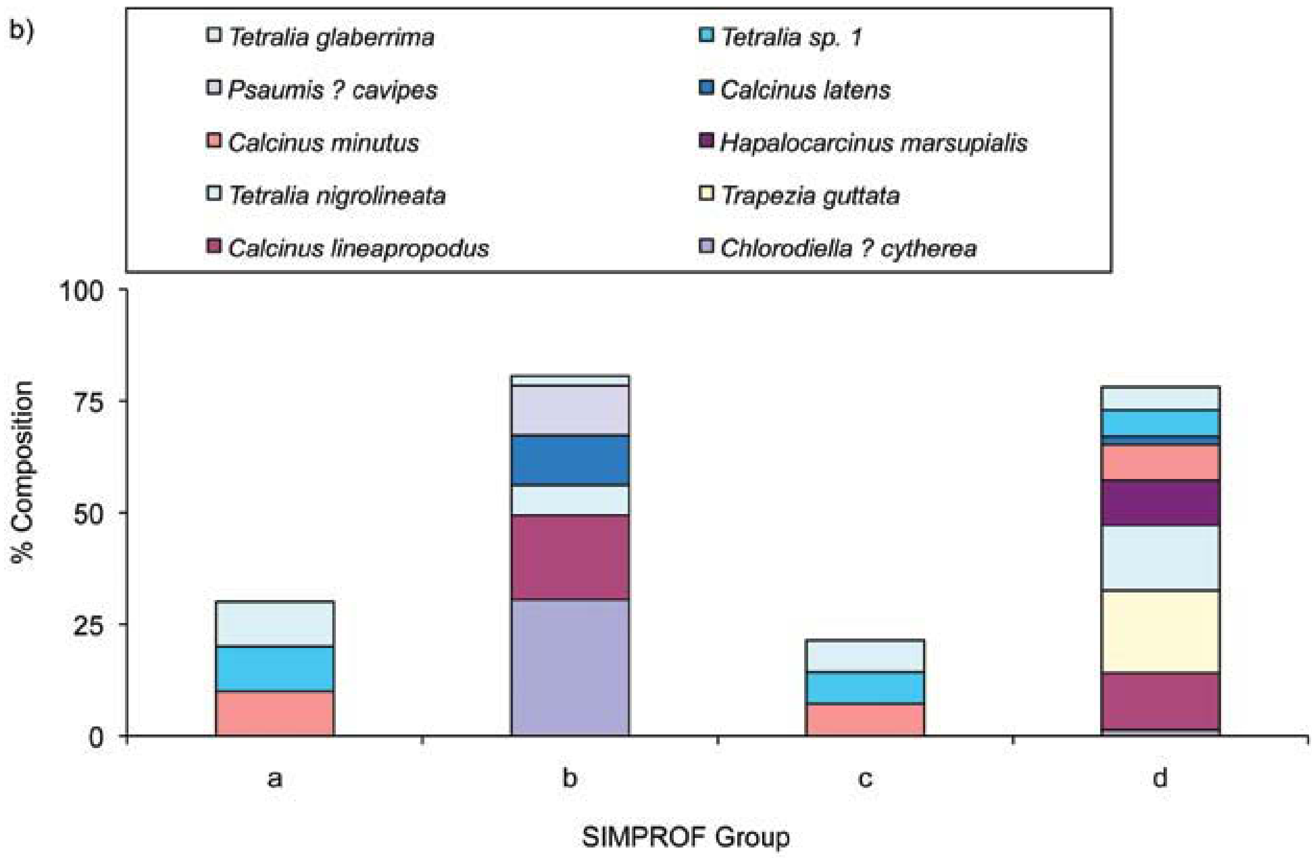


Figure 6. a) Two-dimensional ordination of lagoon stations, depth has been pooled. Clusters were significant (SIMPROF, $p < 0.05$). b) Top ten taxa that contributed to the similarity within each group (SIMPER).

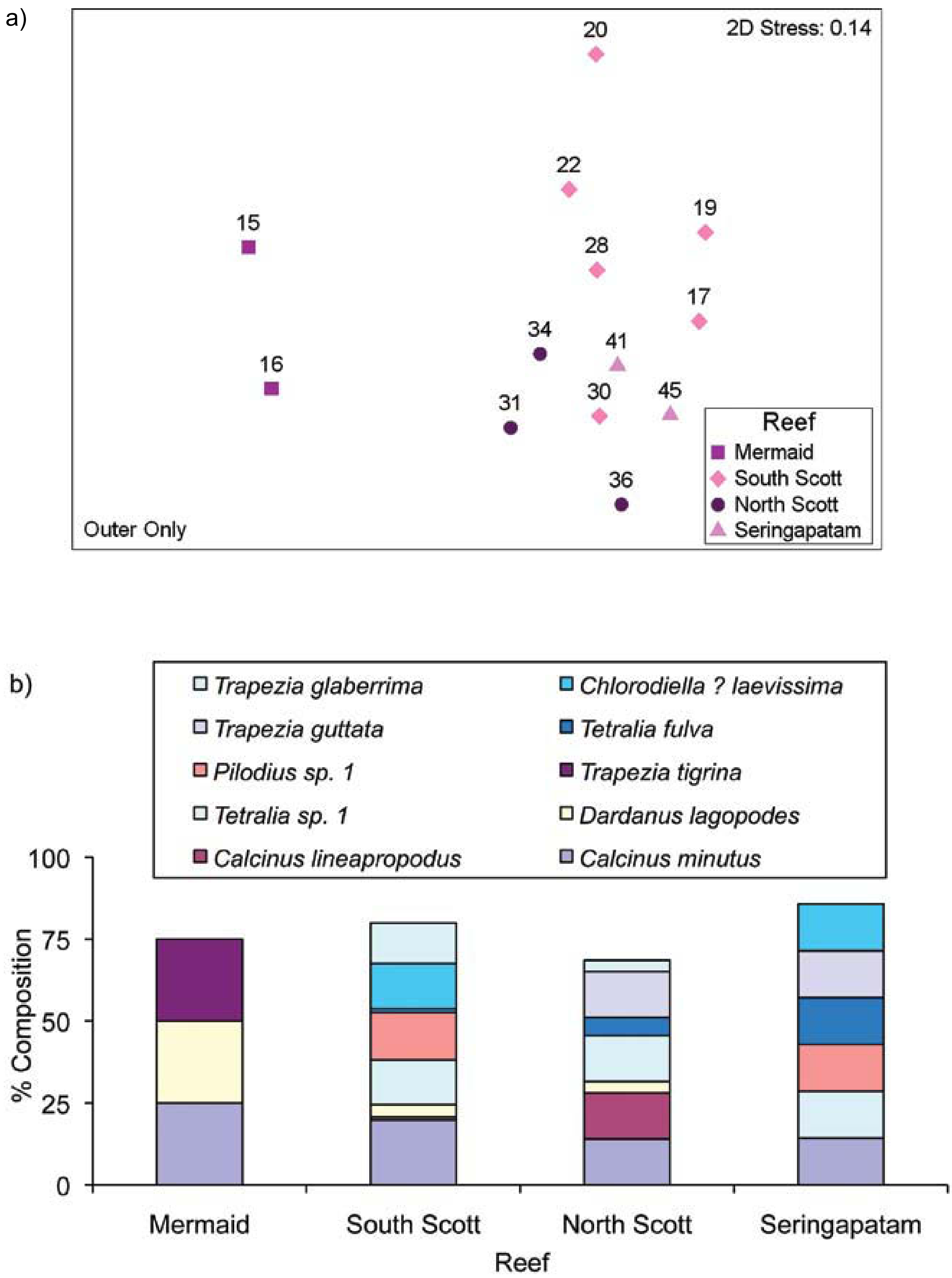


Figure 7 a) Two-dimensional ordination of outer reef stations, depth has been pooled. There was no significant clustering of stations in this habitat (SIMPROF, $p < 0.05$). b) Top ten taxa that contributed to the similarity within each reef (SIMPER).

Above: Boxer crab, *Lybia tesselata* (Latreille, 1812), can be found under coral slabs. (Photo: Clay Bryce)

shared drivers of similarity for South Scott and North Scott reefs stations. The latter species also contributed to similarity at Mermaid Reef. South Scott and Seringapatam reefs shared two species, *Chlorodiella* ? *laevissima* and *Pilodius* sp. 1. One species, *Trapezia guttata*, was shared by the closely situated North Scott and Seringapatam reefs.

DISCUSSION

Species richness

The increased number of species recorded in this survey compared with previous studies is due to increased sampling effort and the close examination of a variety of substrates. The fact that many previously recorded species have been collected again at the same location is encouraging and with completion of all species identifications the discrepancy between previous collections and repeat collections is expected to further diminish.

Comment on temporal changes in the crustacean communities between surveys is not practical as previous collections were limited. Nonetheless, between the first faunal surveys (early 1980s and 1990s) and the 2006 survey significant natural events, such as cyclonic activity, have occurred and led to the destruction of corals and physically altered the reefs. It would, therefore, be expected that some change should also be visible in the crustacean fauna. Firstly, these anticipated changes to the fauna could have been expressed in abundance rather than in diversity values, which highlights the need to include abundance studies in future surveys. Abundance studies would need to be targeted on specific taxa. For example, a study of the abundance of trapeziid crabs per area would be a good measure of the potential effects that coral damage could have on these crustaceans. Secondly, each species defines an ecological niche, which is potentially affected by change and the more species recorded the more likely that minor changes can be detected. The high diversity presented in this survey will therefore provide a good baseline and starting point for future monitoring programs.

The Xanthidae have long been recognised as a strong element of coastal reef communities. Previous collections from Scott, Seringapatam and Ashmore reefs, as well as Cartier Island indicated this pattern is also true of the north-western Australian shelf atolls, and certainly the high diversity recorded in the present study strongly supports this. The Xanthidae is the most diverse crab family in Australian waters, reaching its highest diversity in shallow reef communities (Davie, 2002). The family encompasses a broad range of trophic levels and associations with substrate types and the recorded high diversity during the survey likely reflects this ability to fill

Above: The shrimp, *Allogalathea elegans* (Adams & White, 1848) is only found on crinoid seastars. (Photo: Clay Bryce)

many ecological niches within a habitat. The large proportion of rare species (occurring at three or less stations) suggests the composition of the family is highly variable between stations. A high occurrence of rare species in the north-west reef communities would also indicate that to adequately sample xanthids a greater number of sample sites are required. The less sampled reefs of North Scott and Seringapatam reefs recorded a considerably lower diversity in this family.

The painted rock lobster, *Panulirus versicolor* (Latreille, 1804), is the only species of rock lobster known from the reefs. Live specimens were recorded only from North and South Scott reefs and all were juveniles. A single carapace of a juvenile was also collected from Mermaid Reef, Rowley Shoals, indicating the species occurs there but possibly in low numbers. Berry and Morgan (1986) did not record the species from the Rowley Shoals during the WA Museum 1984 survey and suggested there may be too many predators of spiny lobsters present, such as large serranid fishes, for the species to exist in the Rowley Shoals. However, high numbers of these fishes also occur in coastal waters where spiny lobsters are abundant (B. Hutchins, pers. comm.). It remains unknown as to why only juveniles of *P. versicolor* were recorded. While adults of the species are known to tolerate slightly less turbid conditions than juveniles, the known suitable habitats for both life history phases were sampled adequately during this present expedition. If recruitment of spiny rock lobster larvae to these offshore reefs is low, predation may be enough to keep numbers of individuals low. These outer-shelf atolls are under the influence of the Indonesian Throughflow, the warm water body that pushes through the Indonesian Archipelago to eventually form the Leeuwin Current (Hutchins, 2001). Thus the recruitment source for the atolls is likely to be from the Indonesian Archipelago. This fact would help to explain the extremely rare occurrence of the species at Mermaid Reef, which experiences a reduced impact from the current due to the reef's distance from the current source. Further investigations are nevertheless required into current strength and flow patterns from the Indonesian Archipelago to the atolls before any conclusions can be made regarding lobster recruitment.

Distribution

Mermaid Reef is situated 400 km south-west of Scott Reef and was the most southerly reef surveyed. It is therefore not surprising that results presented by the multidimensional scaling analysis and PERMANOVA established a clear separation of the Mermaid Reef communities from the more northerly Scott and Seringapatam reefs. This was particularly true of the lagoon stations, where Mermaid Reef stations were significantly different (SIMPROF, $p < 0.05$) from the stations at the other reefs. Compared to the other reefs surveyed Mermaid Reef has suffered less environmental disturbance from high sea water temperatures than the more northerly reefs (Gilmour *et al*., 2007). Nor has the reef been subjected to the same levels of fishing pressure as the northern reefs due to its status as a marine national nature reserve since 1991 (DEWHA, 2009). Furthermore, the frequency and ferocity of cyclonic events appears to be lower at Mermaid Reef than experienced at Scott and Seringapatam reefs (Bureau of Meteorology, 2009). Distance from such events may allow for sites within the Mermaid reef system to develop greater site distinctness.

The geographic separation of Mermaid Reef from the northern atolls is likely to result in greater differences in crustacean assemblages than in the other reefs. The life histories of many crustacean species include a long-distance larval dispersal phase. A dilution effect of the Indonesian Throughflow could explain the absence, or reduced influence, of the species at Mermaid Reef with such a life history, and Indo-Malaysian affinities. Castro (2000) suggested that geographic distribution of most species of the brachyuran family Trapeziidae (*Trapezia* spp.) and Tetraliidae (*Tetralia* spp. and *Tetraloides* spp., Castro *et al*., 2004) is best explained by long distance larval dispersal. Members of these families had a strong presence in the top ten taxa contributing to similarity within reefs, and showed considerable variation in composition between the reefs, the greatest difference being at Mermaid Reef. Serious consideration must be given to the fact that members of these families of crabs are obligate symbionts of reef building, hermatypic corals and other colonial cnidarians. Species of *Trapezia* are associated with pocilloporid corals and *Tetralia* and *Tetraloides* with acroporid corals (Castro & Titelius, 2007). Their distribution is therefore linked to the distribution and occurrence of their hosts. Along the Western Australian coastline the numbers of species of these families of corals declines at lower latitudes, five species of *Pocillopora* and 48 species of *Acropora* have been recorded from Western Australian waters in the Timor Sea and only one species of *Pocillopora* and two species of *Acropora* being recorded south of Perth (Veron, 1993). By comparison, 17 species from within the three genera of these crabs have been recorded from Western Australian waters previously and of these only five species occur as far south as Perth (Castro & Titelius, 2007).

The close proximity of Scott and Seringapatam reefs to one another (approximately 25 km apart) is evident in the degree of clustering observed between the reef communities in the multidimensional scaling plots. The PERMANOVA results indicated the North Scott lagoon fauna is more similar to Seringapatam Reef despite its closer proximity to South Scott Reef. The open morphology of the South Scott lagoon possibly contributes to this difference (see maps in station and transect data, this volume). The open lagoon of South Scott Reef is likely to reduce differences between lagoon and outer reef environments. It could also explain the separation of the two South Scott lagoon stations from the northern reef collective group in the two-dimensional plots.

There was a strong separation of all reef platform communities from outer reef and lagoonal sites. The fauna encountered on the platforms need to withstand the extreme conditions experienced when the reef is exposed. The diversity of living substrates (such as corals) with which some crustaceans associate is dramatically reduced in such exposed areas. Furthermore, the absence or presence of tidal pools can have a dramatic effect on the species diversity observed in a platform environment. The high variability of platform habitats is evident in the low level clustering of the stations in the multidimensional scaling analysis.

Sampling methods for crustaceans

Many crustaceans are inherently cryptic, well camouflaged and highly mobile. This ″…habit of lurking in crevices…″ and when alarmed "… darting with great swiftness through the water…" (Calman, 1911) requires the employment of special collection and extraction methods. It also means that the process of collecting and extracting crustaceans from their substrate, in order to obtain a species record, is more time consuming than the recording of species of other groups.

A fully quantitative method of sampling involving quadrat counts and transect visual surveys was initially trialled for the collection and documentation of crustaceans (stations 1–4), but did not produce the best possible results for recording biodiversity. Collecting particular substrates and thereby capturing the large proportion of crustaceans that live as epi- and endofauna was found to be the most successful method for maximising species richness. Because this type of study is more time consuming than relying mainly on visual recognition of species, a study of abundances was not possible within the timeframe set for each station. Should abundance studies be included in future surveys, it is suggested that these should be based on selected less cryptic and easily identifiable species, such as hermit crabs. One of the main advantages of the substrate sampling method is that species are identified with the habitat they are associated with. This information is often missing from faunal surveys but is invaluable in directing future sampling efforts and collection methods, in understanding and interpreting the complexity of ecosystems and in providing topics for future studies into the biology of marine crustaceans. For instance, a study linking the distribution of trapeziid crabs, which inhabit corals, with the distribution and abundance of the host coral species may highlight the dependencies between these two taxa. One of the discoveries made during this survey was a pilumnid crab inhabiting tube-shaped sponges. It would be worthwhile to explore the possible relationship between the sponge and the crab species to investigate the biology of the crab, which is found in breeding pairs within the sponge, apparently forming part of the crabs' reproductive strategy.

The fact that many crustaceans are nocturnal has not been addressed by the collection method employed in this survey. Nocturnal collections would undoubtedly provide a more accurate estimate of crustacean biodiversity and most likely expand the current species list. It would be worthwhile, therefore, to include some night sampling in future surveys. The current sampling regime also does not take into account the biphasic life style of many crustaceans. Many species are known to colonise a particular habitat as juveniles (for example shallow depths) and then migrate to a different habitat (deeper depths) as reproductive adults. As this survey only sampled depths to 12 m mean sea level the inclusion of sampling to greater depths would increase the chance of discovering adult specimens of species currently only represented by juveniles in this study.

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The macromolluscs of Mermaid (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia.

Clay Bryce and Corey Whisson
Department of Aquatic Zoology

Mollusc Section, Department of Aquatic Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, WA 6986, Australia.
Email: Clay.Bryce@museum.wa.gov.au, Corey.Whisson@museum.wa.gov.au

Abstract – This paper records 339 macromolluscan species comprising 261 gastropods, 70 bivalves, six cephalopods and two chiton species from the north-western Australian atolls of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reefs.

These records result from a survey undertaken by the WA Museum in September 2006, during which both qualitative and quantitative data sets were recorded. The data included a comprehensive inventory of molluscs, based on a presence/absence statistical assessment, and quantitative density records along replicated transects at outer slope and lagoonal stations. The qualitative survey results are compared with those from WA Museum surveys to the Rowley Shoals in 1982 and Scott and Seringapatam reefs in 1984, as well as from other locations of regional significance. While Mermaid Reef appeared little affected, habitat changes were apparent on Scott and Seringapatam Reefs. The shifts in some molluscan populations since the surveys in the 1980s may be related to warm water incursions, cyclonic activity and/or unregulated fishing. The populations of three gastropod species, *Cerithium echinatum*, *Conus miliaris* and *Conus musicus*, appeared to have increased, probably due to habitat change, when compared to data from the 1980s. However, the populations of giant clams (*Tridacna* spp. and *Hippopus hippopus*) and trochus (*Tectus niloticus*) on Scott and Seringapatam reefs had significantly declined, probably with the added pressure of unregulated fishing. These latter declines are supported by the findings of the senior author during a separate survey concerning a survey of the invertebrate marine resources of Scott Reef, Seringapatam Reef and Browse Island in February, 2006 (Bryce, 2006). A new Australian record for *Marchia martinetana* (Röding,1798) (Muricidae), is documented from North Scott Reef, and three new Western Australian records, for *Euplica deshayesii* (Crosse,1859) (Columbellidae), *Notodoris serenae* Gosliner and Behrens, 1997 (Aegiridae) and *Monitilora* simplex (Reeve,1850) (Lucinidae) are also documented. The records of *Pitar spoori* Lamprell and Whitehead, 1990 (Veneridae) is also significant as that species has only previously been recorded from Hibernia Reef, off north-western Australia.

INTRODUCTION

The Western Australian Museum (WA Museum) has now undertaken three marine macromolluscan surveys of oceanic, shelf-edge atolls off the North West Shelf of northwestern Australia. The first was to the Rowley Shoals, visiting Clerke and Mermaid Reefs in 1982, the second to North and South Scott Reefs and Seringapatam Reef in 1984 - the results for these two surveys being published in 1986 (Wells and Slack-Smith *in* Berry, 1986). A third survey to Ashmore Reef and Cartier Island was completed in 1986 (Wells *in* Berry, 1993).

This paper inventories the macromolluscs (Table 1) recorded during a WA Museum marine biodiversity survey undertaken in September 2006 at Mermaid Reef (Rowley Shoals), North and South Scott Reefs and Seringapatam Reef. Comparisons are made with the results from the WA Museum's 1986 report.

Since 1986 several surveys of the offshore reefs and atolls of that region have also been carried out by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Skewes, 1999a, 1999b) and the Australian Institute of Marine Sciences (AIMS) (Rees, 2003; Smith, 2005). The aim of those surveys was to examine the marine resources of the reefs, including species of giant clams belonging to the genera *Tridacna* and *Hippopus,* and the trochid gastropod,

Above: *Tectus niloticus* Linnaeus, 1767. Species numbers were very poor due to unsustainable fishing practices. (Photo: Clay Bryce)

Tectus niloticus. In February 2006 the senior author surveyed the marine invertebrate resource species of holothurians, giant clams and trochus of Scott Reef, Seringapatam Reef and Browse Island (Bryce, 2006).

METHODOLOGY

Only macromolluscan species are included in this report. Macromolluscs are defined as species with adult size greater than or equal to one centimetre. Only those species taken/recorded during this survey are included. Data from molluscan collections, recorded over time during collecting trips by this and other museums, have not been included.

The previous molluscan surveys undertaken in 1982 and 1984 were qualitative in nature and recorded observed species at each station. The methodology adopted for this 2006 survey incorporated both qualitative and quantitative aspects. The former recorded species presence at all stations while the latter recorded the density of molluscs along replicated transects for lagoon and outer reef slope stations. Intertidal reef platform (intertidal platform) and channel stations were not sampled quantitatively. All stations were sampled over one hour and during daylight hours for logistical and safety reasons.

Transect stations: Outer Reef slope and lagoonal stations.

Replicate transects (each one metre wide and five metres apart) were established at outer slope and lagoonal stations. Transects were searched by two divers who recorded the presence and abundance of molluscan species. However, species from the families Vermetidae and Hipponicidae were not counted because of time constraints.

Transects ran from the deepest (maximum of 20 m) to the shallowest points of each station and followed a preset compass bearing. While this provided the greatest degree of habitat change it also resulted in transects of differing lengths. To compensate, molluscan density data were standardised to 50 m^2.

Because of the hidden nature of most molluscs, rocks and coral slabs, when abundant, were turned at five metre depth intervals along the transects. Where the rocks and slabs on the transects were few, all were turned and investigated. Small, scattered sand patches were raked for infaunal molluscan species and larger sand plains were sub-sampled by raking an area of 1 m^2 at every alternate metre along the transect lines. Short handled rakes, 500 cm wide, which penetrated the substrate to a maximum depth of 5 cm, were used for this purpose.

During the transect-swims, extra qualitative, off-transect searches were undertaken to increase the coverage of mollusc species recorded for the station. This was accomplished in two ways. Firstly, by the diver periodically halting his progress along the transect, marking his position and then exploring mollusc-rich habitats adjacent to that point on the transect. Secondly, by investigation of areas adjacent to the transects once the transect-swim had been completed. This ensured that the molluscan fauna from all depths and habitats along and adjacent to the transects was surveyed within the allotted one hour dive time.

Progressing along each transect, each diver manually recorded the species and numbers of all macromolluscs encountered. Unidentified or noteworthy specimens were collected and later identified and retained as registered vouchers in the collections of the WA Museum.

This method proved efficient. By swimming the compass bearing, the time taken to lay and retrieve a transect-tape was saved. This time saving impacted favourably on maximising in-water

Above: *Lambis chiragra* (Linnaeus, 1758). A common reef species collected by fishers for the international shell trade. (Photo: Clay Bryce) data collecting time and limiting the overall diver nitrogen loads.

Non-quantitative stations: Intertidal reef platform and channel drift stations.

Intertidal platform stations presented a particular problem for recording molluscan densities. Effective sampling of the very wide intertidal reef platforms, often over one kilometre wide, was difficult within the workable period of a low tide cycle. Intertidal platform stations were treated as biodiversity sites and no attempt was made to quantify the species.

Faunal surveys of the stations in the channels, where excessive water flow precluded detailed searching, could be accomplished only by drift diving and so were also limited to qualitative assessments.

HABITAT DIVISIONS

References to habitats in this paper are double tiered. The first habitat tier describes the broad-scale topographical features found on many atolls, such as the lagoon, intertidal reef platform and the outer reef slope. The second tier refers to those habitat divisions within each station that are relevant to molluscan biology and life history. Survey stations, particularly those around the outer reef slope and in the atoll lagoons, generally encompassed several intergrading habitats e.g. a subtidal coral reef merging through broken coral rubble with sandy pockets to an open sandy plain.

Second tier habitat divisions adopted here are:

Intertidal Hard Substrate (IH):

This is an intertidal zone consisting mainly of coral rubble and reef pavement. These hard substrates may be covered with a thin coating of sediment and algal turf.

Above: *Lopha cristigalli* (Linnaeus, 1758). This species, with *Hyotissa hyotis* (Linnaeus, 1758) and *Hyotissa numisma* (Lamarck, 1819), had suffered severe population loss due to the destruction of coral habitat from a combination of coral bleaching and cyclonic activity. (Photo: Clay Bryce)

Above: *Hyotissa hyotis* (Linnaeus, 1758) (Photo: Clay Bryce)

Subtidal Hard Substrate (SH):

As above, but situated below low-tide level at outer slope and lagoon stations.

Sediment (S):

Intertidal and subtidal sand habitats. In such habitats, molluscan species may be infaunal or epifaunal.

Pelagic (P):

This habitat is represented by the water column from the sea surface to the substrate.

Associated with another organism:

This habitat type applies to those molluscs whose survival strategy involves an intimate and obligatory association with another life form.

Epiphytic (EP):

Plant-related associations, in which a species of seagrass or alga is the obligatory substrate

Epizooic (EZ)

Faunal related associations where an animal forms the obligatory substrate, such as coral, gorgonians and another species of m ollusc.

RESULTS AND DISCUSSION:

The molluscan species recorded during the 2006 survey are listed in Table 1 with WA Museum registration numbers being given for significant species. The taxonomic order adopted follows Beesley *et al*., 1998, with some subsequent taxonomic amendments. Station numbers, relevant habitat divisions and comparative records from the 1986 survey report (Wells and Slack-Smith 1986) are also included whether or not the species were recorded during this survey.

During the 1982 survey, 389 species were

Table 1 Molluscan species occurrence per station for the macromolluscs of Mermaid (Rowley Shoals), Scott (North and South) and Seringapatam reefs, Western Australia.
Habitat key: IH=intertidal hard substrate; SH= subtidal hard substrate; S= sand; EZ = associated with animal, EP = associated with plant
1986 Records: C= Clerke, M= Mermaid, SS= Scott South, SN= Scott North, SE= Seringapatam

Taxa	1986 Records	ATOLL RECORDS - 2006				
		Mermaid	Scott South	Scott North	Seringapatam	Habitat
Polyplacophora						
CHITONIDAE						
Lucilina lamellosa (Quoy and Gaimard, 1835) (s31174)		1		32,39		IH
Chiton sp.	SS					
CRYPTOPLACIDAE						
Cryptoplax occulatus (Burrow, 1815) (s31196)				36		IH
Cryptoplax sp.	C					
Gastropoda						
PATELLIDAE						
Scutellastra flexuosa (Quoy and Gaimard, 1834)	SS,SN					IH
HALIOTIDAE						
Haliotis asinina Linnaeus, 1758	C,M	8				IH,SH
Haliotis crebisculpta Sowerby, 1914 (s31059)	SN	5				IH
Haliotis ovina (Gmelin, 1791) (s31048)	C,M,SS,SE	7,14	18,20	36		SH
Haliotis planata Sowerby, 1833	C		18,20			IH
Haliotis cf. *varia* Linnaeus, 1758		14		36,38		IH,SH
Haliotis cf. *pustulata* Reeve, 1846 (s31189)				36		SH
TURBINIDAE						
Astralium rhodostoma (Lamarck, 1822)	C	7,8,15	25,26,29		45	SH
Turbo argyrostomus/chrysostomus	C,M,SS,SN,SE	2,3,4,5,9,10,15,16	17.19,20,21,22,23,24,26,28,30	31,34,35,36,37,39,40	41,44	IH,SH
Turbo argyrostomus Linnaeus, 1758 (s31029)	C	4	30	31,33, 35	41,44	IH
Turbo chrysostomus Linnaeus, 1758 (s31218)	C	3		31,33		IH SH
Turbo cf. *haynesi* Preston, 1914 (s31181)				33		IH
Turbo petholatus Linnaeus, 1758	C,SN	4,12,13	17,18	36		IH SH
Turbo cf. *radiatus* (juvenile) Gmelin, 1791	C,M					IH
TROCHIDAE						
Angaria delphinus (Linnaeus, 1758)	SS,SN,SE		21			IH
Clanculus atropurpureus (Gould, 1849)	C,M					SH
Clanculus margaritarius (Philippi, RA, 1846) (s31083)		13	27			SH
Clanculus sp. (juvenile)	SS					
Euchelus instrictus (Gmelin, 1791)	SS					SH

Stomatella varia A..Adams, 1850	SS					SH
Stomatella impertusa Burrows, 1815 (s31090)		4,16				SH
Stomatia phymotis (Helbling, 1779)	C,M					SH
Tectus niloticus (Linnaeus, 1767)	C,M,SS,SE	1,2,3,4,7,9,16	17,18,19,21,22,30	33		IH.SH
Tectus virgatus Gmelin, 1791(s31096)		15,16	30	31		SH
Tectus pyramis (Born, 1778)	C,M,SS,SN,SE	1,2,3,4,6,9,13,14,15,16	17,18,19,20,22,23,28,29,30	37,38,39,40	41,45	IH,SH
Tectus cf. *triserialis* (Lamarck, 1822)	C					SH
Trochus maculatus Linnaeus, 1758	C,M,SS,SN,SE	4,15	21,24,27	31,37		IH
Trochus histrio Reeve, 1842	C					SH
Trochus cf. *histrio* Reeve, 1842 (s31000)	M,SS	1,4,7,8,14,15	20	38	41	IH,SH
Trochus triserialis (Lamarck, 1822)(s31009)	M	1, 7,9,12,14,15,16	18,29,30	38,39		SH
NERITIDAE						
Nerita albicilla Linnaeus, 1758	C,SS,SN,SE					IH
Nerita plicata Linnaeus, 1758	C,SS,SN,SE					IH
Nerita polita Linnaeus, 1758	C,SN,SE					IH
CERITHIIDAE						
Cerithium alveolus Hombron and Jacquinot, 1854	C					S
Cerithium atromarginatum Dautzenberg and Bouge, 1933	C,SS					S
Cerithium citrinum Sowerby, 1855 (s31168)				31	41,42	S
Cerithium columna Sowerby, 1831	C,SS,SN,SE					S
Cerithium echinatum Lamarck, 1822 (s31013)	C	2,3,4,5,13,15,16	17,19,20,21,22,23,24,27,28,30	31,34,36	41,44,45	SH,S
Cerithium egenum Gould, 1849	C					S
Cerithium lifuense Melvill and Standen, 1895 (s31192)				36		S
Cerithium nesioticum Pilsbry and Vanatta, 1905 (s31121)	C,M,SS		20,22		41	S
Cerithium nodulosum Bruguiere, 1792	C,SS,SN,SE		17,18,20,21,22,24,27,	31	41	IH,SH
Cerithium salebrosum Sowerby, 1855 (s31076)	SN	6,12				S
Cerithiium torresi Smith, 1884 (s31077)		12				S
Cerithium trailli (Sowerby, 1855)	SN					S
Cerithium zonatum (Wood, 1828)				40		S
Cerithium munitum Sowerby, 1855 (s31147)			26			S
Rhinoclavis articulata (Adams and Reeve, 1850)	C,SS,SN					S
Rhinoclavis aspera (Linnaeus, 1758)	C,M,SS,SN	7,11,12,13,14	18,21,24,25	31,34,35,36	45	S
Rhinoclavis brettinghami Cernohorsky, 1974		13				S
Rhinoclavis fasciatus (Bruguiere, 1792)	C,SS,SN				45	S
Rhinoclavis sinensis (Gmelin, 1791)	C,M,SS,SN,SE		19,20,21,24,27,28	33,34,37	41,44	S
Rhinoclavis vertagus (Linnaeus, 1767)	C					S

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
PLESIOTROCHIDAE						
Plesiotrochus sp.	SE					IH, SH
MODULIDAE						
Modulus tectum (Gmelin, 1791)	SN		25,28	31		SH
LITTORINIDAE						
Littoraria undulata Gray, 1839	C					IH
STROMBIDAE						
Lambis chiragra (Linnaeus, 1758)	C,M,SS,SN,SE	3,7,10	17,18,20,21,24,27	31,33,37	44	IH,SH
Lambis lambis (Linnaeus, 1758)	SS	7,8, 9,12,16	21,24,27,29	31,33,35,39,40		S
Lambis scorpius (Linnaeus, 1758)			17			SH
Lambis truncata (Humphrey, 1786)	C,SN	1,14	28	36	45	S
Strombus dentatus Linnaeus, 1758	SS					S
Strombus fragilis (Röding , 1798)(s31175)				32		S
Strombus gibberulus Linnaeus, 1758	C,SN,SS	6,7,8,9,14	24	35		S
Strombus latissimus Linnaeus, 1758	SS			31		S
Strombus lentiginosus Linnaeus, 1758	C,SS,SN,SE	7,8,15	17,18,21,24,27,30	31,33,35	41	S
Strombus luhuanus Linnaeus, 1758	SS,SN,SE		21,29	35		S
Strombus microurceus Kira, 1959 (s31127)			21		41	S
Strombus mutabilis Swainson, 1821	C,SS,SN		21,24,25,27	35	44	S
HIPPONICIDAE						
Hipponix conicus (Schumacher, 1817)	C,M,SS,SE					EZ
VANIKORIDAE						
Vanikoro cancellata (Lamarck, 1822) (s31061)	SE	4				SH
VERMETIDAE						
Vermetid spp.		1 to 16	17 to 30	31 to 40	41 to 45	IH,SH
CYPRAEIDAE						
Cypraea annulus Linnaeus, 1758	C,SS,SN			39		IH
Cypraea arabica Linnaeus, 1758	SS,SN,SE	3	24,27	33		IH
Cypraea asellus Linnaeus, 1758	M	3	19,24,27	35,40	41	SH
Cypraea caputserpentis Linnaeus, 1758	C,M,SS,SN,SE	7	20,21	33,35,37	44	IH
Cypraea carneola Linnaeus, 1758	C,M,SS	10	19,20,21,22,23,24,26,30	36,38,39,40	41	SH
Cypraea caurica Linnaeus, 1758			27			SH
Cypraea chinensis Gmelin, 1791	SE		25			SH
Cypraea cicercula Linnaeus, 1758 (s31093)		7,15				SH
Cypraea cylindrica Born, 1778			23,24,25	37		SH

Cypraea depressa Gray, 1824	M,SS,SE			33		IH
Cypraea erosa Linnaeus, 1758	C,SS,SN,SE	4,7,12	20,21,22,24,27	32,33,35,37,38,39	41	SH
Cypraea flaveola Linnaeus, 1758	SS,SN,SE		17,19,20,22,23,24,27,30	31,36	41	SH
Cypraea cf. *globulus* Linnaeus, 1758		15	19			SH
Cypraea helvola Linnaeus, 1758	C	13	29			SH
Cypraea hirundo Linnaeus, 1758	C,SE					SH
Cypraea histrio Linnaeus, 1758	C,SS,SN	3,7,8,12	21,28	33		IH
Cypraea isabella Linnaeus, 1758	C,M,SS,SN,SE	7,13,15	19,20,21,24,25,26,30	31,33,37	41	SH
Cypraea kieneri Hidalgo, 1906	SN					SH
Cypraea limacina Lamarck, 1810		6				SH
Cypraea lynx Linnaeus, 1758	C,M,SN,SE		23,27	31,33,37,38		SH
Cypraea mappa Linnaeus, 1758			18			SH
Cypraea moneta Linnaeus, 1758	C,M,SS,SN,SE	1,3,8,12,16	19,21,24,27	33,35	44	IH
Cypraea nucleus Linnaeus, 1758 (s31113)	C		19	31,33	45	SH
Cypraea poraria Linnaeus, 1758	M	13	17,18,19,24	40		SH
Cypraea cf. *scurra* Gmelin, 1791				37		SH
Cypraea staphylaea Linnaeus, 1758	SS,SN,SE					SH
Cypraea stolida Linnaeus, 1758 (s31114)			19			SH
Cypraea talpa Linnaeus, 1758	SS	15,16	30	38		SH
Cypraea teres Gmelin, 1791		16	19,20			SH
Cypraea testudinaria Linnaeus, 1758	SE					SH
Cypraea tigris Linnaeus, 1758	C,M,SS,SN	7,9,10,11,14	20,22,23,25,28,29	33,35,37	43,44	SH
Cypraea ursellus Gmelin, 1791			27		44	SH
Cypraea vitellus Linnaeus, 1758	C,M,SS,SE	7	28			SH
Cypraea ziczac Linnaeus, 1758					42	SH
OVULIDAE						
Calpurneus lacteus (Lamarck, 1810)	M					EZ
Phenacovolva sp.	SS					EZ
Prosimnia semperi (Weinkauff, 1881) (s31204)				40		EZ
TRIVIIDAE						
Trivia oryza (Lamarck, 1810) (s31055)	C	7	22			EZ
VELUTINIDAE						
Chelynotus tonganus (Quoy and Gaimard, 1832)	C,M					SH
NATICIDAE						
Natica bougei Sowerby, 1908	SS					S
Notocochlis gualteriana (Recluz, 1844)	C,SS					S
Natica robillardi Sowerby, 1843	C					S

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Polinices melanostomus (Gmelin, 1791)	C,SS		24			S
Polinices powisiana (Recluz, 1844)	SE					S
Polinices mammilla (Linnaeus, 1758)	C,SS,SN	6,9,11	24	33,37,38,39	44	S
Polinices simiae (Deshayes, 1838)			27			S
BURSIDAE						
Bursa bufonia Gmelin, 1791	C,SS,SN,SE			33,37,39		IH,SH
Bursa cruentata (Sowerby, 1841) (s31104)	C,M,SS,SN		17	33,37	41,44	IH,SH
Bursa granularis (Röding, 1798)	C		24	33,39		IH,SH
Bursa lamarckii (Deshayes, 1853) (s31070)		10,11,15	20,22,24	31,38	44,45	IH,SH
Bursa rhodostoma (Beck in G. B. Sowerby II, 1835) (s31033)		4	20,21,22	33		IH,SH
Bursa sp. (s31169)				31	42	SH
Bursa granularis (Röding, 1798)	SS,SN,SE					SH
Tutufa bubo (Linnaeus, 1758)	SS,SE			33,37		IH,SH
Tutufa rubeta (Linnaeus, 1758)	SN	11		33,34		SH
CASSIDAE						
Casmaria erinaceus (Linnaeus, 1758) (s31081)	C,M,SS,SN,SE	13,15	21,23,24,27	33,35,38		S
Cassis cornuta (Linnaeus, 1758)	SS,SN					S
Cypraecassis rufa (Linnaeus, 1758)	SS					S
PERSONIDAE						
Distorsio anus (Linnaeus, 1758)	M,SS	13	27		41	SH
RANELLIDAE						
Charonia tritonis (Linnaeus, 1758)	SS	10,12				SH
Cymatium aquatile (Reeve, 1844)	C,M,SS	2,4	23	31,39	41,43,44	SH
Cymatium clandestinum (Lamarck, 1816)	C,SS					SH
Cymatium gemmatum (Reeve, 1844)	C,M,SS,SE	13				SH
Cymatium hepaticum (Röding, 1798)	C,SE		17			SH
Cymatium mundum (Gould, 1849) (s31178)		6		33,37		SH
Cymatium muricinum (Röding, 1798) (s31126)	C,SS		21,24		44	SH
Cymatium rubecula (Linnaeus, 1758)	C,SN					SH
Gyrineum lacunatum (Mighels, 1845) (s31227)		13		31		SH
TONNIDAE						
Malea pomum (Linnaeus, 1758)	C,SS,SN		21,27			S
Tonna cepa (Röding, 1798)			24			S
Tonna perdix (Linnaeus, 1758)	SS	13	26,29	35		S

MURICIDAE						
Chicoreus brunneus (Link, 1807) (s31137)	SS,SN		23,30	31,34,36,38,39,40		SH
Chicoreus microphyllus (Lamarck, 1822)			18,19,20,27			SH
Coralliophila costularis (Lamarck, 1816)	C					EZ
Coralliophila cf. *craticulatus* (Linnaeus, 1758)	C					EZ
Coralliophila erosa Röding, 1798)	C					EZ
Coralliophila neritoidea (Lamarck, 1816) (s31032)	C,M,SS,SN,SE	4,8,9,10,11,12,14,15,16	17,18,19,20,22,25,26,27,28,29,30	31,32,34,35,36,38	41,42,45	EZ
Coralliophila stearnsii Pilsbry, 1895	SS				42	EZ
Drupa grossularia (Röding, 1798)	SS,SN,SE		19,20,26	36,37,40	41,44,45	IH
Drupa morum (Röding, 1798)	C,SS,SN,SE		30	33,37	44	SH
Drupa ricinus (Linnaeus, 1758)	C,M,SS,SN	2,3,5,15,16	17,18,19,20,22,27,28,30	31,33,34,37	44	IH
Drupa rubusidaeus Röding, 1798	C,SS,SN,SE	1,3,4,5,15,16	18,20,28,30	31,34,37,38,39,40	41,44	IH,SH
Drupella cornus (Röding, 1798)	C,M,SS,SN,SE	1,2,3,4,5,6,7,8,9,10,12,14,15,16	17,18,19,20,22,23,25,26,28,29,30	31,32,33,34,36,38,39,40	41,42,44,45	EZ
Drupella rugosa (Born, 1778)			26			SH
Maculotriton serriale (Deshayes, 1834) (s31213)	C,SS				45	SH
Marchia martinetana (Röding, 1798) (s31184)				34		SH
cf. *Morula* sp. (s31221)				36		SH
Morula biconica Blainville, 1832 (s31031)	M,SS,SN	4	18,19,20,22,30	31,32,34,36,39,40	41,45	IH,SH
Morula dumosa (Conrad, 1837) (s31108)			17,22			SH
Morula granulata (Duclos,1832)	C,SS,SN,SE	15,16		33,37	44	IH,SH
Morula margariticola (Broderip, 1832)(s31047)		7,9,10,12,14,15		38		SH
Morula nodicostata (Pease, 1868)	C,SS,SE					IH,SH
Morula spinosa (H. and A. Adams, 1835)	C,M,SS,SE	10,15,16	19,20,21,23,29	38,39	43	IH,SH
Morula uva (Röding, 1798) (s31004)	C,M,SS,SN	1,3,4,5,15,16				IH,SH
Morula sp.	M					
Muricodrupa fiscella (Gmelin, 1791)	C,SS,SN,SE					IH,SH
Muricodrupa jacobsoni Emerson and D'Attilio, 1981 (s31038)		4,7,13				SH
Muricodrupa stellaris (Hombron and Jaquinot, 1853)	C,M					SH
Nassa serta (Bruguiere, 1789) (s31030)	SS,SN	4	26	33		IH,SH
Pascula ochrostoma (Blainville, 1832) (s31177)				32		SH
Quoyula monodonta (Broderip, 1833) (s31010)		2	26,28	38		EZ
Rapa rapa (Linnaeus, 1758)	C					EZ
Thais aculeata (Deshayes, 1844)	SS				44	IH
Thais armigera (Link, 1807)	SS,SN,SE		20			IH, SH
Thais tuberosa (Röding,1798)	C,SS,SN,SE				44	IH
Muricid sp.	C					

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
TURBINELLIDAE						
Vasum ceramicum (Linnaeus, 1758)	C,M,SS,SN,SE	16	21	31,33,34		IH,SH
Vasum turbinellum (Linnaeus, 1758)	C,M,SS,SN,SE	1,2,3,4,5,10,11,15,16	17,19,20,21,22,26,28,30	31,32,33,34,36,37,38,39,40	41,44,45	IH,SH
BUCCINIDAE						
Cantharus pulcher (Reeve, 1846) (s31119)			20			SH
Cantharus undosus (Linnaeus, 1758) (s31161)	C,M,SS,SN,SE		30	33,39		SH
Cantharus wagneri (Anton, 1839) (s31156)			29	36		SH
Colubraria muricata (Lightfoot, 1786) (s31063)		9,10,16			41	S
Colubraria sp.	SS					S
Engina alveolata (Kiener, 1836) (s31202)	C			32,39		SH
Engina bonasia (von Martens, 1880) (s31226)		13				SH
Engina curtisiana (Smith, 1884) (s31207)					41	SH
Engina lineata (Reeve, 1846)	C,M,SS,SN,SE			38		SH
Engina mendicaria (Linnaeus, 1758)	SS,SE		24			SH
Engina zatricum Melvill, 1893	C,M					SH
Nassaria sp.	SS					
Pisania ignea (Gmelin, 1791)					42	SH
Pisania iostomus (Broderip, 1833) (s31225)		13				SH
COLUMBELLIDAE						
Euplica turturina (Lamarck, 1822) (s31091)	SS,SN	15,16	17,18,19,20,22,25,30	31,36,39	41,45	SH
Euplica varians Sowerby, 1832	C,M,SS,SN					EP
Euplica deshayesii (Crosse, 1859) #					43	EP
Mitrella albina (Kiener, 1841) (s31117)		13	19		41	EP
Pyrene punctata (Bruguiere, 1789) (s31124)	SS,SN		20			IH,SH
Pardalina testudinaria (Link, 1807)	M					SH
NASSARIIDAE						
Hebra horrida (Dunker, 1847)	C					S
Nassarius albescens (Dunker, 1846)	C,M,SS	14	24	39	42	S
Nassarius gaudiosus (Hinds, 1844)	M,SS					S
Nassarius granifer (Kiener, 1834)	C	11,14				S
Nassarius papillosus (Linnaeus, 1758)	C	13	19,20	31		S
FASCIOLARIIDAE						
Fusinus undatus Gmelin, 1791	SS					SH
Latirolagena smaragdula (Linnaeus,1758)	C,M,SS,SN,SE	3,10,15	17,18,19,20,23,30	33,37	44	IH
Latirus amplustris (Dillwyn, 1817) (s31035)		2,4				SH

Latirus craticulatus (Linnaeus, 1758)	C,SS	16				SH
Latirus nodatus (Gmelin, 1791) (s31005)	C,M,SS	1,2,4,8,9,11,15,16	19,20,21,22	34,36,38	44,45	SH
Latirus polygonus (Gmelin, 1791) (s31021)	C	3,5	20			SH
Latirus turritus (Gmelin, 1790)	C,SS,SN	2,5,9,15,16	17,19,20,22,30	32,34,36,38		SH
Latirus sp.	C					SH
Peristernia fastigium (Reeve, 1847) (s31012)	M,SS,SN	2,4,5,10,12,15,16	17,18,19,20,21,22	36	41	SH
Peristernia incarnata Kiener, 1840		13				SH
Peristernia nassatula (Lamarck, 1822) (s31011)	C,M,SS,SN,SE	2,3,4,5,8,10,15,16	19,20,22,24,27	33,36,37,40,	44,45	SH
Peristernia ustulata (Reeve, 1847)	C,SS					SH
Pleuroploca filamentosa (Röding , 1798)	C,SN,SE	13	20	36		SH
OLIVIDAE						
Oliva annulata (Gmelin, 1791)	C,SS,SN,SE	13	19,21,26,27,28		41	S
Oliva caerulea (Röding , 1798)	SS,SN					S
Oliva cf. *panniculata* Duclos, 1835	SS					S
Oliva tessellata Lamarck, 1811	SS					S
Oliva textilina Lamarck, 1811	SS					S
HARPIDAE						
Harpa amouretta Roiling, 1798 (s31134)	SE		22	38	41	S
MITRIDAE						
Cancilla filaris (Linnaeus, 1758) (s31105)	C	11,14	17		42	S
Imbricaria olivaeformis (Swainson, 1821)	SS					S
Imbricaria punctata (Swainson, 1821)	C,SS					S
Mitra acuminata Swainson, 1824 (s31084)	C,M,SS,SN,SE	13		33,37		SH
Mitra ambigua Swainson, 1829			25, 27			SH
Mitra aurora floridula Sowerby, 1874 (s31153)			26			S
Mitra coffea Schubert and Wagner, 1829 (s31154)	M		26			S
Mitra chrysalis Reeve, 1844	SE					S
Mitra chrysostoma Broderip, 1836 (s31123)	SS	20	29	36		SH
Mitra cucumerina Lamarck, 1811	SN					S
Mitra decurtata Reeve, 1844	SS					S
Mitra eremitarum Roiling, 1798	M		20			S
Mitra ferruginea Lamarck, 1811 (s31082)		13				S
Mitra imperialis Roiling, 1798	SS					S
Mitra cf. *luctuosa* (Adams, 1853) (s31220)		13				S
Mitra litterata Lamarck, 1811	C,SS					S
Mitra mitra (Linnaeus, 1758)	C,SS,SN,SE		25,27			S
Mitra paupercula (Linnaeus, 1758)	C,SS,SN,SE					S

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Mitra retusa Lamarck, 1811	SS					S
Mitra cf. *rubritincta* Reeve, 1844	SS					S
Mitra stictica (Link, 1807)	SN			37		S
Mitra vexillum Reeve 1844 (s31138)			23, 29, 30			S
Neocancilla papilio (Link, 1807) (s31185)	C,SS,SN		24	35		S
Pterygia dactylus (Linnaeus, 1767)	SE					S
Pterygia nucea (Gmelin, 1791)	SS					S
COSTELLARIIDAE						
Vexillum cadaverosum, Reeve, 1844	SS			38		S
Vexillum consanguineum (Reeve, 1845) (s31160)	SN	2	30	36		S
Vexillum corallinum (Reeve, 1845) (s31146)			25			S
Vexillum crocatum (Lamarck, 1811) (s31170)		4		31		S
Vexillum deshayesi Reeve, 1844	SN					S
Vexillum granosum Gmelin, 1790	SN	11				S
Vexillum infaustum (Reeve, 1845) (S31206)					41	S
Vexillum lucidum (Reeve, 1845) (s31171)				31		S
Vexillum cf. *roseum* Broderip, 1836	SN					S
Vexillum sanguisugum Linnaeus, 1758	SS		30	31		S
Vexillum semicostatum Anton, 1839				36	42	S
Vexillum cf. *semifasciatum* Lamarck, 1811 (juvenile)	SN					S
Vexillum speciosum (Reeve, 1844) (s31116)	SS		19		45	S
Vexillum stainforthi Reeve, 1841 (s31209)					42	S
Vexillum cf. *turrigerum* (Reeve, 1845)	C,SN					S
Vexillum unifascialis (Lamarck, 1811) (s31145)		13	25			S
Vexillum zelotypum (Reeve, 1845)	SN					S
TURRIDAE						
cf. *Eucithara funiculata* (Reeve, 1846)	SN					S
cf. *Eucyclotoma albomacula* Kay, 1979	M					S
Lienardia rubida (Hinds, 1844)	C,SN					S
Pseudodaphnella pulchella (Pease, 1860)	C,SN					S
cf. *Turris* sp. 1	C,SS					S
TEREBRIDAE						
Hastula albula Menke, 1843	SS					S
Hastula lanceata (Linnaeus, 1767)				34		S
Terebra affinis Gray, 1834	C,SS,SN		21,24,27	31	42	S

Terebra areolata (Link, 1807)	SS					S
Terebra crenulata (Linnaeus, 1758)	C,SS,SN	6,9				S
Terebra dimidiata (Linnaeus, 1758)	C		24			S
Terebra felina (Dillwyn, 1817)	C,SS,SN	10	19,24,27	37		S
Terebra guttata (Röding , 1798)	SS					S
Terebra maculata (Linnaeus, 1758)	C,SS,SN	6,11	18,21,23,24,27	35	45	S
Terebra nebulosa (Sowerby, 1825)	C,SS		27			S
Terebra undulata Gray, 1934	SN		24			S
Terebra subulata (Linnaeus, 1767)					45	S
CONIDAE						
Conus arenatus Hwass in Bruguiere, 1792	SS,SN,SE					SH
Conus capitaneus Linnaeus, 1758	SS,SN			35,36,38	43,44	S,IH
Conus catus Hwass in Bruguiere, 1792	C,M,SS,SN,SE		20	33		S,IH
Conus ceylanensis Hwass in Bruguiere,1792	C,M	5				S,IH
Conus chaldeus (Röding , 1798)	M,SS,SN,SE			37	44	S,IH
Conus coronatus Gmelin, 1791	C,M,SS,SN,SE					S,IH
Conus distans Hwass in Brugiuere, 1792 (s31094)	C,M,SS,SN,SE	3,5,15	19,22,24	33,37,40	44	S,IH,SH
Conus ebraeus Linnaeus, 1758	C,SS,SN,SE					S,IH
Conus eburneus Hwass in Bruguiere, 1792	C,SS,SE		27	34		S,IH
Conus flavidus Lamarck, 1810 (s31094)	C,M,SE			33		S,IH
Conus glans Hwass in Bruguiere, 1792	C,M		20,27			S,SH
Conus imperialis Linnaeus, 1758 (s31115)	C,SS,SN,SE	5,15	19,21,24	31,33,35		S,IH,SH
Conus legatus Lamarck, 1810 (s31131)	SN		22	36	41	SH
Conus leopardus (Röding , 1798)	C,SN	9	25			S
Conus litoglyphus Hwass in Bruguiere,1792	SN		21,27,30	33		S
Conus litteratus Linnaeus, 1758	SS		25			S
Conus lividus Hwass in Bruguiere, 1792	C,M,SS,SN,SE		17,18,19,20,21,24,25,27	33,37	44	S,IH
Conus magnificus Reeve, 1843 (s31085)		13				S
Conus marmoreus Linnaeus, 1758	SS,SN,SE	3,9,10	19,21,24			S
Conus miles Linnaeus, 1758	C,M,SS,SN	2,3,4,5,6,10,15,16	17,20,22,23,25,26,28,29,30	31,33,34,36,37,39,40	41,44,45	S
Conus miliaris Hwass in Bruguiere, 1792 (s31007)	SN	1,2,3,4,10,16	17,19,20,?21,22,24,27,30	33,34,36,37,38,39	41,44	S
cf. *Conus miliaris* Hwass in Bruguiere, 1792 (s31023)		9	20,22	38,40	41	S
Conus musicus Hwass in Bruguiere, 1792 (s31034)	SS	4,5,7,10,15	17,19,20,22,23,25,26,28,29,30	31,36,37,38,39,40	41,44,45	S
Conus omaria Hwass in Bruguiere, 1792	C					SH
Conus planorbis Born, 1778 (s31212)					44	S,IH
Conus pulicarius Hwass in Bruguiere, 1792	C,SS,SN,SE	6,11,14	21,24,27	33,34,35	42	S
Conus quercinus Solander, 1786	SS,SN		27			S,IH

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Conus rattus Hwass in Bruguiere, 1792	C,M,SS,SE	7,12,14,16	17,20,26	39	41	S,IH
Conus sanguinolentus Quoy and Gaimard, 1834		10,14	20,22,30	31,33,37,40	41,44	S,IH
Conus sponsalis Hwass in Bruguiere, 1792 (s31214)	C,SS,SN,SE	1,3	20,22,25,30	32, 33	44,45	S,IH
Conus striatus Linnaeus, 1758	SS,SN,SE					S,IH
Conus sugillatus Reeve, 1844	SS,SE					S,IH
Conus tessulatus Born, 1780	SN	13	24,28	35	45	S,IH
Conus vexillum Gmelin, 1791	SS,SN					S,IH
Conus vitulinus Hwass in Bruguiere, 1792 (s31199)	C,M,SS,SN			32,38		S,IH
ARCHITECTONICIDAE						
Philippia radiata (Röding , 1798) (s31069)	C	11				S
PYRAMIDELLIDAE						
cf. *Otopleura mitralis* A. Adams, 1855	C					S
cf *Otopleura* sp. 1	C					S
AGLAJIDAE						
Chelidonura amoena Bergh, 1905	SN	1	27			EZ
Philinopsis pilsbryi (Eliot, 1900) (s31058)		7,12				SH
Philinopsis reticulata (Eliot, 1903) (s31142)			24			S
Aglajid sp. 1	SS					S
Aglajid sp. 2	C					S
Aglajid sp. 3	C					S
HAMINOEIDAE						
Atys cylindricus (Helbling, 1779)			26			S
BULLIDAE						
Bulla ampulla Linnaeus, 1758	C,SN		21,27			S
PLAKOBRANCHIDAE						
Plakobranchus ocellatus van Hasselt, 1824			21		42,44	EP
PLAKOBRANCHIDAE						
Elysia sp.	SS					EP
Thuridilla bayeri (Marcus, 1965)		1	21,27,29			EP
POLBRANCHIIDAE						
Polybranchia cf. *westralis* Jensen, 1993 (s31208)					41	EP
APLYSIIDAE						
Dolabella auricularia (Lightfoot, 1786)			27			IH,SH
PLEUROBRANCHIDAE						
Berthellina citrina (Ruppell and Leuckart, 1828)			20,29			IH, SH

Pleurobranchus forskalii (Ruppell and Leuckart, 1828)			26			SH
POLYCERIDAE						
Nembrotha kubaryana Bergh, 1877			22			EZ
Nembrotha cristata Bergh, 1877			23		45	EZ
Thecacera pacifica Bergh, 1883			20	34		S
GYMNODORIDIDAE						
Gymnodoris citrina (Bergh, 1875)			21,25			IH,SH
AEGIRIDAE						
Notodoris serenae Gosliner and Behrens, 1997 (s31151)			26			EZ
DISCODORIDIDAE						
Atagema spongiosa (Kelaart, 1858)			27			EZ
Atagema intecta (Kelaart, 1858b)			27			EZ
Discodoris boholensis Bergh, 1877 (s31022)		3	27			SH
Halgerda tessellata (Bergh, 1880)			27			SH
Jorunna pantherina (Angas, 1864) (s31152)			25			EZ
Jorunna rubescens Bergh, 1876			27			EZ
CHROMODORIDIDAE						
Ardeadoris egretta Rudman, 1984 (s31075)		11				SH
Chromodoris coi (Risbec, 1956)			29		42	SH
Chromodoris elisabethina Bergh, 1877		2,3,5,10,11,14,15,16	19,22			SH
Chromodoris lineolata (Hasselt, 1824)	C					IH, SH
Chromodoris cf. *quadricolor* (Ruppell and Leuckart, 1831)	M					SH
Chromodoris sp.	SS					SH
Glossodoris atromarginata (Cuvier, 1804)					42	SH
Glossodoris sp.	SE					SH
DENDRODORIDIDAE						
Dendrodoris tuberculosa (Quoy and Gaimard, 1832)		2,4				SH
Dendrodoris nigra (Stimpson, 1855)				31	42	SH
PHYLLIDIIDAE						
Phyllidia elegans Bergh, 1869	C,SS,SN,SE	5,14,15,16	19,20,27,28	31		SH
Phyllidia coelestis Bergh, 1905	SS,SN		17,19,20,22,28,30	34,36		SH
Phyllidia varicosa Lamarck, 1801	SS	8	21,27	38		SH
Phyllidiella lizae Brunckhorst, 1993	SS					SH
Phyllidiella nigra (van Hasselt, 1824) (s31074)		9				SH
Phyllidiella pustulosa (Cuvier, 1804)	SS,SE	2,4	17,25,27,28,30	31,32,33,36,39	41,43,45	SH
Phyllidiella rudmani Brunckhorst, 1993 (s31067)		10				SH
Phyllidiopsis krempfi Pruvot-Fol, 1957					45	SH

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Phyllidiopsis striata Bergh, 1888 (s31066)	SS,SN	10,12,16	28			SH
Reticulidia fungia Brunckhorst and Gosliner in Brunckhorst, 1993				36		SH
TETHYDIDAE						
Melibe bucephala Bergh, 1902 (s31224)					42	SH
AEOLIDINA						
Aeolidia sp. 1	SS					EZ
FACELINIDAE						
Phidiana indica (Bergh, 1896)				34		SH
Pteraeolidia ianthina (Angas,1864)		13,15	18,20		42	SH
ONCHIDIIDAE						
Onchidium sp.	C,M,SS	3	24,27	33,37		S
Bivalvia						
MYTILIDAE						
Botula cf. *fusca* (Gmelin, 1791)	C					
Botula cf. *silicula* (Lamarck, 1819) (s31198)				38		SH
Lithophaga cf. *nasuta* (Philippi, 1846)	C,M,SN					EZ
Modiolus auriculatus Krauss, 1848	C					
Septifer bilocularis (Linnaeus, 1758)	SS,SN	13	23,25,28,29,30	31,32,33,34,36,38,39,40	43,45	SH
ARCIDAE						
Anadara antiquata (Linnaeus, 1758)	SN					S
Arca avellana Lamarck, 1819	C,M					
Arca avellana/ventricosa Lamarck, 1819 complex (s31042)		1,2,3,5,6,7,8,9,11,12,14,15,16	18,19,20,23,24,26,28,29,30	31,32,33,34,36,38,39	42,45	SH
Arca ventricosa Lamarck, 1819	C,M,SS,SN,SE	6				SH
Barbatia amygdalumtostum (Röding, 1798) (s31143)	C,M,SS,SN,SE	9	22,23,24,25,26,27,28	38		SH
Barbatia aff. *coma* (Reeve, 1844) (s31194)				31,32,33,34,36,38,39,40		SH
Barbatia foliata Forsskal, 1775 (s31109)		5,9,11,12,14	18,19,22,28,29	31,34,36		SH
Barbatia plicata (Dillwyn, 1817) (s31014)	C,SS,SN,SE	2,12,15,16	20,22,25	31,34,36,40	41	SH
Barbatia tenella (Reeve, 1843)	M,C					
Barbatia sp.	M,C					
GLYCYMERIDIDAE						
Tucetona pectunculus (Linnaeus, 1758) (s31079)	C,M,SS,SN,SE	7,12	21,24,25,27	35		S
PTERIIDAE						
Electroma alacorvi (Dillwyn, 1817)	C,M					AA,SH
Electroma ovata (Quoy and Gaimard,1834) (S31182)	SS,SN			34		SH

Pinctada albina (Lamarck, 1819)	C,M					SH
Pinctada maculata (Gould, 1850)	SS,SN					SH
Pinctada margaritifera (Linnaeus, 1758)	C,M,SS,SN	6,8,9,11,12	17	32		SH
Pteria chinensis (Leach, 1814)	SS					AA,SH
Pteria producta (Reeve, 1857)		2				AA,SH
Pteria penguin (Röding, 1798)		10	26,27,29	34,35,38		AA,SH
Pteria sp.	C					
ISOGNOMONIDAE						
Isognomon isognomum (Linnaeus, 1758) (s31149)	C	12	26		43	SH
Isognomon legumen (Gmelin, 1791)	C,SS,SE					SH
Isognomon perna (Linnaeus, 1758)	C,M,SS,SN,SE					SH
PINNIDAE						
Atrina pectinata (Linnaeus, 1767)	BEACHDR					S
Atrina vexillum (Born, 1778) (s31089)	SN	6				S
Pinna muricata Linnaeus, 1758 (s31088)		14,15				S
Pinna bicolor Gmelin, 1791 (s31173)				31,32,34,36,39		S
Streptopinna saccata (Linnaeus, 1758) (s31092)	C,SS	9,11,15	18,19,20,22,23,25,26,27,28,29	31,34,36,39	41,43,45	SH
Ctenoides annulatus						
LIMIDAE						
Ctenoides annulatus (Lamarck, 1819) (S31148)	M	5	23, 26,30			S
Limaria fragilis (Gmelin, 1791)	C,M,SS,SN,SE	6,15	22,26	31,36	45	S,SH
Lima sp.	SS					
GRYPHAEIDAE						
Hyotissa hyotis (Linnaeus, 1758)	C,M,SS	7,9,11,12	23,29	32,34,38	43	SH
Hyotissa numisma (Lamarck, 1819)	C,M,SS,SN,SE					SH
OSTREIDAE						
Lopha cristigalli (Linnaeus, 1758)	M	8,12	23,26,29	32,39	43	SH
Dendostrea sp.	C,M					
PLICATULIDAE						
Plicatula australis (Lamarck, 1819) (s31026)	C,M	3, 7				AA?, SH
PECTINIDAE						SH
Chlamys cf. *cookei* Dall, Bartsch and Rehder, 1938	C					
Chlamys funebris (Reeve, 1853)	C					
Chlamys cf. *pacifica* Broderip, 1835	SS,SN,SE					SH
Decatopecten radula griggi (Webb, 1957) (s31049)	SN	7			42	SH
Excellichlamys histrionica (Gmelin, 1791)	SS	15,16		34		SH
Gloripallium pallium (Linnaeus, 1758)	C,SS,SN		18,23			SH

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Gloripallium speciosum Reeve, 1833 (s31037)	C	4,10,13,16	18			SH
Laevichlamys squamosa (Gmelin, 1791)	C,M,SS,SN					SH
Laevichlamys cuneata Reeve, 1833 (s31203)		1,5,13,15,16	17,18,19,20,23,25,26,30	31,32,34,36,39	41	SH
Pedum spondyloideum (Gmelin, 1791)	C	1,2,5,7,9,10,11,14,15,16	18,19,25,26,29,30	31,32,34,35,36,38	42,43,45	AA,SH
Semipallium dianae (Crandall, 1979) (s31222)		5,10,15				
Semipallium tigris (Lamarck, 1819)	C					
Semipallium sp. 1	C					
Semipallium sp. 2	C					
SPONDYLIDAE						
Spondylus ducalis (Röding , 1798)	C,M					SH
Spondylus pacificus Reeve, 1856	M					SH
Spondylus varius Sowerby, 1827			29,30			SH
Spondylus spp. (s31016)	SS,SN	1,2,3,6,7,8,9,11,12,14,15,16	18,19,21,23,24,25,26,27,28,29	31,33,34,36,38,39	43,44	SH
ANOMIIDAE						
Anomia sp. (juvenile)	M					
CHAMIDAE						
Chama cf. *iostoma* Conrad, 1837	C,M,SN					SH
Chama lazarus (Linnaeus, 1758) (s31101)	M	12				SH
Chama pacifica Broderip, 1835	C,M					SH
Chama plinthota Cox, 1927 (s31001)		1				
Chama spp.		1,2,3,5,6,7,9,10,11,12,14,15	18,19,23,26,27,28,29,30	31,33,34,36,39,40	41,43,44,45	SH
LUCINIDAE						
Codakia cf. *paytenorum* (Iredale, 1937) (s31128)			21			S
Codakia punctata (Linnaeus, 1758) (s31186)	C,SS,SN	11	24,27	35		S
Ctena bella (Conrad, 1837)	C					
Linga sp.	C					
Fimbria fimbriata (Linnaeus, 1758)	C,SS,SN					
Monitilora simplex (Reeve, 1850) (s31129) #			21			S
Wallucina gordoni (Smith, 1886)	C					
Wallucina sp.	C					
CARDITIDAE						
Beguina semiorbiculata (Linnaeus, 1758) (s31110)	SS,SN		18,19,23,25,26,28,29	31,32,34,36,38,39	43,45	SH
Cardita variegata (Bruiguiere, 1792)	C,M,SS		24,25,26,29	36,39,40	45	SH
CARDIIDAE						
Acrosterigma alternatum (Sowerby, 1841) (s31046)		6,7,9,12,14,15				S

Acrosterigma mendanaense (Sowerby, 1896) (s31068)		10				S
Acrosterigma orbitum (Broderip and Sowerby, 1833) (s31125)	C,SS,SN	1,10,11,12,16	18,20,28,29	31,32,36		S
Acrosterigma sp.	C					
Corculum cardissum (Linnaeus, 1758)	C,M					S
Fragum fragum (Linnaeus, 1758)	C,SS,SN,SE	6,14		35	42,44,45	S
TRIDACNIDAE						
Hippopus hippopus (Linnaeus, 1758)	C,M,SS,SN,SE	8,14	21,24,27		42	IH
Tridacna crocea Lamarck, 1819	C,M,SS,SN,SE	1,2,3,4,5,6,7,8,9,10,11,12,14, 15,16	18,19,21,22,23,24,25,26,27,2 8,29,30	31,32,33,34,35,36,37,38,39,40	41,42,43,44,45	IH,SH
Tridacna derasa (Röding, 1798)		1,6,7,8,12,14	21	34	42	SH
Tridacna gigas (Linnaeus, 1758)	C,SN	6,7,9,14				SH
Tridacna maxima (Röding, 1798)	C,M,SS,SN,SE	1,2,3,4,5,6,7,8,9,10,11,12,14, 15,16	18,19,20,21,22,23,25,26,27,2 8,29,30	31,32,34,35,36,37,38,39	41,42,43,44,45	IH,SH
Tridacna squamosa Lamarck, 1819	C,M,SS,SN	1,6,7,8,9,12	22,25,26,28	32,33,38,39,40	43	IH,SH
MESODESMATIDAE						
Atactodea stricta (Gmelin, 1791)	C					
TELLINIDAE						
Exotica obliquaria (Deshayes, 1854)	C					
Exotica rhomboides (Quoy and Gaimard, 1833)	C					
Quadrans gargadia (Linnaeus, 1758) (s31188)	C			35		S
Tellina crassiplicata Sowerby, 1758	C,M					S
Tellina cf. *crucigera* Lamarck, 1818 (s31044)		6				S
Tellina cf. *exculta* Gould, 1850 (s31193)				35,36		S
Tellina linguafelis (Linnaeus, 1758) (s31150)	M		26			S
Tellina perna Spengler, 1798	SS					S
Tellina remies Linnaeus, 1758 (s31155)	SS		27	38		S
Tellina robusta Sowerby, 1867	C					
Tellina scobinata Linnaeus, 1758 (s31056)	C,M,SS,SE	7,9,11,14	18,21,24,27	32,35,36		S
Tellina semitorta Sowerby, 1867	C					
Tellina staurella (Lamarck, 1818) (s31172)				31		S
Tellina virgata Linnaeus, 1758	SS					S
Tellina sp. (s31144)			24			S
SEMELIDAE						
Semele sp. (s31028)		3				SH
Semele sp.	C					
TRAPEZIDAE						
Trapezium oblongum (Linnaeus, 1758) (s31072)	C,M	11,13,16	20	31		SH

Taxa	1986 Records	ATOLL RECORDS - 2006				Habitat
		Mermaid	Scott South	Scott North	Seringapatam	
Trapezium obesa (Reeve, 1843) (s31167)				31,39	41	SH
VENERIDAE						
Antigona clathrata (Deshayes, 1854) (s31080)		12	19,21,22		45	S
Antigona reticulata (Linnaeus, 1758) (s31027)	C,M	3,10	24	36,40		S
Antigona resticulata (Sowerby, 1853) (s31053)	C,SS,SN	7,9,11,12,14,15	29	35,39		S
Dosinia sp.	SS					S
Globivenus toreuma (Gould, 1846) (s31098)	C	4,16	17,19,20,23,28	33,39	41	S
Lioconcha ornata (Dillwyn, 1817) (s31111)	SS,SN		18			S
Lioconcha castrensis (Linnaeus, 1758) (s31071)		6,9,11,12	21,24,25,29	31,34,36		S
Lioconcha cf. *tigrina* (Lamarck, 1816) (s31187)	SS,SN			35		S
Pitar cf. *prora* (Conrad, 1837)	SN					S
Pitar spoori Lamprell and Whitehead, 1990 (s31073) #		11,12	30			S
Pitar sp.	SN					S
Tapes literatus (Linnaeus, 1758) (s31201)				38		S
Tapes platyptycha (Linnaeus, 1758) (s31057)		8,12				S
Timoclea sp. 1	C					
Timoclea sp. 3	C					
GASTROCHAENIDAE						
Gastrochaena cf. *cuneiformis* (Spengler, 1783)	C					
Cephalopoda						
NAUTILIDAE						
Nautilus pompilius Linnaeus, 1758	C,SS,SE					
SPIRULIDAE						
Spirula spirula (Linnaeus, 1758)	SN					
SEPIIDAE						
Sepia latimanus Quoy and Gaimard,1832	C,SS	8	18			SH
Sepia pharaonis Ehrenberg, 1831	SS		24			Beach
LOLIGINIDAE						
Sepioteuthis cf. *lessoniana* Férussac, 1831				32		SH
Photololigo sp. (s31223)				open water		
OCTOPODIDAE						
Octopus cf. *cyaneas* Gray 1929 (not collected)		3				IH,SH
Octopus cyaneas Gray 1929		7,14	19,21	31	43	IH,SH
Octopus sp.	C,SS					
Octopus sp. (juvenile) (s31097)		16				SH
Octopus sp. (s31210)					44	SH
Octopus sp. (s31211)					44	SH

Above: *Tridacna derasa* (Röding, 1798) (Photo: Clay Bryce)

recorded comprising 280 gastropods, 101 bivalves, six cephalopds and two chitons. Molluscs identified during the 2006 survey totalled 339 species, comprising 261 gastropod, 70 bivalve, six cephalopod and two chiton species. Table 2 provides a summary of the total number of species recorded from each reef surveyed, arranged from south to north, together with the percentage of total species for each reef as represented by the various habitat divisions. Many species occurred in more than one habitat division and so were counted for each.

As indicated in Table 2, Subtidal-Hard (SH) and Sediment (S) are the two habitat types for which higher species percentages were consistently recorded. The percentages of species from those sites, when considered as totals from all reefs surveyed, far exceed those from the third dominant division, the Intertidal Hard (IH), and the remaining habitat divisions. These differences may be attributed to the greater number of habitat niches available to molluscs within the subtidal breakaway zones of the outer and inner reef slopes, which include the majority of SH and S sites. The difference in environmental conditions between the outer slope, with its vigorous wave action, and the inner reef edge, with a relatively quieter, cross-platform water flow, provides greater opportunities for habitat niche variability and nutrient retention.

In comparison, IH sites on the intertidal platforms are subjected to a water flow gradient across their width, diminishing from the wave-pounded outer slope to the relatively calm waters of the lagoon. Intertidal platforms are also topographically flat providing little protection for biota in the form of tide pools and coral slab debris. There is little sediment to be found on the platforms except in isolated back-reef areas. However, a limited molluscan fauna exists where there is a sufficient depth of sediment. Desiccation from low tide exposure, wide temperature fluctuations and increased predation of collectable species by Indonesian fishers also has an impact on diversity and abundance (pers. obs. C. Bryce).

Table 3 displays the average species count per station and the average species count at each major topographical reef feature (outer slope, intertidal platform and lagoon), with the number of stations in brackets. The molluscan faunas of South Scott and North Scott Reefs appear to be the most diverse with greater average species counts per station and across the three topographical reef features. In general, average species counts were higher at all reefs on the outer slope than at lagoon or intertidal platform habitats. A comparison of the combined outer slope and lagoon figures (equating to SH and S in Table 2) compared with the intertidal count (IH); indicate a similar outcome, as expressed with Table 2.

Analysis using Multi-Dimensional Scaling (MDS)

Table 2 Percentage of total molluscan species for each habitat division for the 2006 survey.

Reef	Total Species	Habitat Divisions					
		IH	SH	S	EP	EZ	P
		% Species					
Mermaid	185	22.99	60.96	34.23	1.07	4.81	0.00
South Scott	221	21.72	52.94	38.91	1.36	5.88	0.45
North Scott	183	29.35	54.35	41.30	0.00	3.17	0.54
Seringapatam	120	28.10	56.20	35.54	3.31	4.13	0.00

Table 3 Reefs surveyed in 2006, with average species and number of stations (x).

Reef	Average species **per station**	Average species for **outer reef slope**	Average species for **intertidal platform**	Average species for **lagoon**
Mermaid	34 (16)	37 (5)	37 (1)	33 (8)
South Scott	47 (14)	49 (6)	59 (3)	38 (5)
North Scott	43 (10)	51 (3)	44 (3)	39 (3)
Seringapatam	36 (5)	45 (2)	46 (1)	23 (2)

of the molluscan biodiversity presence /absence data is presented in Figures 1 and 2 using the Bray Curtis Similarity Matrix. The data for the intertidal platform and channel stations were omitted to maintain a consistent sampling strategy for all stations.

The breakdowns of data in the MDS plot (Figure 1) supported by the dendrogram (Figure 2), clearly differentiate Mermaid Reef, 400 km to the south, from South and North Scott and Seringapatam Reefs.

At a finer scale the data for the lagoons and outer slopes, for all reefs, show a meaningful separation. There is also an organised spread of sampling points related to the prevailing environment from very exposed to very protected stations, progressing outward from the centre of the plot (Figure 1). To the left, the sampling points align with increasingly-exposed, high-energy environments (Stations 17 and 41) and to the right they align with increasingly protected, low energy, lagoonal sites (Stations 6, 7 and 43).

From the dendrogram (Figure 2), outlier stations are evident at Stations 1, 18 and 43. Station 1 at the eastern side of Mermaid Reef lagoon revealed a similarity with Stations 32 and 38 from North Scott lagoon, even though the distance between the two reefs is more than 400 kms. Examination of Table 1 revealed the inclusion of several common outer reef platform species, such as *Drupa rubusidaeus*, *Vasum turbinellum*, *Conus miliaris*, and *Conus sponsalis* at Station 1 to be a contributing factor. All four species are common on the outer reef platform. A comparison of the remaining Mermaid lagoonal reef-edge stations (Stations 6, 7, 8 and 11) indicated that the difference in intertidal platform width has an influence. At Station 1 the intertidal platform was narrow with a more uniform habitat across its entire width, which is favoured by these commonly-occurring species. This is not the case for the stations on the considerably wider western lagoon edge (Stations 6, 7 and 8), where deposited coralline sands dominate the inner half of the intertidal platform providing poor habitat for these same species. Station 11, although on the same narrow platform as Station 1, is subjected to a constant dusting of silt due to its proximity to the channel (pers. obs. C. Bryce).

Station 18 at South Scott Reef (Figures 1 and 2), appears to be intermediate between those of the lagoon and outer reef stations of Mermaid Reef. Work being undertaken by AIMS has revealed that the water influencing Station 18, between the western horn of South Scott Reef and Sandy Islet, is constantly mixed with oceanic water (Gilmore – AIMS pers. comm.) This water mixing, combined with that location's habitat complexity, may have buffered the molluscan communities from the effects of elevated water temperatures, which had affected so much of South Scott Reef in 1998 and 2003. Mermaid Reef had also been affected at those times but to a lesser extent (Rees *et al.*, 2003; Gilmore *et al.*, 2007).

Figures 3 and 4 indicate the more common species of bivalves and gastropods respectively, expressed as the average number of individuals/50 m^2.

Considerable variation is evident between the

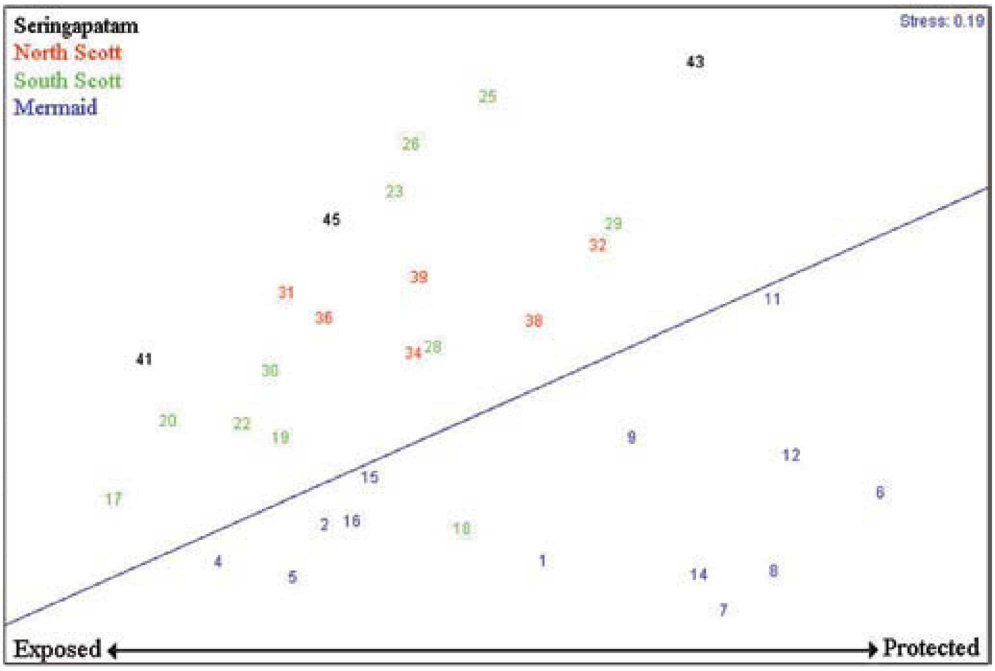

Figure 1 Multi-dimensional scaling ordination of molluscan presence /absence data for surveyed lagoon and outer slope stations.

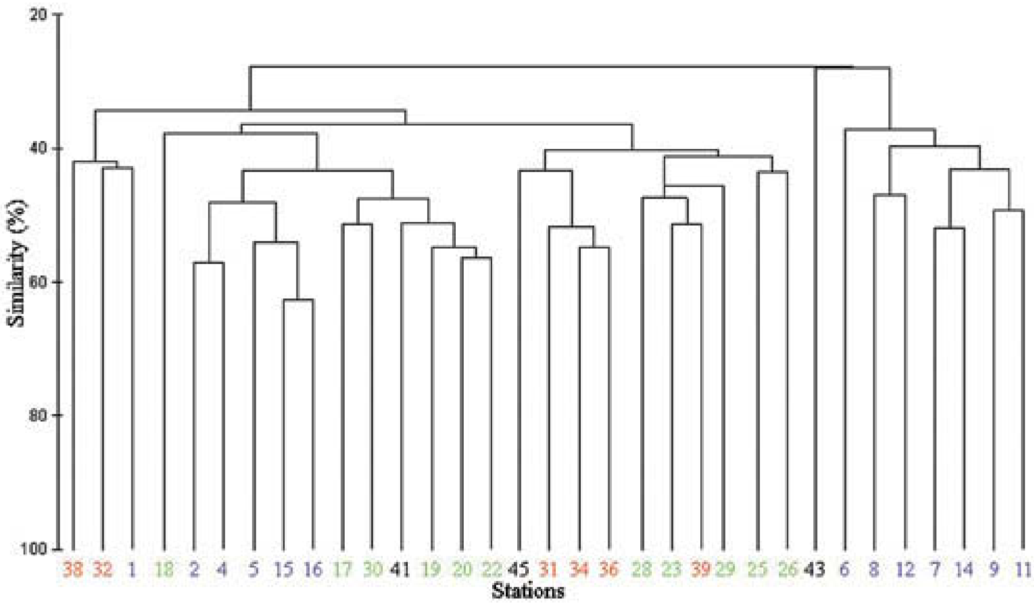

Figure 2 Dendrogram showing station similarity of molluscan presence/absence for lagoon and outer slope stations.

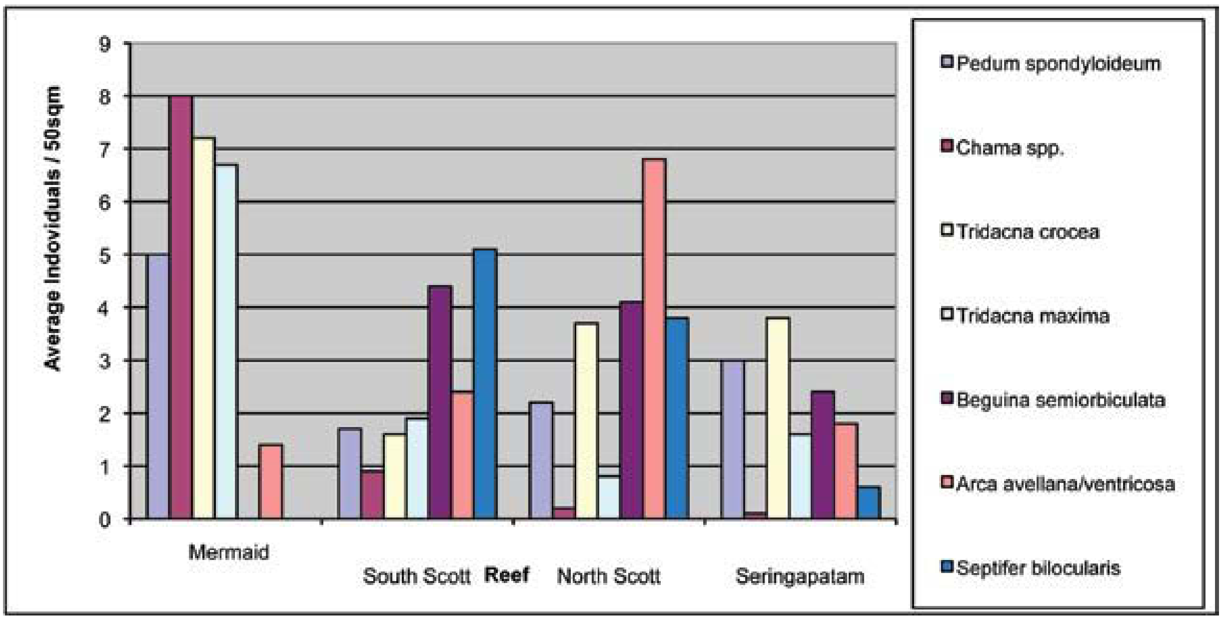

Figure 3 Average bivalve individuals / 50 m2

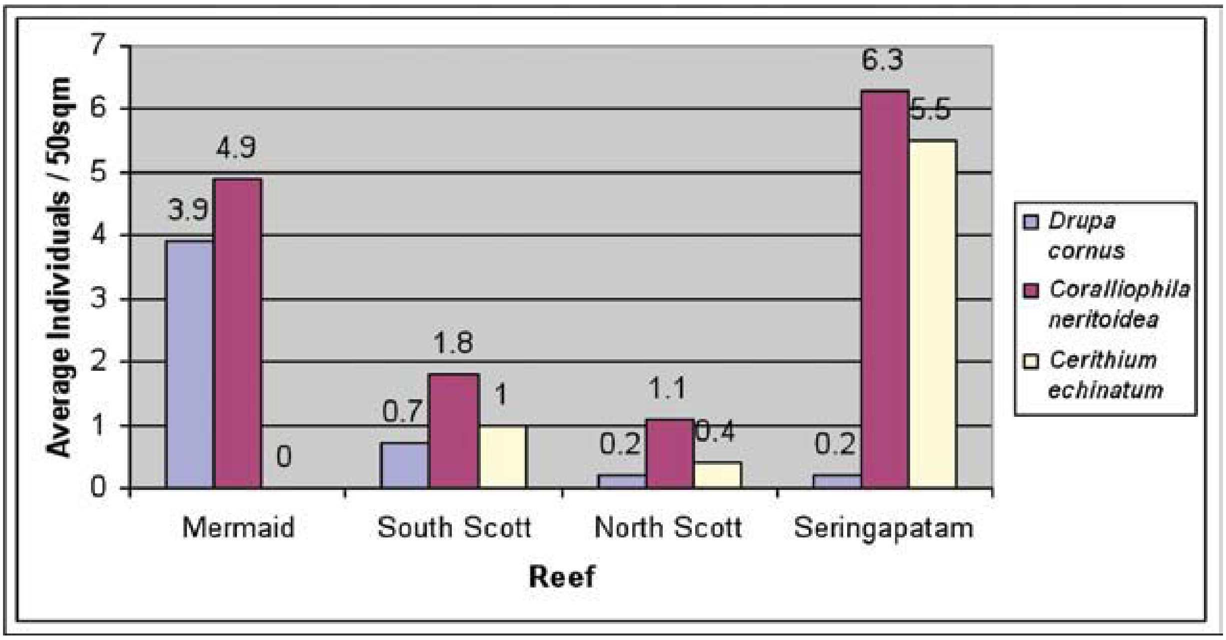

Figure 4 Average gastropod individuals / 50 sq. metres

density and makeup of the molluscan assemblages for North and South Scott Reefs and Seringapatam Reefs, when compared with those of Mermaid Reef. Of particular note is the lower numbers of the giant clam species, *Tridacna maxima* and *Tridacna crocea*, at North and South Scott Reefs and Seringapatam Reef. The densities of the other giant clam species, *Tridacna gigas*, *Tridacna squamosa* and *Tridacna derasa*, were too low for a meaningful comparison between reefs. These findings are consistent with the results reported by the senior author from a survey of the invertebrate marine resources of the shallow water habitats of North and South Scott Reefs undertaken in the first half of 2006 (Bryce, 2006).

The density of the coral nestling pectinid, *Pedum spondyloideum*, is also lower at Scott and Seringapatam Reefs compared with that at Mermaid Reef. The low numbers in this species at the more northerly reefs may be attributed to the decline in coral abundance due to bleaching and cyclonic activity (Rees *et al.*, 2003; Gilmore *et al.*, 2007).

The high densities of the bivalves, *Beguina semiorbiculata*, *Septifer bilocularis* and the *Arca avellana / ventricosa* species complex at North

Above: *Lambis lambis* (Linnaeus, 1758) (Photo: Clay Bryce)

Scott Reef, and to a lesser extent at South Scott and Seringapatam Reefs, is intriguing. At some survey stations, high numbers of these species are associated with isolated massive coral colonies and it would appear that North Scott Reef has a greater number of such stations. Just as intriguing is the situation with *Septifer bilocularis* on Mermaid Reef. While this mussel species is common on the mainland coast and the more northern atolls, it was recorded from only a single station on Mermaid Reef and not from any of the replicated, quantitative transects. This situation could perhaps be due to the isolation of Mermaid Reef from the more "clumped" northern reefs closer to Indonesia, and hence from the northern larval-carrying currents. However, further work needs to be undertaken to fully comprehend the geographical distribution of this and other molluscan species. Some caution has had to be exercised with regard to both the qualitative and the quantitative data from Seringapatam as the reef was under-sampled, during this and all other surveys undertaken so far.

The most common gastropods encountered at Mermaid Reef were *Coralliophila neritoidea* and *Drupella cornus* (Figure 4). Both of these corallivorous species are dependant on live coral for survival. Neither species could be considered to be in plague proportions on this reef at this time. However, at North and South Scott Reefs and to a lesser extent at Seringapatam Reef, the low numbers may reflect the damage to coral stock from coral bleaching and subsequent cyclonic activity as described by Rees *et al.* (2003) and Gilmore *et al.* (2007).

Cerithium echinatum was moderately abundant at Scott (North and South) and Seringapatam Reefs during the 2006 survey, being recorded from 50% of transects. There were no records of the species from the quantitative transects at Mermaid Reef although the species was recorded, in low numbers, from 44% of the survey stations (Table1). The species does not appear to have been common during the 1980s. The WA Museum's 1986 survey report records the species from only a single station at Mermaid Reef and not at all on North or South Scott Reefs or Seringapatam Reef. However, Wilson (1985) recorded two specimens from Seringapatam Reef in 1978. Representatives of the family Cerithiidae, to which this species belongs, are generally gregarious detrital feeders consuming microalgae, bacteria and detrital matter (Wilson, 1993). With the decline of holothurians on

Table 4 Number of stations sampled for Molluscs - 1986 publication and 2006 survey.

	Clerke	Mermaid	Sth. Scott	Nth. Scott	Sering.	Totals
1986 publication	20	2	12	11	2	47
2006 survey		16	14	10	5	45

Scott Reef (Bryce, 2006) it could be assumed that nutrient levels in the sediment have increased. With that in mind, it would seem possible that the rise in numbers of *Cerithium echinatum* may be related to such a nutrient increase. It should be noted that holothurian numbers and diversity on Mermaid Reef are far greater than on the northern atolls (Bryce and Marsh, this volume) and would, presumably, have some effect on controlling sediment nutrient levels and so might account for the lesser numbers of this gastropod species at Mermaid Reef.

The density spike for *Cerithium echinatum* on Seringapatam Reef (Figure 4) is unexplained. Two of the three Seringapatam stations recorded very high numbers giving an average density of 5.5 individuals per 50 m^2. If more stations had been sampled, this average figure may have been reduced to levels more comparable with the other stations. It seems possible that the density of *Cerithium echinatum* may be increasing on all atolls, particularly on the northern reefs, until a new ecological balance is reached. Obviously, further work would be needed to clarify the matter.

There is also an apparent increase in abundance of *Conus musicus* and *C. miles*. Both species are vermivorous, preferring sandy pockets on intertidal and shallow subtidal reefs (Röckel, *et al*., 1995). In the WA Museum's 1986 published results, the former species was found at three stations, all from around Sandy Islet on South Scott Reef but the latter was recorded only from a single site on North Scott Reef (Wells and Slack-Smith, 1986). During the 2006 survey, both species were more widely encountered (Table 1) and, as with *Cerithium echinatum,* this may signify a population increase has occurred, perhaps due to habitat changes associated with a possible increase in levels of nutrient in the sediment.

Comparative results – 1986 report and 2006 survey.

Table 4 lists the number of stations surveyed at each reef for the 2006 survey compared with the previous WA Museum survey results, so providing an estimate of the differences in effort and collection opportunity across the reefs. The numbers of survey stations providing the 1986 and 2006 data sets are comparable, being 47 and 45 respectively.

By combining the stations for each reef system (i.e., Clerke and Mermaid, South and North Scott, and Seringapatam) and comparing them for both the 1986 publication results and the present survey, a clearer indication of collecting effort was determined (Figure 5). For example, 20 stations were sampled in the data published in 1986 for Clerke Reef with only two stations at Mermaid Reef - giving a total of 22 stations for the reef system. The third atoll of the system, Imperieuse Reef, was not surveyed in 1986. When this figure (22 stations)

Left: Pedum spondyloideum (Gmelin, 1791); **Right:** Lambis truncata (Humphrey, 1786) (Photos: Clay Bryce)

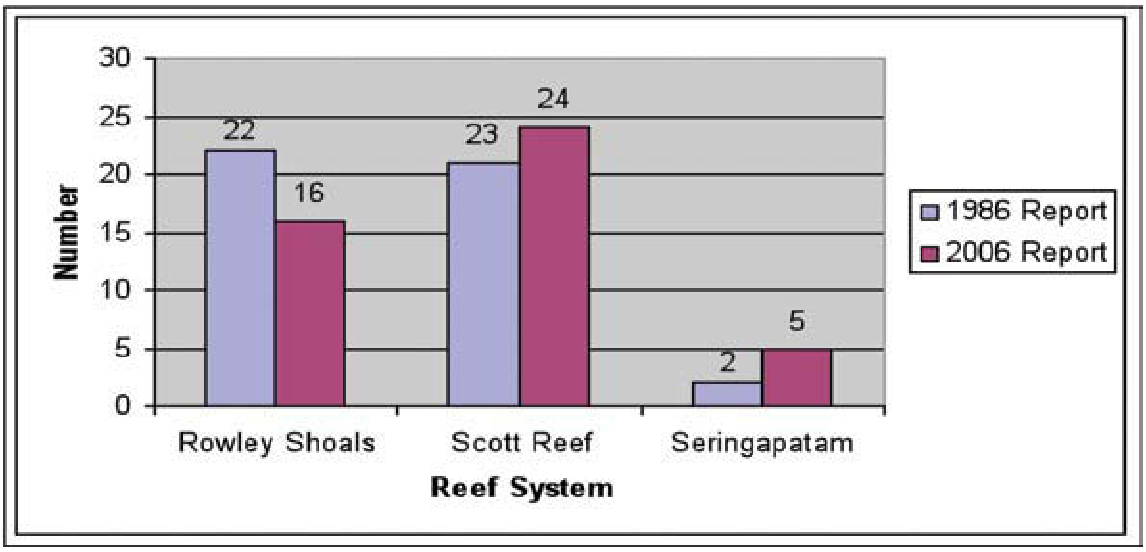

Figure 5 Comparison of the number of stations between reef systems for 1986 and 2006 reports.

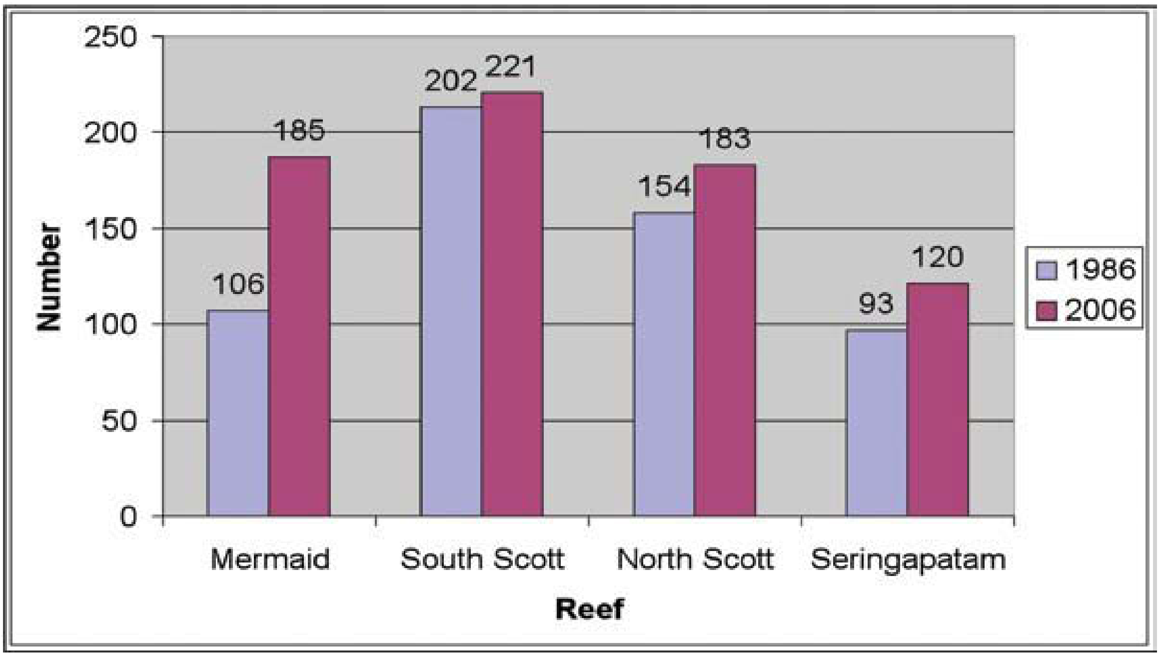

Figure 6 Comparative total species counts for Mermaid, South Scott, North Scott and Seringapatam Reefs for 1986 publication results and 2006 surveys.

is compared to the 2006 Rowley Shoals count (16 stations), the comparison can be seen to be more meaningful.

A comparison of total molluscan species recorded for all reefs during this survey and for those published in 1986 is provided in Figure 6. Slightly more species were recorded in the 2006 survey, which may be due to differing collecting methodologies and advances in taxonomy.

The Venn diagram (Figure 7) portrays the distribution of all 479 species across three reef systems for both the 1986 published results and the 2006 survey, combined.

Scott Reef (North and South), with its greater habitat diversity, had the greater species total (372) and also that of reef-confined species (121). The lower total of species recorded for Seringapatam Reef (173) would seem to be due to a lower collecting effort, yet it still displayed a modest species affinity with its near neighbour, Scott Reef (North and South), sharing 27 species. Rowley

Table 5 Comparison of results of this and similar surveys of northwest Australian areas (listed from north to south)

Surveyed Locality	Indication of Effort		Total species	Source
	Number of Collectors	Survey days		
Christmas I.	3	12 (36 person days)	313	Wells & Slack-Smith, 1988
Ashmore & Cartier Rf.	2	11 (22 person days)	433	Wells, 1993
Cocos (Keeling) Is.	2	20 (40 person days)	380	Wells, 1994
Mermaid, Scott & Seringapatam Reefs	**2**	**16 (32 person days)**	**339**	**This survey**
Mermaid, Scott & Seringapatam Reefs	2	11 (22 person days)	324	Wells & Slack-Smith, 1986
Central Kimberley	1	13 (13 person days)	292	Bryce, 1997
Southern Kimberley	2	13 (26 person days)	232	Wells & Bryce, 1995
Dampier Arch.	2	26 (52 person days)	695	Slack-Smith & Bryce, 2004
Montebello Is.	3	17 (51 person days)	633	Wells, Slack-Smith & Bryce, 1993

Shoals and Scott Reef (North and South) share 100 species but still portray considerable species exclusivity with 85 and 121 species respectively. The three reefs have 124 species in common, with a reduction in overall species diversity from Scott Reef to Mermaid Reef. These figures appear to demonstrate the influence of the Indian Ocean Through-Flow current regime and the effects of inter and intra-reef system recruitment.

Table 5 compares the molluscs recorded from the 2006 survey with those of similar surveys undertaken by the WA Museum at other localities, including an indication of effort. Care should be taken in the interpretation of this table regarding the figures associated with surveys of the nearby Kimberley coast. Despite the greater habitat diversity of the Kimberley coast, the figures give a lower species count than for any of the surveyed oceanic locations. This is probably due to a bias towards the surveying of only intertidal platforms, mangals and general shoreline habitats, and a surveying of only a very small number of subtidal stations. Further surveying of Kimberley subtidal stations would, undoubtedly, increase the mainland-coast species count appreciably.

New molluscan records.

The discovery of the gastropod mollusc, *Marchia martinetana* (Röding, 1798) (Figure 8a) at North Scott Reef is a new record for Australia. New records for the Western Australian fauna are the columbellid gastropod, *Euplica deshayesii* (Crosse, 1859) (Figure 8b), the nudibranch, *Notodoris serenae* Gosliner and Behrens, 1997 (Figure 8c) and the lucinid bivalve *Monitilora simplex* (Reeve, 1850) (Figure 8d). Also of note is the venerid bivalve, *Pitar spoori* Lamprell and Whitehead, 1990 (Figure 8e). This species had previously been recorded in Western Australia only from Hibernia Reef (Willan, 2005).

CONCLUSIONS:

The molluscan fauna of the surveyed atolls is typical of Indo-West Pacific offshore, oceanic coral reefs (Wells & Slack-Smith, 1986; Willan, 2005). From Table 1 it can be seen that the fauna has a greater affinity with that of the Indonesian Archipelago than with the Western Australian mainland. As such, these reefs are considered to represent a unique habitat of great conservation value.

The inclusion of replicated transects into a molluscan collecting regime has added valuable quantitative information by providing an indication of average molluscan density. The very act of swimming a transect tends to focus researchers' attention along a continuous band of substrate. This band is actually a defined slice through an otherwise borderless station area, thus providing for ongoing monitoring opportunities within a more defined area. Planned deviations from the transect and searching areas adjacent to the

From top: *Tridacna crocea* Lamarck, 1819; *Hippopus hippopus* (Linnaeus, 1758); *Tridacna squamosa* Lamarck, 1819; *Tridacna gigas* (Linnaeus, 1758); *Tridacna maxima* (Röding, 1798). (Photos: Clay Bryce)

Above: *Distorsio anus* (Linnaeus, 1758) with eggs. (Photo: Clay Bryce)

Above: *Octopus cyanea* Gray, 1849 (Photo: Clay Bryce)

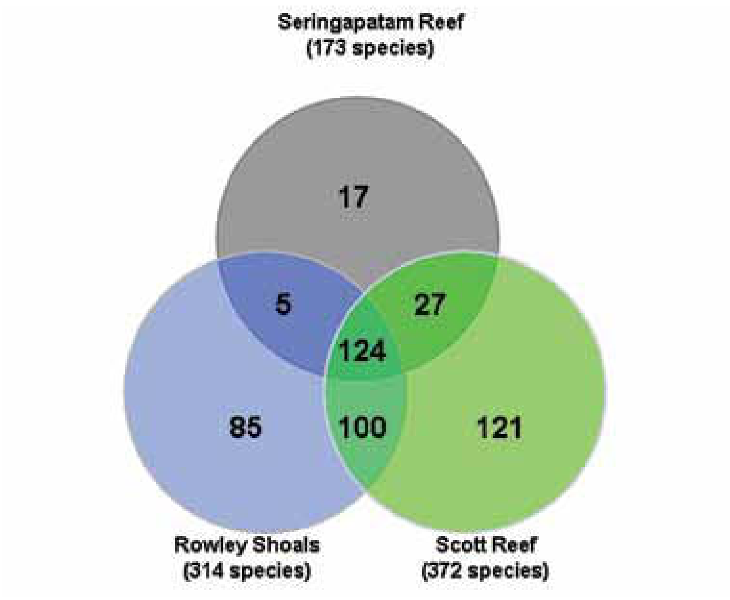

Figure 7 Venn Diagram showing species distributions at the Rowley Shoals, Scott Reef and Seringapatam Reef systems from the 1986 published report and this 2006 survey combined (n = 479 species).

transect did allow for the amassing of qualitative species records. This is evidenced by examination of the species collected during this survey when compared to other surveys (Table 4).

The results of the 2006 survey yielded a total of 339 species of macromolluscs from Mermaid, Scott and Seringapatam Reefs but is not a complete inventory of the molluscan fauna as it does not include the poorly known and highly speciose micromolluscan fauna or faunal records housed in the collections of the WA Museum and of other museums in Australia and elsewhere (Table 4).

The relative diversity and number of marine habitats at these atolls influences their overall molluscan species diversity. South Scott Reef, with its large size, north-facing open lagoon, deep lagoonal waters (not sampled) and fractured back reef edge, provided a greater variety of habitats than the other atolls. However, unregulated fishing, cyclonic activity and recent warm water events leading to coral bleaching appear to have played an important part in reducing molluscan abundance and, to some extent, molluscan diversity on this reef. North Scott and Seringapatam Reefs have also suffered the same environmental and fishing pressures as South Scott Reef but appear to have the added constraint of reduced habitat diversity. This is due to their small size, annular shape and a reduced flushing regime. Mermaid Reef, 400 km to the south, mirrors North Scott and Seringapatam Reefs in shape and dimensions but apparently was little affected by high water temperatures (Gilmore *et al*., 2007) or fishing pressure due to its protected status.

All of these atolls, with the exception of Mermaid Reef, have severely depleted populations of giant clams and of *Tectus niloticus* in both the shallow (Bryce, 2006) and the deeper waters of regions covered in this paper. This was attributed to the effects of environmental pressures and unregulated fishing practices.

The apparent increase in abundance of *Cerithium echinatum, Conus miliaris* and *Conus musicus* since the WA Museum's 1986 report may be attributed to these species having taken advantage of habitat changes due to an increase in nutrient-rich habitats possibly caused by the depletion of holothurian stocks (Bryce, 2006) across all reefs, except Mermaid Reef.

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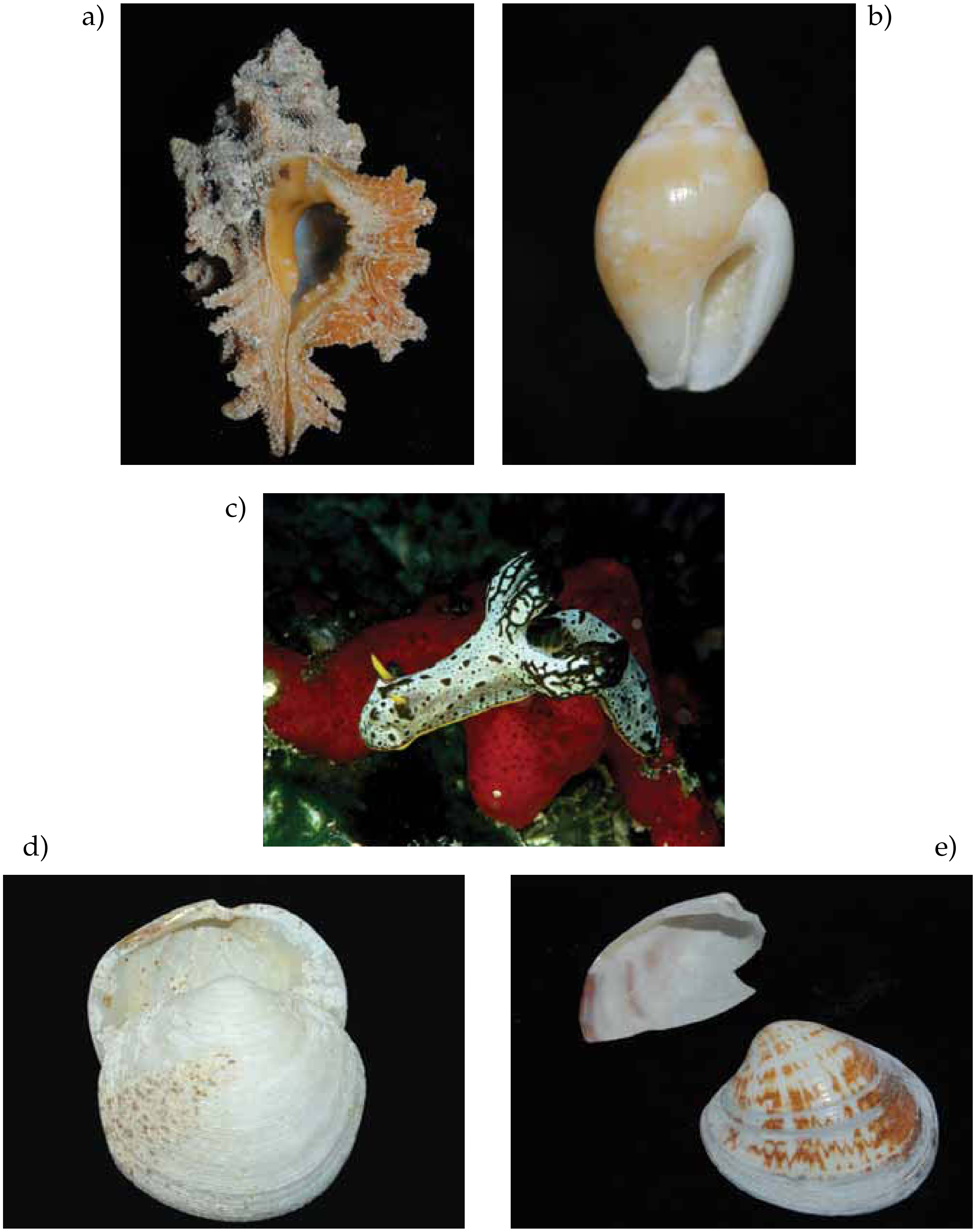

Figure 8 a: *Marchia martinetana* (Röding, 1798); b: *Euplica deshayesii* (Crosse, 1859); c: *Notodoris serenae* Gosliner and Behrens, 1997; d: *Monitilora simplex* (Reeve, 1850); e: *Pitar spoori* Lamprell and Whitehead, 1990.

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Echinodermata (Asteroidea, Echinoidea and Holothuroidea) of Mermaid (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia.

Clay Bryce and Loisette Marsh
Department of Aquatic Zoology

Western Australian Museum, Locked Bag 49, Welshpool, D.C. 6986 Email: clay.bryce@museum.wa.gov.au

Abstract – A survey documenting the diversity and indicative abundance of targeted echinoderms (asteroids, echinoids and holothurians) at Mermaid, Scott and Seringapatam Reefs was conducted in September 2006. Due to logistical constraints species were counted along a single transect furnishing limited scope for statistical analysis. Echinoderms (including some ophiuroids) were collected opportunistically at each station. Fourteen species of echinoderm were collected from the NW atolls for the first time (five species of Asteroidea including a possible new species, six Ophiuroidea and three Echinodea). Voucher specimens of all but the commonest species have been lodged with the Western Australian Museum. The echinoderm fauna of Scott Reef, particularly North Scott Reef, has declined in abundance and species richness since the surveys of the 1980s. This may have been influenced by a significant coral bleaching event in 1998 and subsequent scouring by cyclonic activity. Fishing pressure at South and North Scott Reefs (but not Mermaid Reef) by Indonesian fishers has also had a drastic effect on holothurian populations to the point where oligospermy will be a serious factor.

INTRODUCTION:

In 1986, the Western Australian Museum (WA Museum) published the results of its surveys of the Rowley Shoals, Scott and Seringapatam Reefs (Berry, 1986). Included were the results of the first survey of the echinoderms (Marsh, 1986). There have been no formal biodiversity surveys since that time. Several agencies, including the Australian Institute of Marine Science (AIMS) (Rees *et al*., 2003) and the Commonwealth Scientific and Industrial Organisation (CSIRO) (Skewes *et al*., 1999) have undertaken marine resource evaluations, including holothurians (Smith *et al*., 2005). The WA Museum also undertook a contract rapid assessment survey of the marine resources (including holothurians) of Scott Reef and Seringapatam Reefs and Browse Island in February 2006 (Bryce, 2006). All of these surveys were related to fishing pressure and general stock assessments and did not investigate other echinoderm groups.

Here we report in detail the echinoderms recorded during the 2006 WA Museum survey of Mermaid (Rowley Shoals), Scott and Seringapatam Reefs off the north coast of Western Australia. The information in this paper supersedes that provided in the 2006 unpublished preliminary report (Bryce and Marsh, 2006) of the same survey.

METHODOLOGY
(see Station and Transect Data in this volume)

The echinoderm species were recorded, individuals counted and representatives collected from a single transect, which was one of the two mollusc transects at each station. Additional species were also collected generally from the station area. Due to logistical constraints and lack of time in the field the Ophiuroidea were only collected opportunistically and crinoids were omitted from the survey.

The methodology adopted recorded echinoderm diversity with an indication of abundance. The method (described in detail below) varied dependent on whether the station was located on the outer reef slope, in the lagoon or on the reef platform.

A single transect was swum at all stations, except for reef platform stations and the channel drifts. Extra echinoderm records were made throughout the transect swim to increase the biodiversity list; this was accomplished by opportunistic investigations of the areas adjacent to the transect. The diver would periodically mark his current transect position and then explore habitats and features adjacent to the transect. Further investigations were undertaken by a general swim around the station once the transect had been completed. This ensured all depths and

Table 1 Number of stations sampled for Echinoderms - 1986 and 2006

	Clerke	Mermaid	Sth Scott	Nth Scott	Seringapatam
1986 Report	20	2	12	11	2
2006 Report		16	14	10	5

habitats were represented in the biodiversity list while maximising dive time and completing the transect. The time at each station was limited to approximately one hour of effort, which varied depending on the complexity of the topography, transect length and habitat types encountered.

Outer slope stations:

A single transect, one metre wide, was swum up-slope from a depth of 20 m to reef crest at 3 to 4 m. The transect was determined at the surface by lining up the 20 m station buoy with the two shallower buoys marking the replicated transects of the coral, sponge and crustacean researchers. A transect bearing using an underwater compass was used to keep the diver on course.

As many echinoderms are cryptic, rocks and coral slabs, when abundant, were turned at 20, 15, 10 and 5 m depth increments along the transect. Where rocks and slabs were few all encountered were turned and investigated. Small sand patches occurring intermittently were raked for echinoid species; larger sand plains were sub-sampled by raking a series of one metre squares at every alternate meter along the transect line. Small hand rakes were used for this purpose.

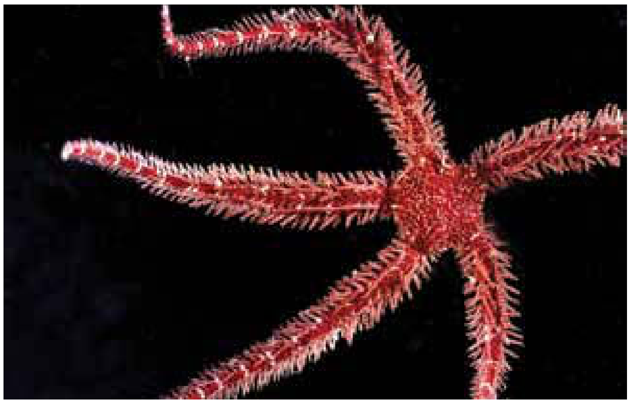
Lagoon Stations:

All lagoon stations were centred on coral outcrops or reef edges to maximise habitat diversity. The methodology for these stations differed little from the outer slope stations, except for instances where the required 20 m starting depth was unobtainable. In these instances, the transect was defined by the distance between the buoys marking the shallow and deep transect series of the coral, sponge and crustacean divers. In this way, the transect ran from deepest to shallowest point and perpendicular to the other transects.

Platform Stations:

Platform habitats have several zones – outer edge, platform centre and lagoonal edge – and these can be more then a kilometre apart. As such, this macro-habitat was treated as a biodiversity site with no attempt to quantify the echinoderms found.

Above: *Choriaster granulatus* Lütken, 1869 (Photo: Clay Bryce)



Left: *Echinaster luzonicus* (Gray, 1840); **Right:** *Ophiomastix annulosa* (Lamarck , 1816) (Photos: Clay Bryce)

Channel Drifts:

The channel drifts, like the platform stations were qualitative only.

Voucher specimens of unknown and noteworthy species were collected, identified at the WA Museum, registered and retained for the collections of the WA Museum.

RESULTS

Results are presented in such a way as to enable comparison with the earlier WA Museum survey (Berry, 1986; Marsh, 1986). However, a direct comparison in a quantitative sense is problematical as the methodology and effort between the surveys differ.

52 echinoderm species from the classes Asteroidea, Echinoidea and Holothuroidea were recorded during the present survey (2006), which is 71% of the species from the same classes recorded by Marsh (1986). Table 1 highlights the differences in the number of stations surveyed between the 2006 report and corresponding reefs from the 1986 publication data. The difference in effort and collection opportunity portrayed in Table 1 is reflected by the variability within and between the reefs for the two survey periods.

However, combining the number of stations for each reef system (Figure 1) a clearer indication of collecting effort can be determined. For example, 20 sampling stations were recorded in the data published in 1986 for Clerke Reef (Rowley Shoals). When this is added to the two stations at Mermaid

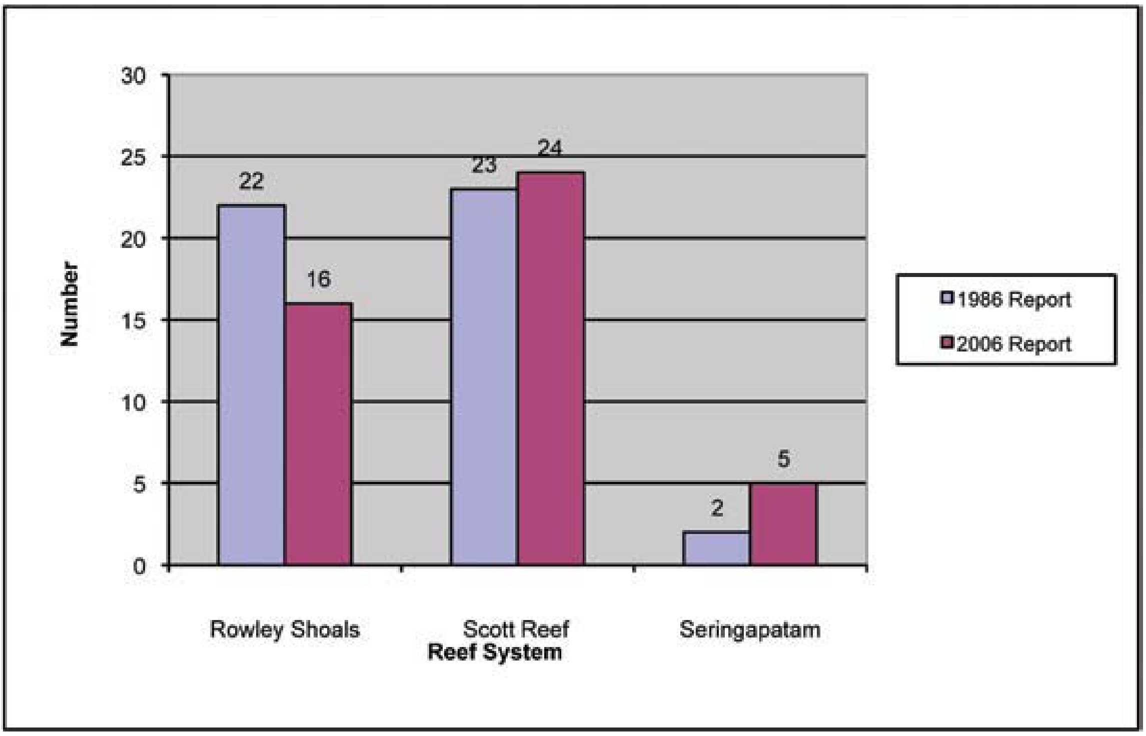
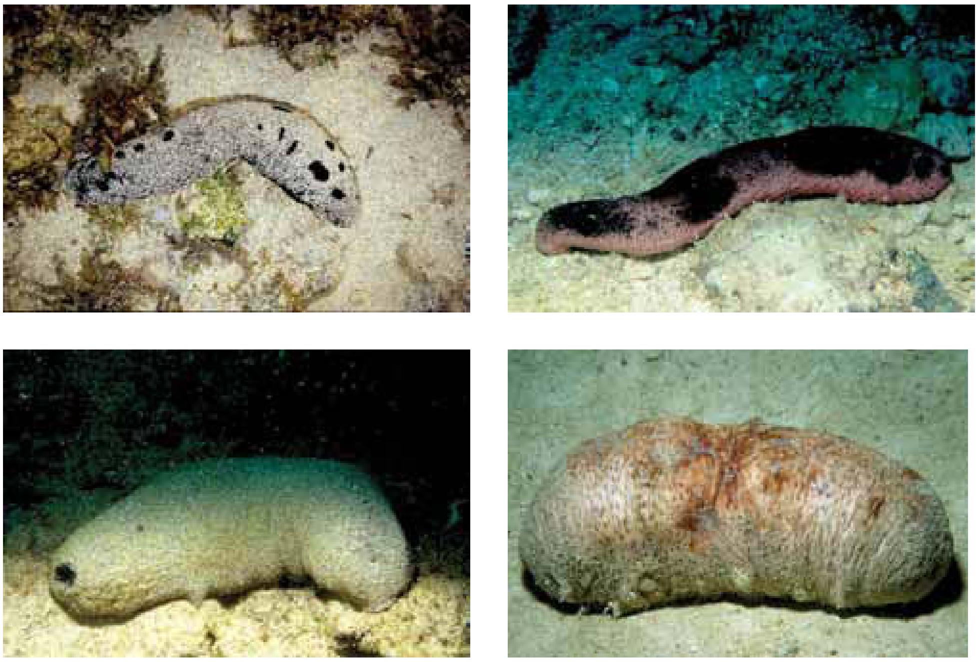


Figure 1 Station comparison between systems for 1986 and 2006 reports



Clockwise From Top Left: *Holothuria atra* Jaeger, 1833; *Holothuria edulis* lesson, 1830; *Holothuria whitmaei* (Selenka, 1867); *Holothuria fuscogilva* Cherbonnier, 1980. (Photos: Clay Bryce)

Reef (Rowley Shoals), the only other reef sampled, and then compared to the 16 Mermaid Reef stations from the 2006 survey a more meaningful coverage of collecting opportunity is observed. A station breakdown of the various reefs visited for the report of 2006 and 1986 publication is provided in Table 1 and relates directly to Figure 1.

A complete list of species' occurrence at each atoll is shown in Table 2, which also lists previous records. A limited list of Ophiuroidea (20 species) is also provided within this table. A breakdown by atoll of the 52 species is presented in Figure 2.

From Figure 2 it can be seen that Mermaid Reef and South Scott Reef have a significantly higher number of total recorded species and correspondingly similar unique species component to the other two atolls. However, Mermaid Reef has a similar geographical shape and habitat diversity to that of North Scott Reef and Seringapatam, while South Scott Reef is large with a greater range of habitats.

Asteroidea

In Marsh (1986), 17 species of seastars were found at Mermaid and Clerke Reefs (Rowley Shoals). Of these 10 were found in 2006 plus four additional species. In the 1986 publication, 19 species were recorded from Scott (north and south atolls) and Seringapatam Reefs, of these 11 were found in 2006 plus two new records including a possible undescribed species. The newly recorded species are *Cistina columbiae* Gray, 1840, *Aquilonastra anomala* (H.L Clark, 1921), *Indianastra sarasini* (de Loriol, 1897) and *Echinaster callosus* Marenzeller, 1895 from Mermaid Reef and *Celerina* sp. and *Cistina columbiae* from South Scott Reef. *Echinaster callosus* is a new record for Western Australia. From North Scott Reef seven species were found in 2006 with no new records. Eight species were found at Seringapatam Reef in 2006, with no new records.

Echinoidea

In the 1986 publication, 14 species of echinoids were recorded from Rowley Shoals; of these six were recorded at Mermaid Reef in 2006 plus one new record, *Nacospatangus (Pseudomaretia) alta* (A. Agassiz, 1863), which is known from Indonesia. From Scott and Seringapatam Reefs 19 species of echinoid were recorded in the 1986 publication, of these only seven species were found in 2006 at the same reefs. From North Scott there was one new record, *Temnotrema elegans* Mortensen, 1918 and a possible new species, cf. *Cyrtechinus* sp.

Figures 3 and 4 demonstrate similar trends for the Asteroidea and Echinoidea in that Mermaid and South Scott Reefs are similar in having high species abundance but show a reduction for North Scott and Seringapatam Reefs. The species diversity is consistent across the reefs except for Seringapatam Reef. This low count is due to limited collecting.

Holothuroidea

In the 1986 publication, 23 species of holothurians were recorded from the Rowley Shoals of which 12 were found at Mermaid Reef in 2006. From Scott and Seringapatam Reefs 26 species were cited in

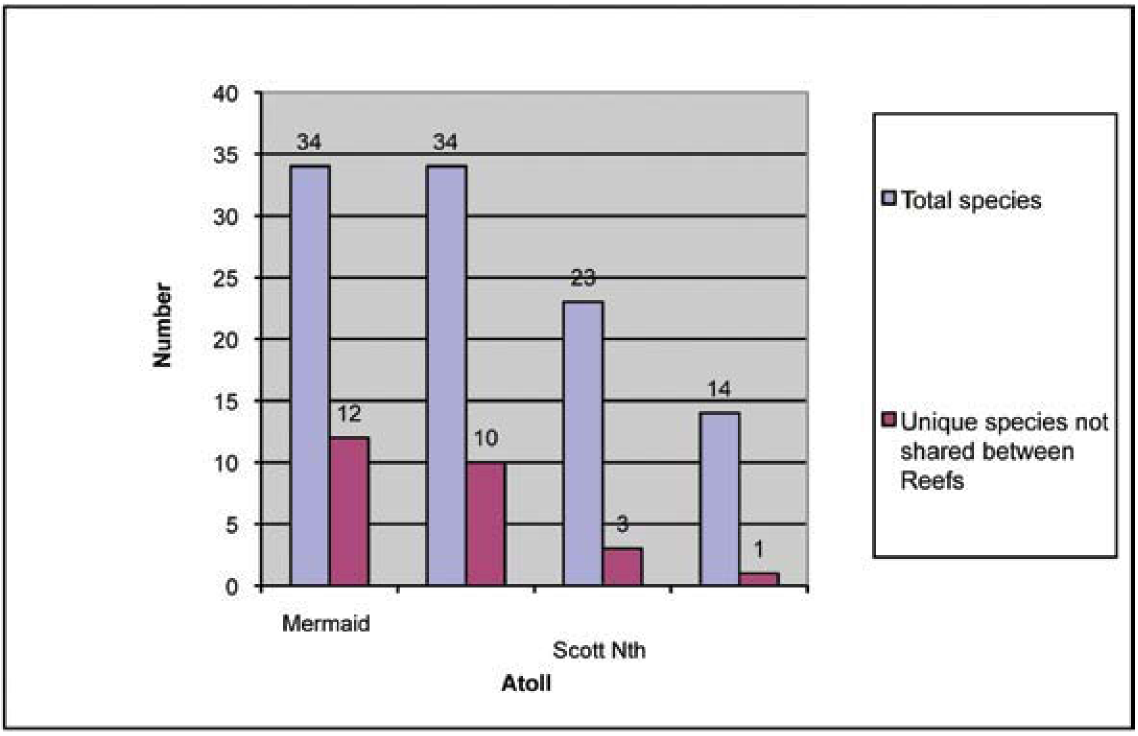


Figure 2 Comparison of the total and unique species of targeted echinoderms from each atoll (2006 Survey)

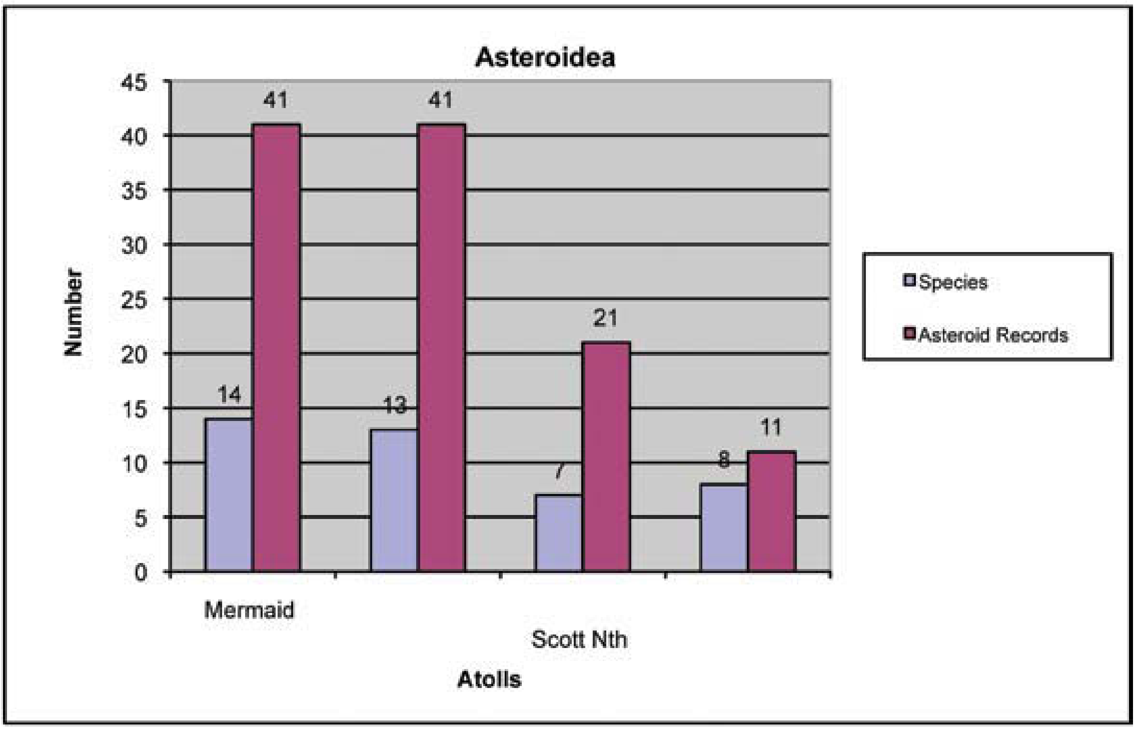


Figure 3 Number of Asteroidea species recorded by Atoll (2006 Survey)

Table 2 Recorded echinoderm species from numbered stations at Mermaid Reef (Rowley Shoals), South Scott Reef, North Scott, and Seringapatam reefs, September 2006, with comparative records published in 1986. (Key: # = new record (2006), M= Mermaid Reef, S= Scott Reef (both North and South combined) and Se= Seringapatam Reef).

Selected Taxa	**1986 Records**	**STATIONS - 2006**			
# = New Record (2006)		**Mermaid Reef (M)**	**Scott South (S)**	**Scott North**	**Seringapatam (Se)**
Asteroidea					
OREASTERIDAE					
Choriaster granulatus Lütken, 1869	M, S, Se	11,14	23,29	34,38	43
Culcita novaeguineae Müller and Troschel, 1842	M, S, Se	1,3,8,9,11,12	23,27,29,30	32,33,35,38	43
ASTEROPSEIDAE					
Asteropsis carinifera (Lamarck, 1816)	M, S, Se				
OPHIDIASTERIDAE					
Celerina heffernani (Livingstone, 1931)	Se				
Celerina sp. #			17		
Cistina columbiae Gray, 1840 #		10	17		
Dactylosaster cylindricus (Lamarck, 1816)	M				
Fromia eusticha Fisher, 1913	M				
Fromia indica (Perrier, 1869)	S, Se		25,26,30		45
Fromia milleporella (Lamarck, 1816)	S, Se	6,9,11			
Fromia monilis Perrier, 1875	M, S, Se	1,2,4,5,12,13,15	19,23,25,27,29,30	31,38,40	43,45
Linckia guildingi Gray, 1840	M, S, Se	10		40	
Linckia laevigata (Linnaeus, 1758)	M, S, Se	1,3,7,8,12	24,25,26,27,30	31,32,33,35,40	44
Linckia multifora (Lamarck, 1816)	M, S, Se	2,4,5,7,8, 9,10,11	17,18,22,23,24,26,27,28,29	31,34,38,40	45
Nardoa tuberculata Gray, 1840	M, S, Se		30		43
Neoferdina cumingi (Gray, 1840)		15	22		
Ophidiaster cribrarius Lütken, 1872	M, S, Se				
Ophidiaster granifer (Lütken, 1872)	M, S, Se		20		
Ophidiaster hemprichi Müller and Troschel, 1842	M, S, Se				
MITHRODIIDAE					
Mithrodia clavigera (Lamarck, 1816)	M, S, Se				
ASTERINIDAE					
Aquilonastra anomala (H.L Clark, 1921) #		14			
Aquilonastra cepheus (Müller & Troschel, 1842)	S, Se	9			
Disasterina abnormalis Perrier, 1875	M, S, Se		24,28		
Indianastra sarasini (de Loriol, 1897) #		10			
ACANTHASTERIDAE					
Acanthaster planci (Linnaeus, 1758)	M, S, Se				

PTERASTERIDAE					
Euretaster insignis (Sladen, 1882)	S, Se				
ECHINASTERIDAE					
Echinaster luzonicus (Gray, 1840)	M, S, Se	11,12,14	23,24,28,29,30	33,35,	43,44,45
Echinaster callosus Marenzeller, 1895 #		4			
Ophiuroidea					
OPHIACANTHIDAE					
Ophiacantha sp. #		8			
OPHACTIDAE					
Ophiactis savignyi (Müller & Troschel, 1842)	M, S, Se	12		32	43
OPHIOTRICHIDAE					
Ophiogymna cf. *pellicula* (Duncan, 1887) #				40	
Ophiothrix purpurea von Martins, 1867	M, S, Se	2,13	22	40	41
Ophiothrix armata Koehler, 1905	S, Se	3,12	29	34	
Ophiothrix exigua Lyman, 1874 #				40	
Ophiothrix nereidina (Lamarck, 1816)	S, Se			32	
Dougaloplus sp. #					41
Macrophiothrix demessa (Lyman, 1861)	M, S, Se			31	
OPHIOCOMIDAE					
Ophiarthrum pictum Müller & Troschel, 1842	M, S, Se	8		35	
Ophiocoma dentata Müller & Troschel, 1842	S, Se	1,14	24		
Ophiocoma doederleini de Loriol, 1899	S, Se		17		
Ophiocoma erinaceus Müller & Troschel, 1842	M, S, Se	16			
Ophiocoma cf. *pusilla* (Brock, 1888)	M, S, Se	16	29		41
Ophiocoma schoenleinii (Müller & Troschel, 1842) #		14	30		
Ophiomastix annulosa (Lamarck, 1816)	M, S, Se		24		
Ophiomastix variabilis Koehler, 1905	M, S, Se	12			
OPHIODERMATIDAE					
Ophiarachnella septemspinosa (Müller & Troschel, 1842)	M, S, Se	12	20		
Ophiarachna incrassata (Lamarck, 1816)	S, Se		24		
OPHIONEREIDIDAE					
Ophionereis dubia (Müller & Troschel, 1842) #		9			
Echinoidea					
CIDARIDAE					
Eucidaris metularia (Lamarck, 1816)	M, S, Se		17,20,22,23,29	31,32,34	41,43
DIADEMATIDAE					

Selected Taxa	1986 Records	STATIONS - 2006			
# = New Record (2006)		**Mermaid Reef (M)**	**Scott South (S)**	**Scott North**	**Seringapatam (Se)**
Diadema savignyi Michelin, 1845	M, S, Se		19,21	35,39	
Diadema setosum (Leske, 1778)	S, Se				
Echinothrix calamaris (Pallas, 1774)	M, S, Se		23,24,27	33,35,39	44
Echinothrix diadema (Linnaeus, 1758)	M, S, Se	5,6,7	21,22,23,24,25		
TEMNOPLEURIDAE					
Mespilia globulus (Linnaeus, 1758)	S, Se				
Temnotrema elegans Mortensen, 1918 #				32,39	
TOXOPNEUSTIDAE					
Toxopneustes pileolus (Lamarck, 1816)	S, Se				
Tripneustes gratilla (Linnaeus, 1758)	M, S, Se				
cf. *Cyrtechinus* sp. #				40	
PARASALENIIDAE					
Parasalenia gratiosa A. Agassiz, 1863	S, Se	1,2 5,8, 10,11,12,13,14,15	30	32	
Parasalenia poehli Pfeffer, 1887	S, Se	4			
ECHINOMETRIDAE					
Echinometra mathaei (de Blainville, 1825)	M, S, Se	1,2,4,5,10,11,13,15	19,20,22,23,24,25,26,28,29,30	32,33,34,35,40	43,44,45
Echinostrephus molaris (de Blainville, 1825)	M, S, Se	2,3,5,15	17,18,19,20,22,24,28.29,30	31,34,40	45
Heterocentrotus mammillatus (Linnaeus, 1758)	M	1,2,3,4,5,13,14	17,18,20,22	31	
ECHINONEIDAE					
Echinoneus cyclostomus Leske, 1778	M, S, Se				
CLYPEASTERIDAE					
Clypeaster reticulatus (Linnaeus, 1758)	M, S, Se				
LAGANIDAE					
Peronella orbicularis (Leske, 1778)	M				
FIBULARIIDAE					
Fibularia ovulum Lamarck, 1816	S, Se				
Fibularia volva L. Agassiz, 1846	S, Se				
SPATANGIDAE					
Nacospatangus alta (A. Agassiz, 1863) #		11			
SCHIZASTERIDAE					
Schizaster sp.	S, Se				
BRISSIDAE					
Brissus latecarinatus (Leske, 1778)	M, S, Se				
Metalia dicrana H.L. Clark, 1917	M				

Metalia spatagus (Linnaeus, 1758)	M, S, Se	11			
Holothurioidea					
CUCUMARIIDAE					
Colochirus robustus Östergren, 1898	S, Se				
cf. *Plesiocolochirus dispar* (Lampert, 1889) #				34	
PHYLLOPHORIDAE					
Cladolabes acicula (Semper, 1868)	S, Se				
HOLOTHURIIDAE					
Actinopyga mauritiana (Quoy and Gaimard, 1833)	M, S, Se	1	21	33	
Actinopyga miliaris (Quoy and Gaimard, 1833)	S	4,8,11,12			
Bohadschia argus Jaeger, 1833	M, S, Se	1,4,6,7,8,9,10,11,12,14,15	21,29	31,34,38	45
Bohadschia marmorata Jaeger, 1833	M, S, Se	6,7,11	20,21,27		
Pearsonothuria graeffei (Semper, 1868)	M, S, Se	2,4,6,7,8,9,10,11,12,14,15	17,18,26,28	32	
Labidodemas pertinax (Ludwig, 1875)	S, Se				
Labidodemas semperianum Selenka, 1867	M, S, Se		17		
Holothuria inhabilis Selenka, 1867	M				
Holothuria atra Jaeger, 1833	M, S, Se	1,4,7,8,9,10,11,12,14	18,21,25,29	39	
Holothuria edulis Lesson, 1830	M, S, Se	1,2,4,6,7,8,9,12,13,14	18,20,21,24,25,26,29,30	32,34,38	
Holothuria pardalis Selenka, 1867	M, S, Se	6			
Holothuria leucospilota (Brandt, 1835)	M, S, Se		25,27		
Holothuria pervicax Selenka, 1867	M, S, Se				
Holothuria hilla Lesson, 1830	M, S, Se		27		
Holothuria whitmaei (Selenka, 1867)	M, S, Se H. nobilis	1,2,6,7,9			
Holothuria fuscogilva Cherbonnier, 1980	M, S, Se H. nobilis		24		
Holothuria difficilis Semper, 1868	M, S, Se				
Holothuria olivacea Ludwig, 1888	S, Se				
Holothuria impatiens (Forskål, 1775)	M, S, Se				44
Holothuria remollescens Lampert,1885	M				
STICHOPODIDAE					
Stichopus chloronotus Brandt, 1835	M, S, Se				
Stichopus horrens Selenka, 1867	M, S, Se		24,27		
Stichopus herrmanni Semper, 1868	M, S, Se	7			
Thelenota ananas (Jaeger, 1833)	M, S, Se	2,4,7,8,10,11,14			
Thelenota anax H.L. Clark, 1921	M	11		40	
SYNAPTIDAE					
Euapta godeffroyi (Semper, 1868)	S, Se		27		
Synapta maculata(Chamisso and Eysenhardt,1821)	M, S, Se		21,24,27		

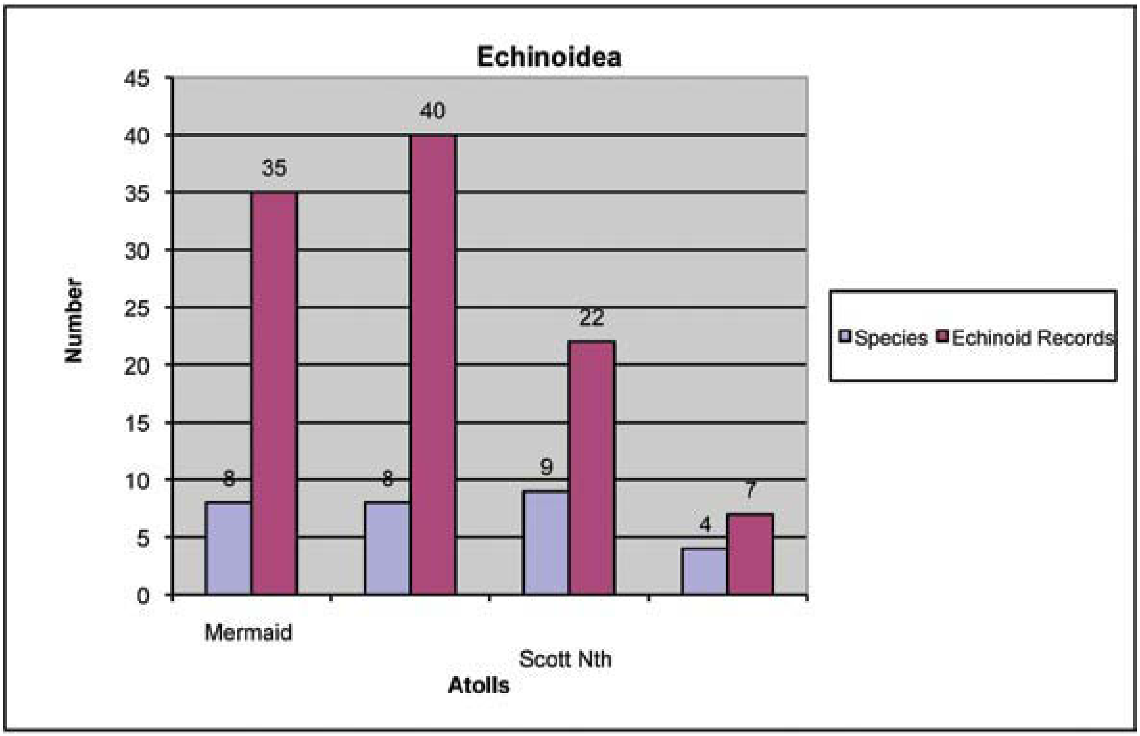


Figure 4 Number of Echinoidea species recorded by Atoll (2006 Survey)

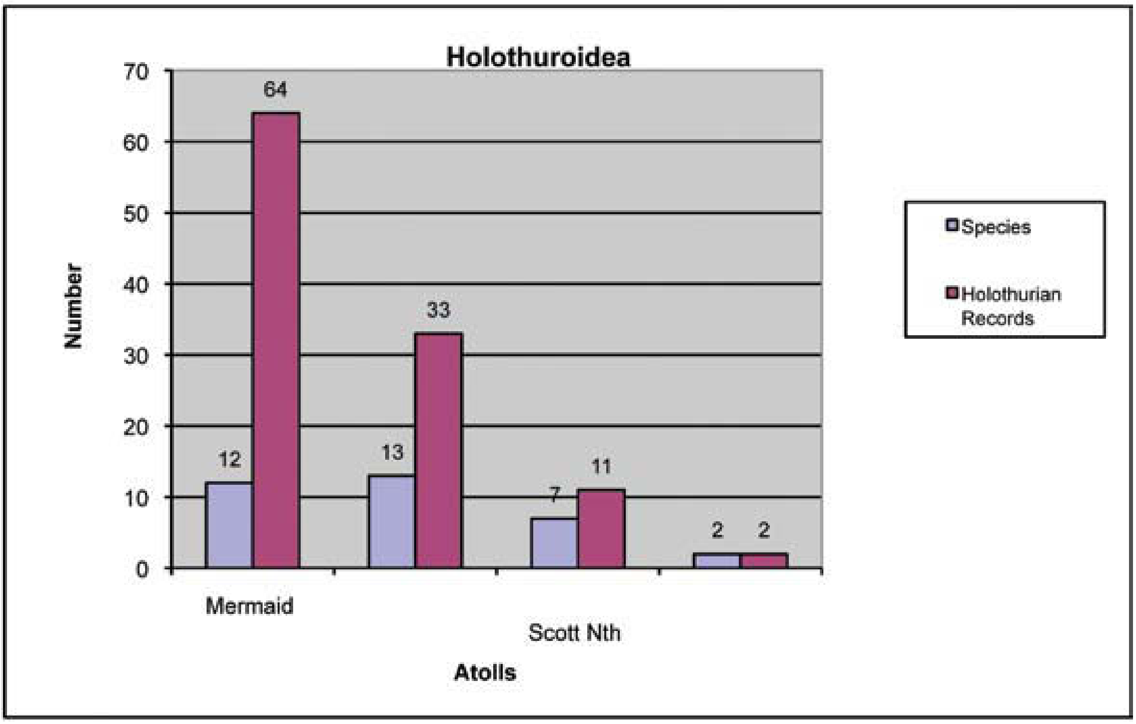


Figure 5 Number of Holothuroidea species recorded by Atoll (2006 Survey)

Top Row From Left: *Pearsonothuria graeffei* (Semper, 1868); *Bohadschia marmorata* Jaeger, 1833; *Bohadschia argus* Jaeger, 1833. (Photos: Clay Bryce)

Bottom Row From Left: *Thelonota anax* H.L. Clark, 1921; *Thelonota ananas* (Jaeger, 1833). (Photos: Clay Bryce)

the 1986 publication, of these 13 were found at South Scott Reef, seven at North Scott Reef and two at Seringapatam Reef. A single new record, cf. *Plesiocolochirus dispar* (Lampert, 1889) from North Scott Reef was collected.

Figure 5 illustrates that the number of individual holothurians from Mermaid Reef to be the highest (64), but South Scott (33), North Scott (11) and Seringapatam Reefs (2) are extremely reduced in numbers.

Ophiuroidea

Brittle stars were not targeted during the 2006 survey but were collected opportunistically and so are not graphed. No meaningful comparisons can be made with the 1986 publication results of the survey. However, ophiuroids are the most speciose group found on coral reefs. In Marsh (1986) 28 species were collected from the Rowley Shoals (all three atolls) and 38 from Scott and Seringapatam Reefs. In 2006 twelve species were collected at Mermaid Reef, nine at South Scott, eight at North Scott and four at Seringapatam. In total 20 species were collected during the 2006 survey. Of note are six species, *Ophiacantha* sp., *Ophiocoma schoenleini* (Müller and Troschel, 1842), *Ophionereis dubia* (Müller and Troschel, 1842), *Ophiothrix exigua* Lyman, 1874, *Dougaloplus* sp. and *Ophiogymna pellicular (*Duncan, 1887) recorded for the first time from the northwest atolls (Table 2).

DISCUSSION

The reduction in echinoderm records (Figure 3, 4 and 5) in North Scott and Seringapatam Reefs when compared to Mermaid Reef, a similar sized atoll, and South Scott Reef, a close neighbour, is noteworthy. The reduction could be due to a number of factors. Seringapatam and North Scott Reefs were heavily damaged by two bleaching events in 1998 and 2003 (Rees, 2003) and by the subsequent erosive cyclonic damage of Cyclone Fay during the 2003 /2004 cyclone season. Mermaid Reef, being of a comparable size to North Scott and Seringapatam Reefs but 400 km south, only suffered minimal damage. South Scott Reef also suffered the same damage as North Scott and Seringapatam, but covers a larger area, has deeper lagoonal waters with better flushing due to its open north end and a more diverse range of habitats.

The bleaching and cyclonic events may also explain the numbers of seastars and echinoids. Under-sampling for Seringapatam Reef would also have been a cause in the low numbers recorded there. Seringapatam Reef has always had the least sampling devoted to it by all expeditions to the region.

Mermaid Reef has the highest numbers of holothurians but stocks at South Scott, North Scott and Seringapatam have declined significantly. This reflects the added factor of fishing pressure by Indonesian fishers under the Australian–Indonesian government's Memorandum of Understanding (MOU74). This MOU allows traditional fishers to utilise the waters of Scott and Seringapatam Reefs, but not Mermaid Reef. As can be seen, the bêche-de-mer (commercial holothurian) stocks of South Scott, North Scott and Seringapatam Reefs have declined significantly to an extremely low level (Berry, 1986; Skewes, 1999; Bryce, 2006) where oligospermy may become a serious factor in slowing population regrowth.

Only seven holothurians, representing three commercial species were found over 21 transects on Scott (North and South) and Seringapatam

Reefs. In contrast, Mermaid Reef had 49 individual holothurians representing 9 species over 16 transects.

The highly sought after *Holothuria whitmaei* (Selenka, 1867) (black teat fish) and *H. fuscogilva* Cherbonnier, 1980 (white teat fish) were notably absent in over 21 transects at Scott and Seringapatam Reefs. There was only one sighting for these two species off the transects and this was a juvenile *H. fuscogilva* at platform station 24. Both these species have a high commercial value but have late sexual maturity and low to medium fecundity resulting in rapid depletion of stocks and slow replenishment after overfishing (Uthicke *et al.*, 2004, 2004a). South Scott and North Scott Reefs exhibit the diversity but not the numbers of this most necessary reef inhabitant. The figures point to near total population collapses at all reefs, other than Mermaid Reef, for this group of echinoderms. In contrast, the holothurian stocks at Mermaid Reef are very much greater with good populations of the above two species.

CONCLUSION

The results of this survey show considerable difference in the echinoderm populations between the reefs. The Mermaid Reef far tot eh south has escaped much of the recent influences of fishing, bleaching events and cyclonic activity (Rees, 2003). Allowing for the differences in methodology and effort between the WA Museum's published report of 1986 (Berry, 1986) and this survey, the echinoderm diversity and numbers for Mermaid Reef appear to be very similar. The same cannot be said, however, for Scott and Seringapatam Reefs. These once pristine oceanic atolls, which form part of a unique habitat off Western Australia's coast (Berry, 1986) appear to be in a state of decline. The collapse of the holothurian populations may have a detrimental effect on reef nutrient loads and general lagoonal turbidity.

The possibly undescribed species of seastar at South Scott Reef is of significance. It has been placed in the genus *Celerina* with further work needed to clarify its species status.

As with much of the Western Australian coastline, new species are still being found and with developments in marine exploration technology improving more will undoubtedly be found. It is, therefore, imperative that the reefs and their inhabitants, which are Australian assets, should be managed with due diligence.

ACKNOWLEDGEMENTS

The authors would like to thank the owners and crew of the Kimberley Quest for their assistance during the expedition. We also thank Mark Salotti for his technical support and Yuki Konishi who thoroughly crosschecked data entry. Valuable input and suggestions from Dr. John Keesing and Dr. Tim O'Hara are also greatly appreciated.

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Fishes of three North West Shelf atolls off Western Australia: Mermaid (Rowley Shoals), Scott and Seringapatam Reefs

Glenn Moore[1,2] and Sue Morrison[1]

[1] Fish Section, Department of Aquatic Zoology, Western Australian Museum, Locked Bag 49, Welshpool DC, WA 6986, Australia. Email: sue.morrison@museum.wa.gov.au

[2] Present address: Centre for Fish and Fisheries Research, School of Biological Sciences, Murdoch University, South St, Murdoch, WA, 6150, Australia. Email: g.moore@murdoch.edu.au

Abstract – The biodiversity of fishes on the Australian North West Shelf atolls is known to be the richest in the state. In recent years however, there has been minimal focus on comprehensive taxonomic fish surveys in this region. Since the atolls are subjected to an increasing frequency of pressures such as major cyclones, coral bleaching, tourism, fishing and natural resource exploitation, it is critical to monitor this region to have the information to safeguard the biodiversity for the future.

To obtain current data that would complement ongoing quantitative surveys in the region, the Western Australian Museum undertook a taxonomic and semi-quantitative survey of the shallow water reef fishes and other major phyla at Mermaid, Scott and Seringapatam Reefs in September 2006. Thirty nine underwater visual surveys were conducted, supplemented by limited intertidal collecting, angling and surface observations.

Analysis of the fish fauna across atolls demonstrated close similarities between North Scott, South Scott and Seringapatam Reefs, and, as a group, these reefs showed certain differences from the more southerly Mermaid Reef. Significant differences were found between lagoonal and outer reef slope habitats. At each atoll, the outer reef slope habitats were more homogeneous and had a greater diversity of fishes than the lagoon habitats, with South Scott lagoon housing a unique mix of both outer reef slope and lagoon species.

Fish diversity was found to increase towards the northern atolls, supporting previous research in the region. The fish fauna at all four atolls had more in common with fish assemblages at equivalent clear-water reefs in Indonesia than with those on the northwest coastal mainland and, as such, are unique within Western Australian waters.

INTRODUCTION

There is considerable concern about the declining biodiversity of coral reef species, including fishes, due to human activities and global warming (Roberts *et al*., 2002). Coral reefs are home to the most diverse shallow water marine ecosystems, with the Indo-Australian Archipelago being the centre of diversity worldwide (Allen, 1999; Bellwood and Wainwright, 2002). The atolls of Australia's North West Shelf are immediately adjacent to this fish diversity 'hotspot' and have some of the most diverse and abundant fish assemblages in the country (Hutchins, 2001; Russell *et al*., 2005). Additionally these atolls are regionally significant because they have many species that do not occur elsewhere in Western Australia (Allen and Russell, 1986; Berry and Marsh, 1986; Hutchins, 2001).

Few coral reefs remain in pristine condition, but some atolls on the North West Shelf are in relatively good condition (Kospartov *et al*., 2006; Gilmour *et al*., 2007). Current concern for the North West Shelf region focuses on increasing human impacts particularly from fishing, recreation and resource exploitation, and also on the increasing incidence and scale of storm events and coral bleaching, possibly exacerbated by global warming (Gilmour *et al*., 2007; Smith *et al*., 2008).

The protection of the biodiversity of the North West Shelf atolls must involve knowledge on how these complex ecosystems function. In order to do this it is important to employ a range of complementary taxonomic and quantitative techniques to examine the flora and fauna at regular intervals. In recent years, however, there has been an emphasis on quantitative surveys of selected families and ecological studies (e.g. Smith *et al*., 2004; Meekan *et al*., 2005) rather than comprehensive taxonomic fish surveys of the North West Shelf atolls.

The fishes of the North West Shelf atolls have been examined many times over the past 35 years (Table 1). The first comprehensive taxonomic survey (non-quantitative) of the shallow water fish fauna of the region was a Western Australian Museum survey in the early 1980's (Allen and Russell, 1986). During three ten-day surveys over three consecutive years the two authors used visual observations, rotenone, spearing, hand netting and angling methods to obtain specimens. Incorporating data from a brief survey made in the region by Hutchins of the Western Australian Museum in 1973, they recorded a total of 485 fish species from the three Rowley Shoals reefs and 483 fish species from the Scott and Seringapatam Reefs, providing a total of 688 species for the whole region.

A different approach, using semi-quantitative visual census methods for recording selected fish families, was employed by Williams, Hutchins and Newman on an Australian Institute of Marine Science (AIMS) expedition in late 1993 (Done *et al*., 1994). In 19 days of visual surveys, they recorded an additional 161 species to those of Allen and Russell, bringing the total for Rowley Shoals, Scott and Seringapatam Reefs to 849 (Hutchins *et al*., 1995).

Table 1 Summary of previous fish surveys on the Rowley Shoals, Scott and Seringapatam atolls. Institute codes as follows: WAM, Western Australian Museum; AMS, Australian Museum; NTM, Museum of Northern Territory; AIMS, Australian Institute of Marine Science; CSIRO, Commonwealth Scientific and Industrial Research Organisation.

Date	Organisation	Author/ Collector	Location	No. stations/ method	No. species
1973	WAM	Hutchins	Rowley Shoals	Taxonomic	33
1979	AMS	Talbot	Scott Reef	5 / Taxonomic	?
1982, 1983	WAM	Allen & Russell, 1986	Rowley Shoals	34 / Taxonomic	485
1984	WAM & NTM	Allen & Russell, 1986	Scott Reef Seringapatam Reef	54 / Taxonomic	483
				Total for region	688
1993	AIMS	Done *et al*., 1994	Rowley Shoals Scott Reef Seringapatam Reef	91 / Taxonomic & quantitative	445
				Total for region	**849**
1995 to 2001	AIMS	Gilmour *et al*., 2007	Rowley Shoals	Long term quantitative monitoring	N/A
1995 to 2008	AIMS	Heyward *et al*., 1995; Smith *et al*., 1994	Scott Reef Seringapatam Reef	Long term quantitative monitoring	N/A
1999	CSIRO	Skewes *et al*., 1999	Scott Reef Seringapatam Reef	Quantitative	N/A
2003	AIMS	Meekan & Cappo, 2004	Rowley Shoals Scott Reef	Shark quantitative monitoring	N/A
2003, 2004	AIMS	Meekan *et al*., 2005	Rowley Shoals Scott Reef	Shark & fin fish quantitative monitoring	N/A

Above: *Zanclus cornutus* (Linnaeus, 1758). A species widespread among all atolls and habitats. (Photo: Clay Bryce)

Since 1995 AIMS has been involved in regular semi-quantitative visual monitoring of fishes and corals at fixed transect sites on the outer reef slope and lagoon habitats at the Rowley Shoals, Scott and Seringapatam Reefs (Heyward *et al*., 1995; Gilmour *et al.*, 2007). Additionally, they have employed baited remote underwater video stations (BRUVs) at greater depths to record deep-water fish assemblages (Meekan and Cappo, 2004; Meekan *et al*., 2005).

Non-quantitative taxonomic surveys of the more northerly atolls of Ashmore, Cartier and Hibernia reefs were conducted by the Western Australian Museum and Northern Territory Museum between 1984 and 1998. Over this period they recorded 924 species, giving a total of over 1,000 fish species for all the North West Shelf atolls (Allen, 1993; Hutchins, 1998; Russell *et al*., 2005).

These surveys found that the North West Shelf atolls had a distinctly different fish fauna from that of the adjacent Australian mainland coast (Allen and Russell 1986; Done *et al*., 1994; Hutchins, 1998; 2001). This was thought to be largely due to the continuous influx of clear oceanic water from the Indonesian throughflow in contrast to the relatively turbid north-west mainland coastal waters (Hutchins, 2001). Many fish species were common to both the Rowley Shoals and Scott Reefs, despite a distance of approximately 400 km between them. There were some clear differences however, with certain species confined to one atoll system and some species that were consistently more abundant at one atoll than the other. For example, the potato cod *Epinephelus tukula* was more abundant at the Rowley Shoals, but the vermicular coral trout *Plectropomus oligocanthus* was only found at Scott Reefs (Allen and Russell, 1986).

Additionally, the data from all surveys indicated a clear gradient of fish diversity increasing from the Rowley Shoals towards Ashmore Reef and Cartier Island, with the more northern fish fauna having stronger Indonesian affinities (Allen and Russell, 1986; Done *et al*., 1994; Heyward *et al.*, 1995; Hutchins, 1998; 2001; Russell *et al*., 2005; Gilmour *et al*., 2007).

Some surveys found major differences between the lagoon habitats and the outer reef slope habitats at all Rowley Shoals, Scott and Seringapatam Reefs, with the lagoons having fewer abundant and/or widespread species than the outer reef slope (Done *et al*., 1994). Only a small number of species were abundant and/or widespread in both lagoon and outer reef slope habitats. Differences between the Rowley Shoals and Scott Reefs were largely due to the lagoonal fish assemblages that were generally more diverse and/or abundant at Scott Reefs. The outer reef slope fish communities were not so distinct between atolls. Clear differences were also demonstrated between the outer reef slopes of the North West atolls and outer reef slopes of the Western Coral Sea and outer Great Barrier Reef at similar latitudes (Done *et al*., 1994).

The aim of this survey was to determine current levels of species richness and semi-quantitative measures of abundance of diurnally active fishes in different habitats (lagoons and outer reef slopes) at the Rowley Shoals, Scott and Seringapatam Reefs. This data would enable the comparison of fish assemblages between different atolls and between different habitats within each atoll.

Additionally, the Western Australian Museum surveys are unique in being able to perform comprehensive and simultaneous assessment of major faunal and floral groups, giving a wider overview of the state of the reef ecosystems at any one time compared with previous surveys (see other contributions this volume).

METHODS

A semi-quantitative visual survey method was employed (Williams, 1982). Fish were counted over a 60-minute period, during which the divers swam from a deep location (maximum of 20 metres) to a shallower location at each station. These survey paths started at the station way point (Station and Transect Data section of this volume) and intersected one end of the fixed-depth invertebrate transect lines that were surveyed concurrently. All fish within a 10 metre wide belt were counted using a $\log_5$ scale of abundance – *1* (1 fish); *2* (2–5 fish); *3* (6–25 fish); *4* (26–125 fish); *5* (126–625 fish); *6* (626–3125 fish); *7* (3126 + fish). Effort was given to including some of the cryptic species in the counts. Counts were progressively recorded onto underwater slates. To ensure confidence in identification, waterproof field-guides were carried and where identification was uncertain, specimens were either collected or photographed for later confirmation. Since one of the main aims of this survey was to document maximum fish species richness, it was decided to balance the two tasks of estimating fish abundance and fish identification, resulting in a single long transect covering a wider range of depths (and therefore more fish species) than would be possible with replicate transects at fixed depths. The transect length varied depending on the physical configuration of each station. For the best estimates of species abundance it is recognised that replicates of a transect are required (Quinn and Keough, 2002), however, restrictions on bottom time for SCUBA divers and overall field time precluded such replication.

Due to the vast diversity and abundance of the known fish fauna at Mermaid, Scott and Seringapatam atolls, species were divided between two observers. G. Moore was responsible for all Chondrichthyes, Caesionidae, Serranidae, Anthiinae, Ephippidae, Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae and

Table 2 Summary of fish survey methodology and habitat types at each station. All stations were surveyed on SCUBA except where indicated for snorkel ^{sk} and rotenone collections ^{ro}.

Atoll	Habitat	Station
Mermaid Reef	Lagoon	*1, 6* ^{sk}*, 7, 8, 9, 11, 12, 14*
	Outer Reef Slope	2, 4, 5, 15, 16
	Intertidal	*3* ^{sk}
	Channel	10, 13
South Scott Reef	Lagoon	18, 23, 25, 26, 29
	Outer Reef Slope	17, 19, 20, 22, 28, 30
	Intertidal	*21* ^{ro}*, 27* ^{ro}
North Scott Reef	Lagoon	32, 38, 39
	Outer Reef Slope	31, 34, 36,
	Intertidal	*33* ^{ro}*, 35* ^{sk}
	Channel	40
Seringapatam Reef	Lagoon	42, 43
	Outer Reef Slope	41, 45
	Intertidal	*44* ^{ro}

several other small families. S. Morrison was responsible for Muraenidae, Synodontidae, Holocentridae, Scorpaenidae, Serranidae, Pseudochromidae, Apogonidae, Carangidae, Lutjanidae, Nemipteridae, Haemulidae, Lethrinidae, Pempheridae, Cirrhitidae, Pinguipedidae, Blenniidae, Gobiidae, Acanthuridae, Siganidae, Balistidae, Monacanthidae, Tetraodontidae, Diodontidae and several other small families. In addition, rare or unusual fishes were recorded by either observer, often following some underwater acknowledgement by both divers. Due to inconsistencies with identifications, scarids were omitted.

Thirty nine visual surveys were conducted on SCUBA or snorkel (Table 2). Station locations and descriptions are provided in the Station Transect Data section of this volume. Four intertidal stations were sampled by rotenone at low tide (Table 2), angling was utilised sporadically and a few species were recorded opportunistically from incidental sightings or via substrate sampling for other phyla. These other records were used to compile the species lists in Appendix 1, and were not included in any analyses. Intertidal Stations 24 and 37 were not sampled for fish because the water movement was too great for a rotenone station. Stations were selected to cover as many representative habitats as possible, within intertidal areas, channels, lagoon floors, bommies, inner reef slopes and outer reef slopes of each atoll, including different levels of exposure and habitat complexity. It was aimed to survey an equivalent number of stations in each of the various habitats, but unfavourable weather and time restrictions limited this plan. The outer reef slope on the west coast of each atoll was under-represented in the survey due to its exposed orientation/aspect and few stations at Seringapatam Reef were surveyed due to time restrictions.

Data were analysed using PRIMER (for Windows v.6.1.10). Data analysis was restricted to those species recorded during the visual surveys at lagoon, outer reef slope and channel sites. No transformation of the data was required since the original data was collected on a $\log_5$ scale. A Bray-Curtis similarity matrix of non-transformed $\log_5$ abundance data was subjected to cluster analysis using group averages to construct a dendrogram. The same similarity matrix was then used for non-metric multi-dimensional scaling analysis (nMDS) of the combined data, selecting the most parsimonious of 30 iterations. Two-way nested analysis of similarity (ANOSIM) was used for comparisons among atolls and among habitats. Two separate one-way ANOSIM analyses were

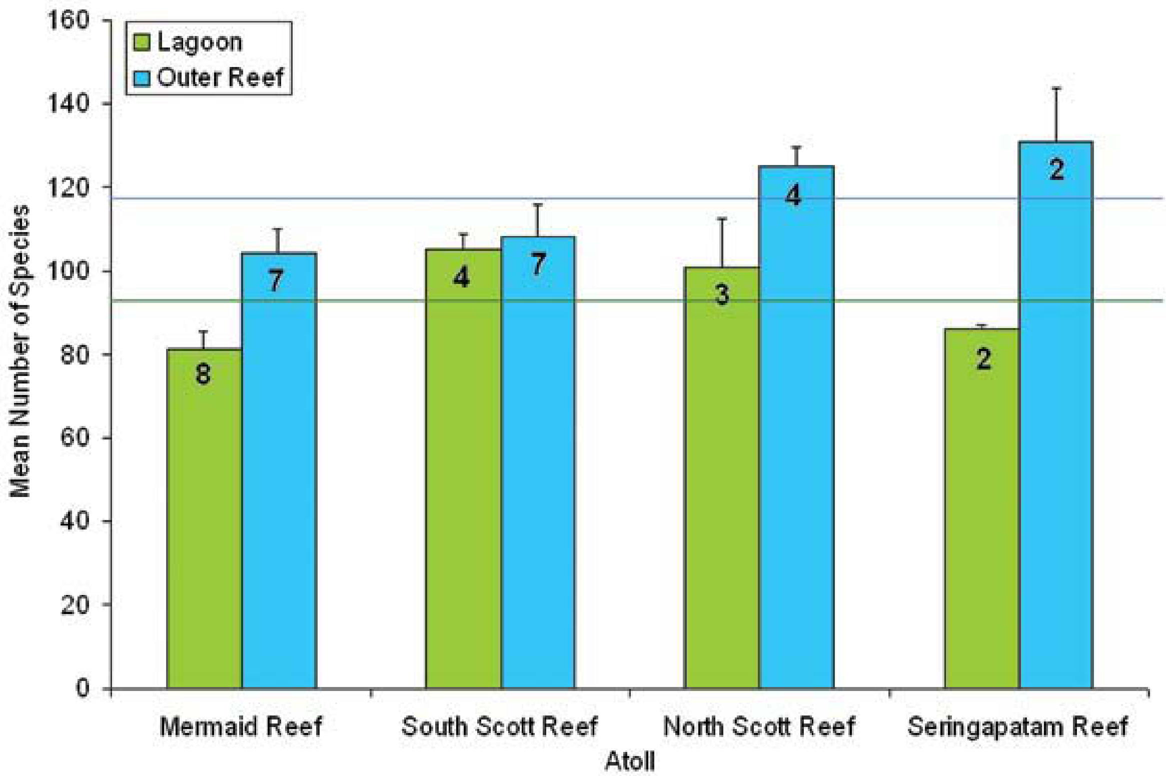


Figure 1 Mean number of species per station within each major habitat across the four atoll systems (visual survey data only). Number of stations is indicated by a numeral within the column and standard error is shown by a bar. Means for each habitat across all atolls are indicated by a green and blue line for lagoon and outer reef slopes, respectively.

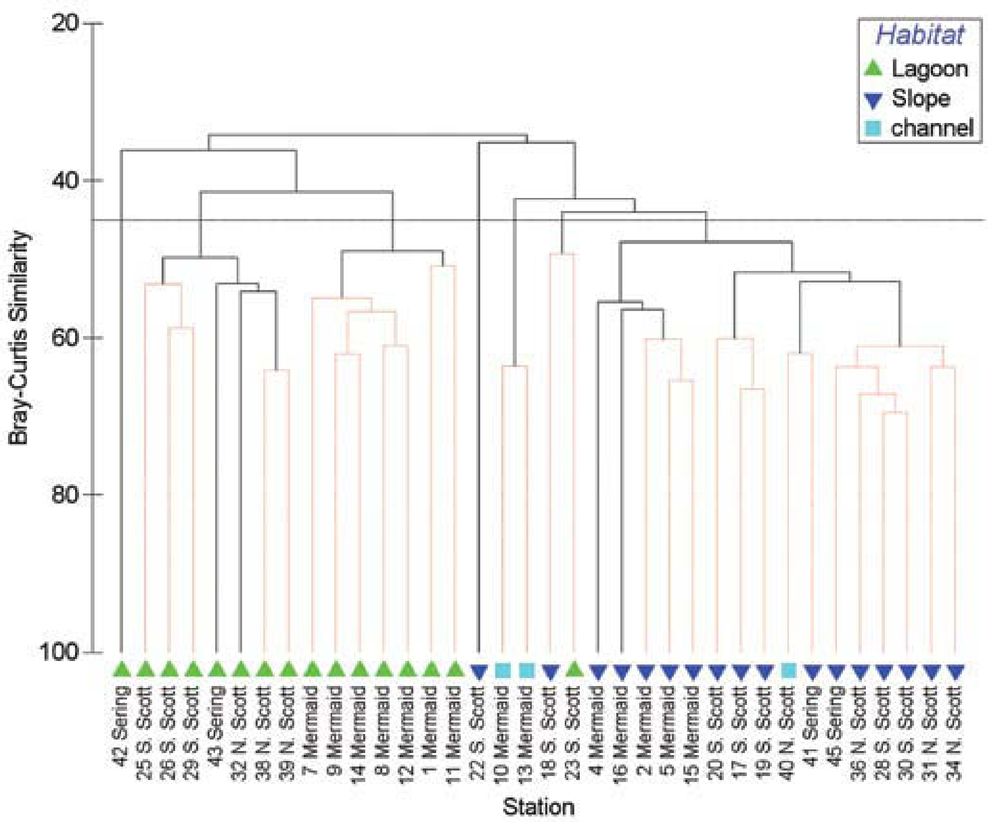


Figure 2 Cluster dendrogram (Bray-Curtis similarity) of $\log_5$ species abundance data from all stations at Mermaid, Scott and Seringapatam Reefs. Groups at 45% similarity are identified as significant by the black lines and non-significant by the red lines as determined by SIMPROF. Station numbers are indicated as a prefix to the atoll name and habitats are coded as in the key.

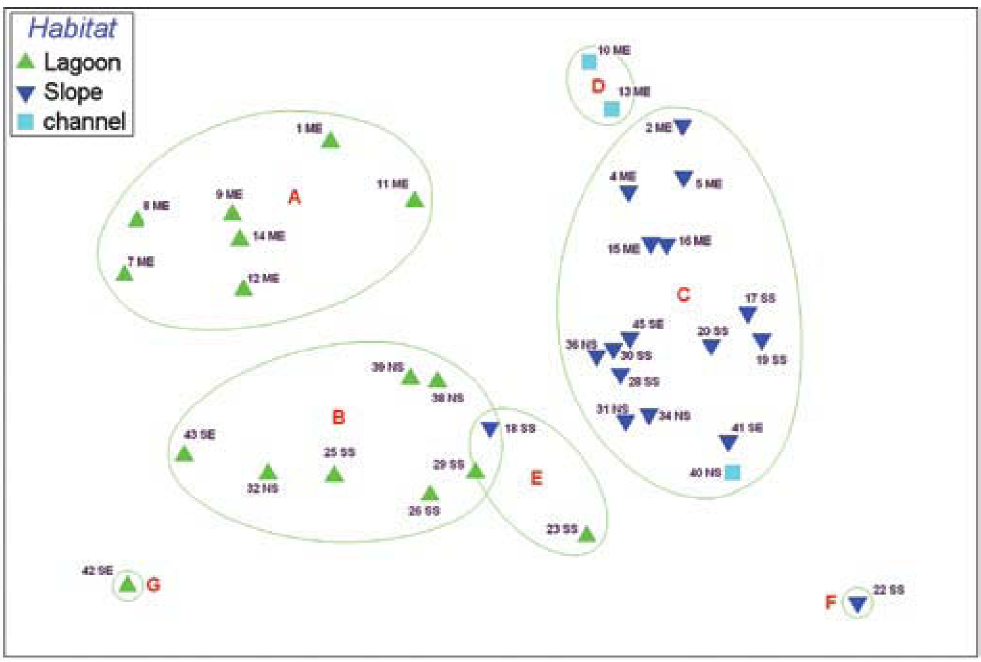


Figure 3 Non-metric multidimensional scaling (MDS) plot of $\log_5$ species abundance data from all habitats at Mermaid, Scott and Seringapatam Reefs (Stress coefficient = 0.14). Cluster pattern at 45% similarity. SIMPROF clusters indicated by letters A to F. Line added to indicate position of Mermaid Reef stations relative to others.

Above: *Caranx sexfasciatus* Quoy & Gaimard, 1825 (Photo: John Huisman)

run for each of the habitat factors (lagoon and outer reef slope) that were found to be significantly different in the nested ANOSIM test. Two separate one-way similarity percentage analyses (SIMPER) of non-transformed log_5 abundance data were performed (excluding the lower 10% of contributing species), to determine the species characterising the assemblages within each habitat at each atoll. SIMPER analysis of the dendrogram cluster groups at the 45% similarity level was carried out to examine which families and species characterise each cluster.

RESULTS

Species richness across all atolls and habitats

A total of 461 species of fishes from 61 families was recorded over all three atoll systems, of which 417 species were recorded during the visual surveys. A further 37 species were added from rotenone and seven from opportunistic sightings and angling. The total fish fauna for each atoll was as follows; Mermaid, 293 species; South Scott Reef, 325 species; North Scott Reef, 271 species (combined Scott Reefs, 387 species) and Seringapatam, 267 species (Appendix 1).

Across all atolls, outer reef slopes ($\bar{x}$ =117 species) were on average more species rich than lagoon habitats ($\bar{x}$ =93 species). Mean species richness of outer reef slope stations increased with decreasing latitude of atoll system such that the outer reef slope stations at Mermaid Reef averaged 104 species and those at Seringapatam Reef averaged 131 species (Figure 1). Similarly, species richness within lagoons was lowest at Mermaid Reef (81 species) and peaked at South Scott Reef (105 species) (Figure 1).

Individual stations with the highest diversity of fishes were outer reef slope habitats at all atolls: Mermaid Reef station 16 (132 species); South Scott Reef station 28 (126 species); North Scott Reef station 34 (138 species) and Seringapatam Reef station 45 (140 species). Lowest diversity was recorded in lagoon habitats at Mermaid Reef stations 1 and 8 (74 species); North Scott Reef station 32 (80 species) and Seringapatam Reef station 42 (85 species), while outer reef slope station 22 on the north side of Sandy Islet held the lowest diversity at South Scott Reef (63 species).

Comparison of fish assemblages between atolls and habitats

Cluster analysis based on abundance data revealed strong clustering of stations by habitat, more so than for atoll (Figure 2). Lagoonal stations of Mermaid Reef were further separated from the Scott/Seringapatam Reef complex and, with a few

Table 3 Pairwise ANOSIM comparisons of lagoon and outer reef slope habitats at all atolls.

	Lagoon		Outer reef slope	
Comparison	**R**	**p**	**R**	**p**
Mermaid/South Scott	0.96	0.003	0.38	0.005
Mermaid/North Scott	0.83	0.008	0.96	0.018
Mermaid/Seringapatam	0.88	0.028	0.83	0.048
South Scott/North Scott	0.30	0.114	0.01	0.450
South Scott/Seringapatam	0.79	0.067	-0.05	0.500
North Scott/Seringapatam	0.42	0.100	0.17	0.400

exceptions, the same was true for outer reef slope stations. The communities at several stations (10, 13, 18, 22, 23, and 42) were 'atypical' in that they did not cluster with the above groups. Channel stations 10 and 13 at Mermaid Reef, and 40 at North Scott Reef had fish communities more similar to the outer reef slope fish assemblages than the lagoonal ones. Notable in this analysis was that lagoon stations 18 and 23 from South Scott Reef tended to cluster in an intermediate position between the outer reef slope and lagoon stations of the Scott/ Seringapatam Reef complex.

Unlike the cluster analysis, multidimensional scaling analysis (MDS) of abundance data indicated a possible difference between the fish communities at Mermaid Reef and those at the two northern atolls (Figure 3). Furthermore, stations at both of the atoll groups (Mermaid and Scott/Seringapatam reef complex) fell into two groupings loosely based on lagoon and outer reef slope habitats (Figure 3). As in the cluster analysis, stations 10, 13, 18, 22, 23 and 42 had various degrees of separation from the main groupings.

To determine whether any of the above differences were significant, two-way nested ANOSIM analysis was carried out. This showed no significant difference between atolls (Global $R = 0.061$, $p=0.353$). Pairwise tests between atolls were therefore not valid. Analysis of the habitats, however, resulted in a highly significant difference between habitats (Global $R = 0.788$, $p=0.0001$).

Separate one way ANOSIM analysis of the lagoon habitats and outer reef slope habitats showed a highly significant difference between lagoons at each atoll (Global $R = 0.77$, $p=0.001$), and between the outer reef slopes at each atoll (Global $R = 0.30$, $p=0.012$).

Pairwise tests between the habitats at each atoll showed significant differences between the lagoon at Mermaid and the lagoons at the Scott/ Seringapatam reef complex, but lagoon habitats at North Scott, South Scott and Seringapatam reefs showed no differences (Table 3). A similar pattern was evident for the outer reef slope habitats (Table 3).

Cluster analysis (Figure 4) and MDS analysis (Figure 5) of the lagoon stations across all atolls clearly supports the separation of Mermaid Reef lagoon assemblages from those at all other atolls. One South Scott Reef lagoon station (23) and one Seringapatam Reef lagoon station (42) were distinct from all other lagoon stations.

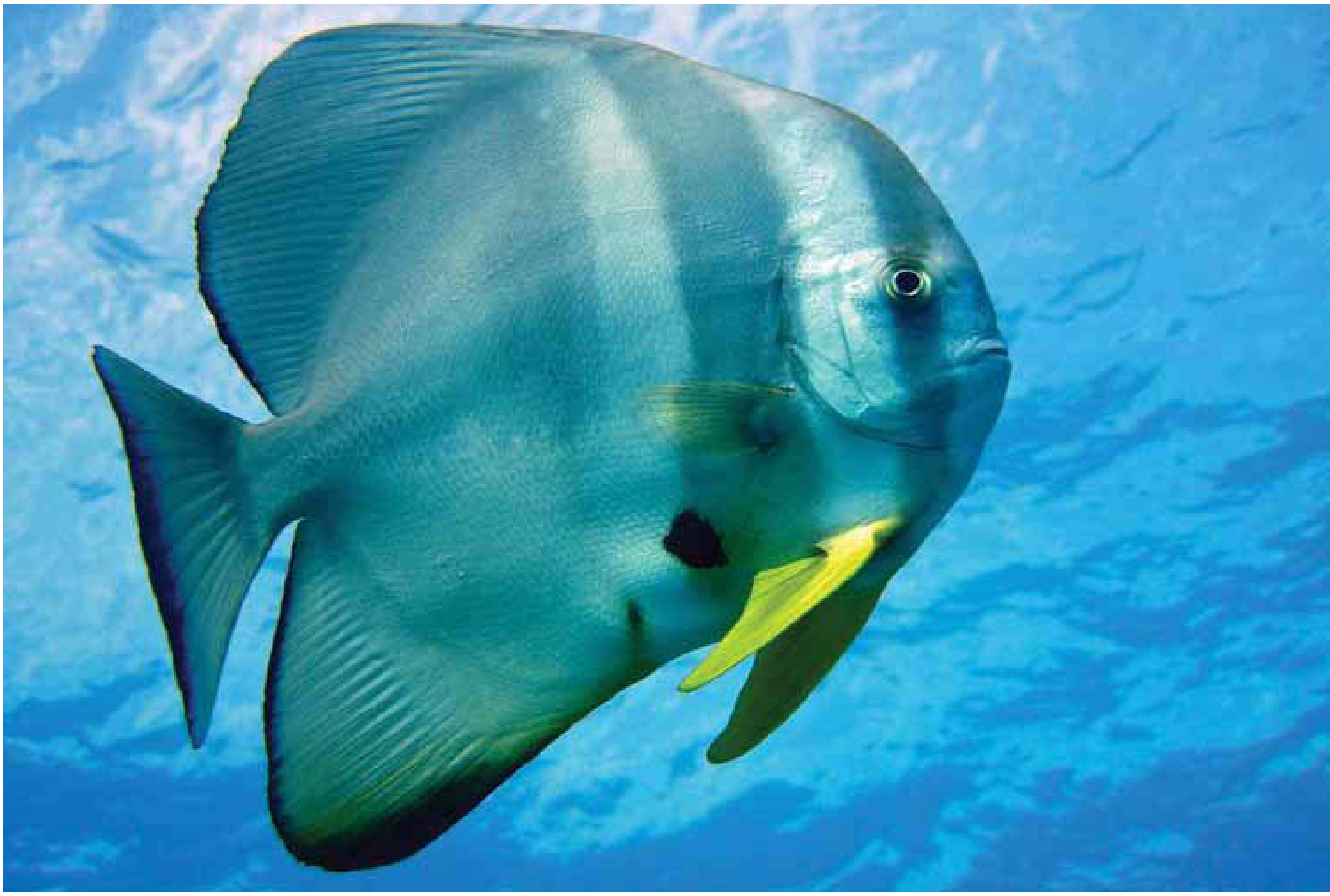
Cluster analysis (Figure 6) and MDS analysis (Figure 7) of the outer reef slope stations across all atolls also supports the separation of Mermaid Reef outer reef slope assemblages from those at all other atolls, although the distinction is not so clear as in the lagoon stations. South Scott outer reef slope stations 18 and 22 and Seringapatam Reef outer reef slope station 42 are distinct from all other outer reef slope stations.

Taxonomic characteristics of SIMPROF groupings

The main differences between the SIMPROF groups were driven by a small number of families. The twenty most abundant fish species were dominated by Pomacentridae, Labridae and Acanthuridae in all groups, except for group G where Acanthuridae were not recorded (Figure 8). Chaetodontidae, Lethrinidae and Lutjanidae were the next most abundant families in the majority of SIMPROF groups. Fifteen other families (Holocentridae, Zanclidae, Apogonidae, Pomacanthidae, Gobiidae, Balistidae, Serranidae, Mullidae, Haemulidae, Carangidae, Nemipteridae, Clupeidae, Cirrhitidae, Synodontidae and Caesionidae) represented the remaining top twenty species to a lesser degree and only occurred in one or two of the SIMPROF groups.

The top twenty species accounted for between 44% and 51% of the abundance at lagoon stations, approximately 37% of the abundance at outer slope stations, and around 52% of the abundance in the channels. Only one species occurred among

Above: *Epinephelus tukula Morgans*, 1959. A species regularly found at the Rowley Shoals. (Photo: John Huisman)



Above: *Platax teira* (Forsskål, 1775) (Photo: John Huisman)

Left: *Pomacentrus vaiuli* Jordan & Seale, 1906 (Photo: Glenn Moore); **Right:** *Amphiprion clarkii* (Bennett, 1830) (Photo: Clay Bryce)

the top twenty in all SIMPROF groups, namely; *Pomacentrus philippinus*. Two species (*Pomacentrus vaiuli* and *Monotaxis grandoculis*) were present in four of the five SIMPROF groups, and six species (*Chromis margaritifer, Dascyllus aruanus, Pomacentrus coelestis, P. moluccensis, Thalassoma amblycephalum and Ctenochaetus striatus*) were present in three of the five SIMPROF groups.

The distribution of species at each atoll indicates that a greater percentage of species were confined to the outer reef slope habitats, compared with the lagoon habitats.(Table 4). Species found in both habitats comprised the greatest proportion at all atolls except Seringapatam Reef where the proportion was intermediate between the lagoon and the outer reef slope habitats.

Fish assemblages at each atoll

All atolls and habitats had slightly different fish assemblages based on the ten most abundant species (Figure 9; Tables 5 to 8). North and South Scott Reefs had six of the ten most abundant species in common, combined Scott Reefs and Seringapatam Reef had five species in common, and Mermaid Reef had four in common with both combined Scott Reefs and Seringapatam Reefs. A great diversity of less-abundant species from these families were recorded, many wide-ranging between atolls and habitats, and others confined to a certain atoll or habitat. Some of the widespread, but not necessarily abundant species among all atolls and habitats were *Chaetodon auriga*, *C. trifasciatus*, *C. ulietensis*, *Chromis margaritifer*, *Pomacentrus vaiuli*, *Halichoeres hortulanus*, *Labroides dimidiatus*, *Thalassoma amblycephalum*, *T. hardwickei*, *Cephalopholis argus*, *Lutjanus bohar*, *L. decussatus*, *L. gibbus*, *Ctenochaetus striatus*, *Naso lituratus*, *Zebrasoma scopas* and *Zanclus cornutus*.

Mermaid Reef

Mermaid Reef lagoon and outer reef slope habitats had distinctly different fish faunas (Table 5). Of a total of 290 fish species recorded visually from Mermaid Reef, approximately 13% were confined to the lagoon, 23% were confined to the outer reef slope and 64% were found in both habitats (Table 4). Of the ten most abundant species only two (*Pomacentrus philippinus* and *P. vaiuli*) were common to both habitats. The most abundant species in both habitats were pomacentrids, however, outer reef slope assemblages were strongly influenced by labrids, acanthurids and

Table 4. Percentage distribution of species at each atoll, using SIMPER dissimilarity analysis (cut off at 90% of species).

Atoll	Lagoon only	Outer Reef only	Both habitats
Mermaid	13%	23%	64%
South Scott	11%	18%	71%
North Scott	12%	31%	57%
Seringapatam	23%	45%	32%

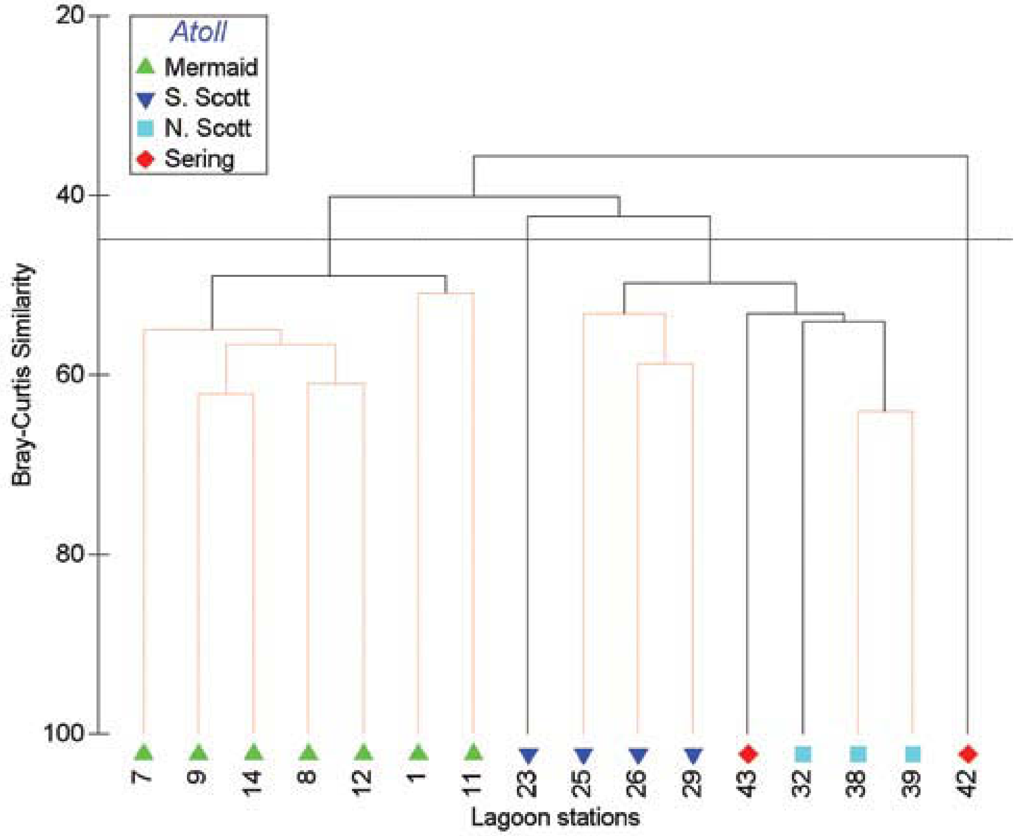


Figure 4 Cluster dendrogram (Bray-Curtis similarity) of log_5 species abundance data from lagoon stations at Mermaid, Scott and Seringapatam Reefs. Groups at 45% similarity are identified as significant by the black lines and non-significant by the red lines as determined by SIMPROF. Station numbers are indicated and atolls are coded as in the key.

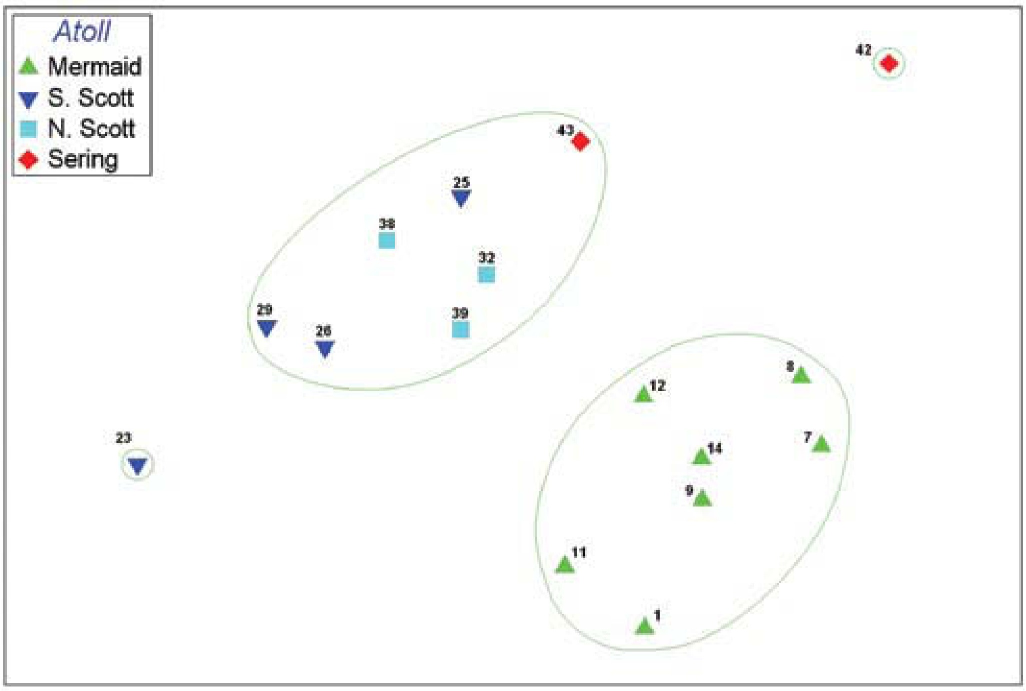


Figure 5. Non-metric multidimensional scaling (MDS) plot of log_5 species abundance data from lagoon stations at Mermaid, Scott and Seringapatam Reefs (Stress coefficient = 0.12). Cluster pattern at 45% similarity.

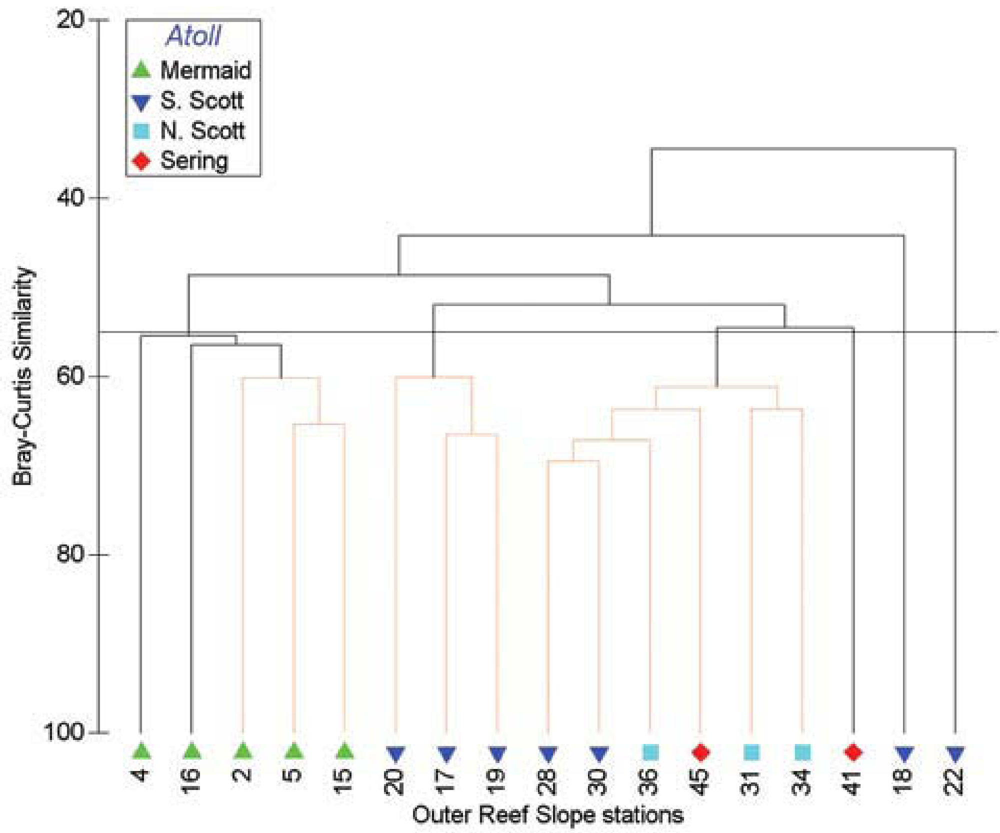


Figure 6 Cluster dendrogram (Bray-Curtis similarity) of $\log_5$ species abundance data from outer reef slope stations at Mermaid, Scott and Seringapatam Reefs. Groups at 55% similarity are identified as significant by the black lines and non-significant by the red lines as determined by SIMPROF. Station numbers are indicated and atolls are coded as in the key.

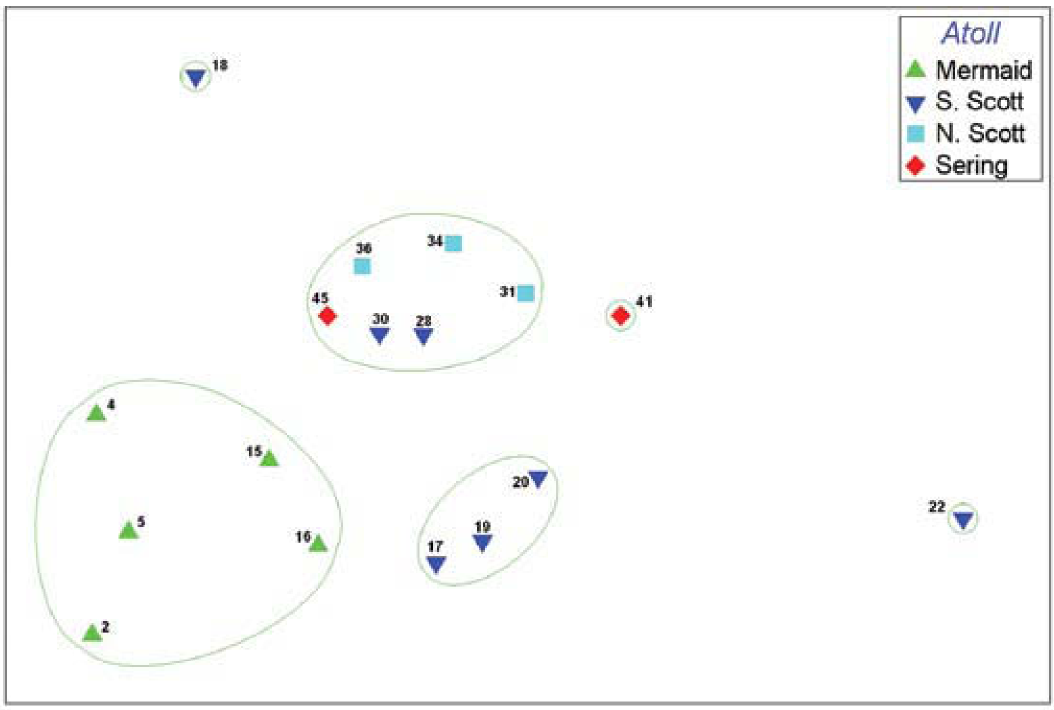


Figure 7 Non-metric multidimensional scaling (MDS) plot of $\log_5$ species abundance data from outer reef slope stations at Mermaid, Scott and Seringapatam Reefs (Stress coefficient = 0.1). Cluster pattern at 55% similarity.

serranids (Table 5). *Pomacentrus moluccensis* was very abundant in the lagoon but occurred in small numbers on the outer reef slope. *Acanthurus nigricans* occurred only on the outer reef slope, wheareas *Zebrasoma scopas*, *Ctenochaetus striatus* and *Naso lituratus* were in greater abundance on the outer reef slope than in the lagoon. Further distinctions were due to *Halichoeres melanurus* being more abundant in the lagoon regions, and *Thalassoma quinquevittatum* and *Pseudanthias tuka* only occurring on the outer reef slope.

The lagoon at Mermaid Reef was characterised by the following abundant and/or widespread species that were only recorded from this habitat; *Epinephelus merra*, *Pseudochromis fuscus*, *Symphorichthys spilurus*, *Dascyllus aruanus*, *Pomacentrus adelus*, *P. grammatorhynchus*, *Hemiglyphidodon plagiometapon*, *Chaetodon punctatofasciatus*, *C. lineolatus* and *Meiacanthus atrodorsalis*. The outer reef slope of Mermaid Reef had a greater number of abundant and/or widespread species confined to this habitat as follows; *Pictichromis paccagnellae, Cheilodipterus quinquelineatus, Lutjanus rivulatus, Parupeneus bifasciatus, Chaetodon unimaculatus, C. meyeri, Abudefduf vaigiensis, Chromis xanthura, Dischistodus perspicillatus, Thalassoma quinquevittatum, Halichoeres melanurus, Siganus doliatus, Acanthurus nigricans, Naso caesius, Melichthys niger* and *M. vidua* (Appendix 1).

South Scott Reef

Of a total of 297 species recorded from South Scott Reef, around 11% were confined to the lagoon, 18% confined to the outer reef slope and 71% were found in both habitats (Table 4). Of the ten most abundant species (Table 6) there were three common to both habitats: *Pomacentrus lepidogenys*, *P. philippinus* and *Ctenochaetus striatus*. Pomacentrids dominated the most abundant species in the lagoon habitats with *Chrysiptera rex*, *Dascyllus aruanus* and *Pomacentrus moluccensis* much more abundant in the lagoon than the outer reef slope region. The labrids *Cirrhilabrus randalli* and *Thalassoma lunare* were also more abundant within the lagoon compared with the outer reef slope. The outer reef slope had the reverse pattern for the pomacentrids *Pomacentrus vaiuli*, *Chromis margaritifer* and the serranid *Pseudanthias tuka*. Of the ten most abundant species, only *Naso caesius* was confined to the outer reef slope.

Pomacentrids and labrids dominated the fish assemblages in the lagoon areas. Some of the more widespread and/or abundant species only recorded from the 'lagoon' stations at South Scott Reef included *Pseudochromis fuscus, Caesio caerulaurea, Forcipiger flavissimus, Dischistodus prosoptaenia, Coris schroederi* and *Ecsenius bicolor*. A greater diversity of species were found confined to the outer reef slope assemblage including the more abundant and/or widespread species; *Plectropomus oligocanthus, Parupeneus bifasciatus, Chaetodon citrinellus, Gomphosus varius, Halichoeres prosopeion, Thalassoma quinquevittatum, Nemateleotris magnifica, Ptereleotris evides, Naso brachycentron, N. caesius, Melichthys niger, M. vidua* and *Sufflamen bursa*. The most speciose families were the chaetodontids, pomacentrids, labrids, acanthurids and balistids.

North Scott Reef

Of the 260 fish species recorded from North Scott Reef, 12% were confined to the lagoon, 31% confined to the outer reef slope and 57% were found in both habitats (Table 4). The lagoon and outer reef slope at North Scott Reef had equivalent numbers of pomacentrids, labrids, acanthurids and

Table 5. The ten most abundant fish species in lagoon and outer reef slope habitats at Mermaid Reef.

Order of abundance	Mermaid lagoon	Mermaid outer reef
1	Pomacentrus moluccensis	Thalassoma amblycephalum
2	Dascyllus aruanus	Zebrasoma scopas
3	Chromis viridis	Acanthurus nigricans
4	Pomacentrus coelestis	Pseudanthias tuka
5	Thalassoma hardwickei	Pomacentrus philippinus
6	Pomacentrus adelus	Ctenochaetus striatus
7	Pomacentrus philippinus	Thalassoma quinquevittatum
8	Pomacentrus vaiuli	Pomacentrus vaiuli
9	Acanthurus blochi	Naso lituratus
10	Halichoeres trimaculatus	Chromis ternatensis
Percentage of total abundance	**31%**	**23%**

Above: *Chaetodon ephippum* Cuvier, 1831 (Photo: Clay Bryce)

lutjanids among the ten most abundant species (Table 7). Of these, three species, *Pomacentrus lepidogenys*, *P. philippinus* and *Lutjanus gibbus*, were common to both regions. Three species of pomacentrids that were restricted to the lagoon were *Chromis viridis*, *Chrysiptera hemicyanea* and *Pomacentrus moluccensis*. Two additional species (*Dascyllus aruanus* and *Thalassoma hardwickei*) were more abundant in the lagoon than the outer reef slope. Of the ten most abundant outer reef slope species, two (*Chromis weberi* and *Naso caesius*) were restricted to this habitat. Of the remaining species, *Thalassoma amblycephalum*, *Cirrhilabrus randalli* and *Pomacentrus nigromarginatus*, were markedly more abundant on the outer reef slope than in the lagoon. There appeared to be less interchange of species between the lagoon and outer reef slope than at South Scott Reef.

Species confined to the lagoon that were abundant and/or widespread included *Epinephelus merra, Amblyglyphidodon curacao, Chromis viridis, Chrysiptera hemicyanea, Plectroglyphidodon lacrymatus, Pomacentrus chrysurus, P. moluccensis, Stegastes nigricans* and *Hemigymnus melapterus*. The assemblages were dominated by pomacentrids and labrids, which differs from the more even spread of families in South Scott Reef lagoon. Species confined to the outer reef slope of North Scott Reef were more diverse and numerous. Among the more abundant and/or widespread were; *Cephalopholis urodeta, Plectropomus laevis, Gymnocranius aurolineatus, Chaetodon ornatissimus, Forcipiger flavissimus, Abudefduf vaigiensis, Amphiprion clarkii, Chromis weberi, C. xanthura, Dascyllus trimaculatus, Bodianus axillaris, Coris gaimardi, Halichoeres marginatus, H. prosopeion, Macropharyngodon meleagris, Pseudodax moluccanus, Nemateleotris magnifica, Acanthurus nigricans, A. olivaceus, Naso brevirostris, N. caesius, Balistoides conspicillum, B. viridescens, Odonus niger, Sufflamen chrysopterus* and *S. bursa*. The most speciose of these families were pomacentrids, labrids, gobiids, acanthurids and balistids.

Seringapatam Reef

Of the 256 fish species recorded from Seringapatam Reef, approximately 23% were confined to the lagoon, 45% were confined to the outer reef slope, and 32% were found in both habitats (Table 4). Among the ten most abundant lagoon and outer reef slope species at Seringapatam, half were restricted to one habitat or the other (Table 8). Only one species, *Labroides dimidiatus*, was common to both habitats. Six species were restricted to the lagoon; apogonids *Cheilodipterus quinquelineata* and *C. macrodon*, pomacentrids *Pomacentrus coelestis*, *Chromis viridis*, *Dascyllus aruanus* and *Amblyglyphidodon curacao*. The labrids *Thalassoma lunare* and *T. hardwickei* were more abundant in the lagoon than the outer reef slope. Four species were restricted to the outer reef slope habitat; *Pseudanthias tuka*, *Cirrhilabrus randalli, Chromis xanthura* and *Naso caesius*. The remaining five species, *Chromis margaritifer, C. weberi, C. lepidolepis, Ctenochaetus striatus* and *Thalassoma amblycephalum* were clearly more abundant on the outer reef slope than the lagoon.

Some of the abundant and/or widespread

Table 6 The ten most abundant fish species at South Scott Reef habitats

Order of abundance	South Scott lagoon	South Scott outer reef slope
1	*Pomacentrus lepidogenys*	*Pomacentrus vaiuli*
2	*Chrysiptera rex*	*Pomacentrus philippinus*
3	*Pomacentrus philippinus*	*Pomacentrus lepidogenys*
4	*Dascyllus aruanus*	*Chromis margaritifer*
5	*Pomacentrus moluccensis*	*Pseudanthias tuka*
6	*Ctenochaetus striatus*	*Halichoeres hortulanus*
7	*Cirrhilabrus randalli*	*Chromis amboinensis*
8	*Thalassoma lunare*	*Ctenochaetus striatus*
9	*Monotaxis grandoculis*	*Naso caesius*
10	*Lutjanus decussatus*	*Thalassoma amblycephalum*
Percentage of total abundance	**27%**	**27%**

Table 7 The ten most abundant fish species at North Scott Reef habitats

Order of abundance	North Scott lagoon	North Scott outer reef slope
1	*Chromis viridis*	*Thalassoma amblycephalum*
2	*Ctenochaetus striatus*	*Chromis weberi*
3	*Pomacentrus lepidogenys*	*Pomacentrus lepidogenys*
4	*Dascyllus aruanus*	*Pomacentrus philippinus*
5	*Chrysiptera hemicyanea*	*Lutjanus gibbus*
6	*Pomacentrus philippinus*	*Cirrhilabrus randalli*
7	*Pomacentrus moluccensis*	*Pomacentrus nigromarginatus*
8	*Thalassoma lunare*	*Pomacentrus amboinenesis*
9	*Lutjanus gibbus*	*Naso caesius*
10	Thalassoma hardwickei	Pomacentrus vaiuli
Percentage of total abundance	**27%**	**23%**

Table 8 The ten most abundant fish species at Seringapatam Reef habitats.

Order of abundance	Seringapatam lagoon	Seringapatam outer reef slope
1	*Cheilodipterus quinquelineatus*	*Pseudanthias tuka*
2	*Thalassoma lunare*	*Chromis margaritifer*
3	*Pomacentrus coelestis*	*Chromis weberi*
4	*Chromis viridis*	*Ctenochaetus striatus*
5	*Dascyllus aruanus*	*Cirrhilabrus randalli*
6	*Thalassoma hardwickei*	*Pomacentrus lepidogenys*
7	*Amblyglyphidodon curacao*	*Chromis xanthura*
8	*Labroides dimidiatus*	*Naso caesius*
9	*Cheilodipterus macrodon*	*Thalassoma amblycephalum*
10	*Naso lituratus*	*Labroides dimidiatus*
Percentage of total abundance	**47%**	**27%**

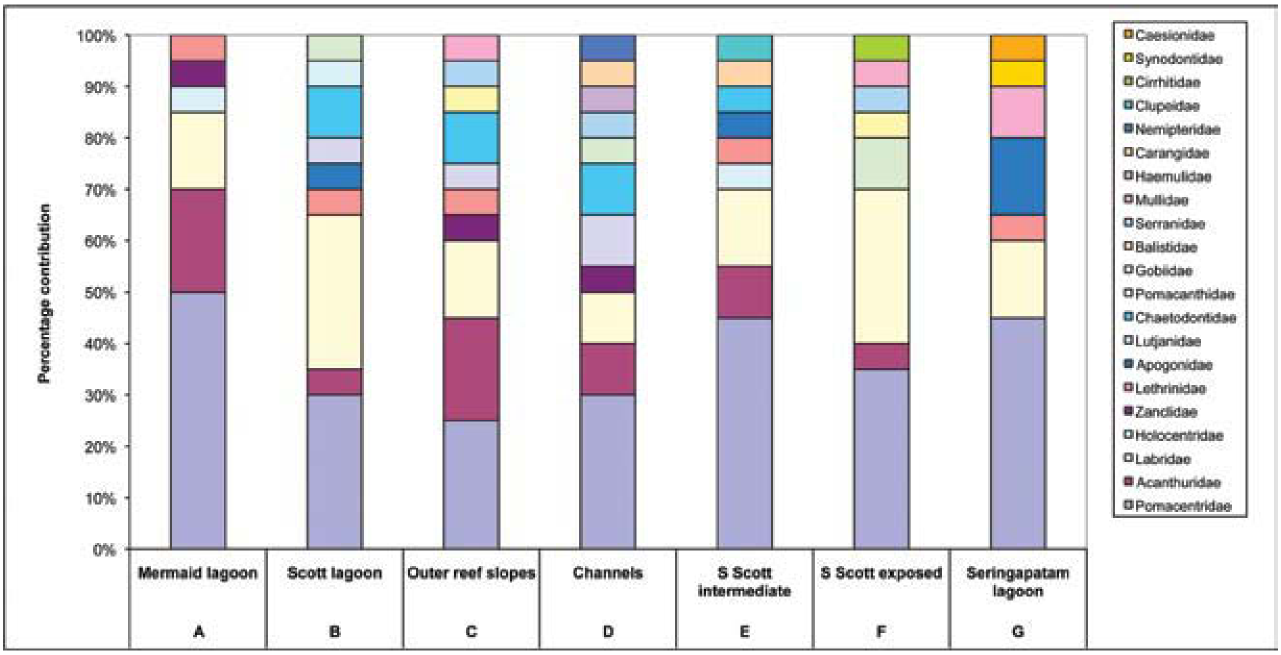


Figure 8 Families of the twenty most abundant fish species in the 45% SIMPROF groupings determined by cluster analysis (Figure 2) and nMDS (Figure 3) derived from log_5 species abundance data from Mermaid, Scott and Seringapatam Reefs. SIMPROF groupings (Figure 3) are labelled A to G.

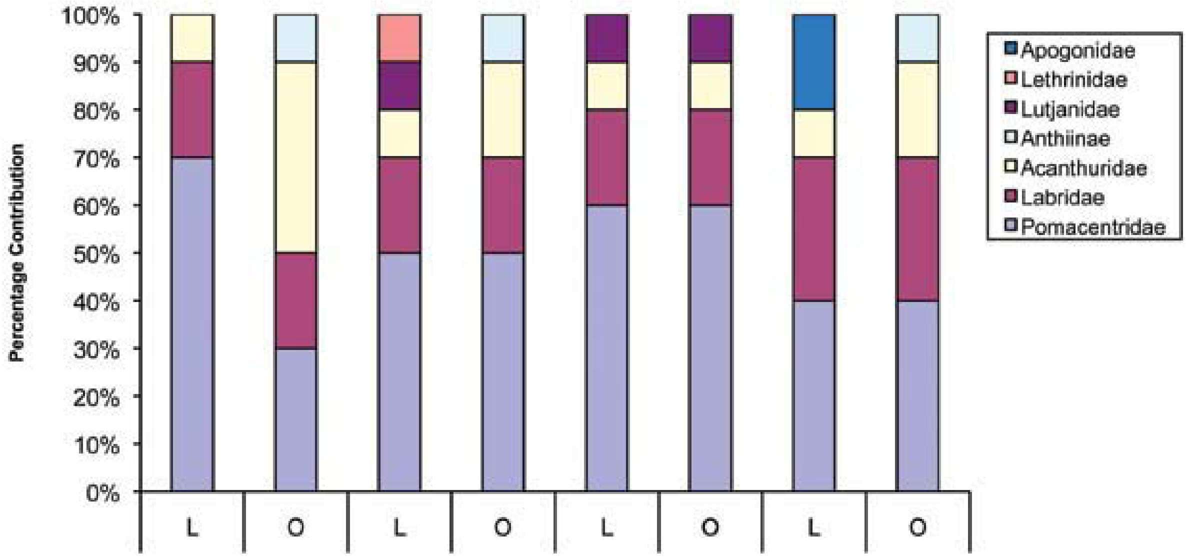


Figure 9 Contribution of families to the ten most abundant species in both habitats at each atoll. L = lagoon, O = outer reef slope.

Above: *Corythoichthys schultzi* Herald, 1953 on the sea star, Müller and Troschel. 1842. (Photo: Sue Morrison)

species confined to the lagoon were; *Epinephelus merra, Cheilodipterus quinquelineatus, Symphorichthys spilurus, Chromis viridis, Dascyllus aruanus, Dischistodus prosopotaenia, Plectroglyphidodon lacrymatus, Pomacentrus moluccensis, Halichoeres melanurus* and *H. trimaculatus*. Species confined to the outer reef slope had the greatest diversity when compared with all other reefs. A selection of the most abundant and/or widespread species are as follows; *Sargocentron caudimaculatum, Cephalopholis urodeta, Lutjanus bohar, Macolor macularis, Parupeneus bifasciatus, Chaetodon vagabundus, C. semeion, Amblyglyphidodon curacao, Chromis atripes, Bodianus axillaris, Cirrhilabrus exquisitus, Epibulus insidiator, Nemateleotris magnifica, Naso brevirostris* and *N. caesius*. This habitat had many speciose families including serranids, chaetodontids, pomacentrids, labrids, acanthurids and balistids.

DISCUSSION

Some 530 fish species have now been reported from the Rowley Shoals and some 600 fish species from Scott/Seringapatam Reefs (Allen and Russell, 1986, Done *et al*., 1994; Hutchins, 1998). This includes collections from all three Rowley Shoals reefs (Mermaid, Clerke and Imperieuse), and derived using a variety of methods including visual surveys, spear, rotenone and angling. The records from the present study include species from 61 families with a range of pelagic, demersal and benthic life histories. Considering the brevity of the present survey, the inclusion of only Mermaid Reef at the Rowley Shoals, limited rotenone sampling and the exclusion of scarids, the results of 293 species at the Rowley Shoals, 387 species at Scott Reefs and 267 species at Seringapatam Reef represent a substantial component of the known fauna. Only one new record was added to the known fauna of the region - *Helcogramma chica* Rosenblatt, 1960. This new record for Australia was found at Seringapatam Reef during the present survey, and was only previously known from the Indonesian region, Christmas Island, Cocos Keeling Islands and north west Pacific region.

Gradient of species richness and recruitment

Reefs closer to Indonesia, which is the centre of reef fish diversity, have a more diverse fish fauna (Allen, 1999). The present results indicate that fish species richness increased in a northerly direction from Mermaid Reef in the Rowley Shoals to the Scott/Seringapatam Reef complex, which supports the findings of Allen (1993), Allen and Russell (1986), Done *et al.*, (1994) and Hutchins (1998). It is thought that the Indonesian throughflow has the potential to transport fish eggs and larvae from Indonesia to the North West Shelf atolls (Hutchins, 2001). It is most likely therefore that the proximity to the rich fish fauna of Indonesia, rather than latitude is the main reason for this species gradient.

The level of self-recruitment at each atoll as opposed to recruitment from further afield however, is not fully known. AIMS have considered weather patterns and oceanic currents to assess the degree of connectivity between the offshore reef systems (Gilmour *et al*., 2007). Results from sub-surface drifters have indicated that dispersal times for fish eggs or larvae between Ashmore and Scott Reefs can be between three to four weeks, and between Scott Reefs and Rowley Shoals around one to two months


Left: *Pseudobalistes flavimarginatus* (Rüppell, 1829); **Right:** *Amblyeleotris steinitzi* (Klausewitz, 1974) (Photo: Clay Bryce)


Left: *Gymnothorax javanicus* (Bleeker, 1859) (Photo: John Huisman); **Right:** *Istigobius rigilius* (Herre, 1953) (Photo: Sue Morrison)

(Gilmour *et al*., 2007). These times would limit fish dispersal between the atolls for most species, and consequently the North West Shelf atolls are likely to depend heavily on self-recruitment (Gilmour *et al*., 2007). The present survey indicates a decreasing species richness of fish assemblages between atolls with increasing distance from Indonesia, which supports slow rates of fish recruitment at the North West Shelf atolls from Indonesia. An example of a species that is potentially a relatively new arrival from Indonesia, is the newly recorded trypterygiid *Helcogramma chica.* The fish fauna of the North West Shelf atolls have more in common with Indonesian reefs than with coastal Australian reefs (Hutchins, 1994; 2001). It has been suggested that the differences in fish assemblages between the Australian mainland and the offshore atolls is largely due to gradients in the physical and biological environments acting as barriers to dispersal (Hutchins, 2001), although most of these are yet to be examined.

Reef Comparisons

Fifteen families dominated the fish assemblages (pomacentrids, acanthurids, labrids and apogonids, with smaller contributions from serranids, lutjanids, chaetodontids, lethrinids, mullids, zanclids, haemulids, clupeids, carangids, synodontids and caesionids) and these accounted for approximately one quarter of the abundance at all atolls. The first seven families are among the most diverse and abundant of the Indo-West Pacific reef fish families (Allen, 1993; Russell *et al*., 2005). Only a very small percentage of fish species were restricted to a single atoll and just under half of all species were common to all atolls. There is a trend for Mermaid Reef fish assemblages to be different from those at the Scott/Seringapatam Reef complex. This is likely to be a consequence of Mermaid Reef being more than 400 km south west of the other atolls. North Scott, South Scott and Seringapatam Reef fish assemblages had more in common with each other, which is to be expected because of their close proximity (there is a maximum of 55 km between them). Exchange of species between these three reefs might be further facilitated by the open formation of South Scott Reef.

The differences in fish assemblages between the North West Shelf atoll systems is thought to be greatly influenced by differences in reef habitat structure (Allen, 1994; Done *et al*., 1994; Hutchins, 2001; Gilmour *et al*., 2007). North and South Scott Reefs, which were more varied in coral species richness, depth and exposure than Mermaid or

Seringapatam Reefs (Done *et al*., 1994) had the greatest fish species richness. After extensive damage by cyclone Jacob at the Rowley Shoals in 1996, the most stable fish population occurred at Mermaid Reef which had the least physical damage and therefore retained the greatest habitat diversity of the Rowley Shoals reefs (Gilmour *et al*., 2007). Furthermore, the present study shows that outer reef slope habitats at Mermaid, Scott and Seringapatam Reefs, which had well developed and steep drop-offs, supported richer fish assemblages than lagoonal habitats at all atolls.

Habitat Comparisons

Fish assemblages in lagoonal and outer reef slope habitats differed from each other. The differences in fish assemblages between the two habitat types are likely to be influenced by physical and oceanographic factors such as shape, orientation, depth, exposure, temperature and salinity, resulting in different benthic biota and ultimately, distinct fish assemblages.

Generally the outer reef slopes assemblages were more homogeneous between reefs than the lagoonal fish assemblages. This is possibly because it is physically easier for fish (both adults and larvae) to move between outer reef slope habitats than traverse the barriers of the reef flats and channels in and out of lagoons at different atolls. Additionally, Mermaid Reef lagoonal fish assemblages were significantly different from all other lagoonal assemblages, which is most likely a function of distance from the other reefs.

South Scott Reef lagoon fish assemblages were distinct from those at other reefs. South Scott Reef is physically different from the other atolls in that it is incomplete along the northern side. Additionally, there are some very deep regions 35 to 55 m depth within the lagoon (Berry and Marsh, 1986), which provide similar habitat to that on the outer reef slope. As such it could almost be considered a third habitat type that is restricted to South Scott Reef. Done *et al*., (1994) also noted this important distinction. This physical structure is likely to allow easy movement of fish between inner and outer reef slope locations, resulting in more uniformity in the distribution of fish species than in the other three atolls. The mixture of lagoonal and outer reef slope species at stations 18 and 23 reflect this idea. Another factor that contributed to the separation of South Scott Reef was outer reef slope station 22 on the outside of Sandy Islet. It had extremely low fish species richness and low abundance that was likely to be a result of it being a very exposed, low relief, well-scoured habitat, and the current at the time of the survey would probably have forced many fish into refuges and out of view.

There were indications that Seringapatam Reef was distinct from other atolls, particularly in the lagoonal fish assemblages, but no strong conclusions can be drawn from this because the reef was under-sampled. For example, station 42 at Seringapatam Reef was shallow and sandy with sparse reef structure, unlike any others sampled in the present study and consequently contained several species largely confined to sandy habitats such as the trichonotids, certain labrids and gobiids. Further surveys at this reef would clarify the fish distribution patterns and abundances.

Impacts on fish assemblages

These offshore atolls are regularly subjected to severe 'natural' damage. For example the Rowley Shoals were hit by cyclone Jacob in 1996, and Scott and Seringapatam Reefs, were subject to a mass coral bleaching event in 1998 (Smith *et al*., 2008) and in 2004 tropical cyclone Fay hit the region (Smith, 2004). Investigations by AIMS after these events indicated major impacts on the hard coral, soft coral and fish communities. These and other natural forces, together with escalating human impacts such as fishing pressures, tourism and global climate change affect the ecology of the region and consequently the fish assemblages. Fish assemblages are constantly changing in response to such factors and are therefore complex. Surveys such as this can only provide data on fish assemblages at a single time, season and at limited locations. No single method will give sufficient data to understand the full biodiversity, ecology and dynamics of fish assemblages. For example, a tool such as rotenone is vital to assess biodiversity since it has been shown that only around 36% of fish species sampled with rotenone may be recorded by underwater visual surveys (Smith-Vaniz *et al*., 2006). Population and community changes need to be assessed by quantitative methods carried out regularly at fixed locations. Temporal changes in fish larval assemblages are known to occur in other areas of the North West Shelf and are likely to influence recruitment and community structure at a local level (Sampey, *et al*., 2004). Deeper water surveys below diving depths are a further challenge, and are currently partially addressed with the use of BRUVs (Meekan, *et al*., 2005). These issues illustrate the need to employ a variety of survey techniques, to cover spatial and temporal variables of natural and human impacts in order to manage and maintain the biodiversity of fish assemblages, along with the physical and biological dynamics, of these unique Australian North West Shelf atolls.

CONCLUSIONS

The present survey recorded an Indo-West Pacific fish fauna with close affinities to fish assemblages

Above: *Naso hexacanthus* (Bleeker, 1855) (Photo: John Huisman)

Above: *Triaenodon obesus* Rüppell, 1837. WhiteTip Reef Shark. (Photo: Glenn Moore) of Indonesia. The range of species and families recorded were similar to those observed in previous taxonomic surveys, and the previously observed gradient of increasing fish species richness with closer proximity to Indonesia, was confirmed. The differences observed between habitats at the different atolls were likely to be a function of physical characteristics and distances between the atolls.

These survey methods would be improved by increasing the number of stations in each of the atolls and within each habitat, and also including replicate surveys at each station. In order to continually assess changes in biodiversity of these unique, yet increasingly utilised atolls, it is important to include a combination of taxonomic, semi-quantitative and quantitative methods.

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Appendix 1.

Fish species recorded from Mermaid, North Scott, South Scott and Seringapatam Reefs, September 2006.
Key: + = present, +* = reef flat, +^ = angling, +o = open water

Scientific name	Common name	Mermaid	Scott	Seringapatam
Ginglymostomatidae	**Nurse Sharks**			
Nebrius ferrugineus (Lesson, 1830)	Tawny Nurse Shark	+		
Carcharhinidae	**Whaler Sharks**			
Carcharhinus amblyrhynchos (Bleeker, 1856)	Grey Reef Shark	+	+	
Carcharhinus melanopterus (Quoy and Gaimard, 1824)	Blacktip Reef Shark	+		
Triaenodon obesus (Rüppell, 1837)	Whitetip Reef Shark	+	+	
Dasyatididae	**Stingrays**			
Dasyatis kuhlii (Müller and Henle, 1841)	Bluespotted Maskray		+	
Taeniura lymma (Forsskål, 1775)	Bluespotted Fantail Ray	+	+	+
Taeniura meyeni Müller and Henle, 1841	Blotched Fantail Ray	+		
Mobulidae	**Devilrays**			
Manta birostris (Donndorff, 1798)	Manta Ray			+
Moringuidae	**Spaghetti Eels**			
Moringua sp.	Spaghetti Eel		+*	
Muraenidae	**Moray Eels**			
Gymnomuraena zebra (Shaw and Nodder, 1797)	Zebra Moray		+*	
Gymnothorax buroensis (Bleeker, 1857)	Latticetail Moray		+*	
Gymnothorax fimbriatus (Bennett, 1832)	Fimbriate Moray		+*	
Gymnothorax javanicus (Bleeker, 1859)	Giant Moray	+	+, +*	+
Gymnothorax pictus (Ahl, 1789)	Painted Moray	+	+*	+*
Rhinomuraena quaesita Garman, 1888	Ribbon Eel		+	
Ophichthidae	**Snake Eels**			
Brachysomophis crocodilinus (Bennett, 1833)	Crocodile Snake Eel		+*	
Leiuranus semicinctus (Lay & Bennett, 1839)	Saddled Snake Eel		+*	
Clupeidae	**Herrings**			
Spratelloides gracilis (Temminck and Schlegel, 1846)	Slender Sprat		+	
Synodontidae	**Lizardfishes**			
Saurida gracilis (Quoy and Gaimard, 1824)	Gracile Saury	+		+
Synodus sp.	Lizardfish		+*	
Synodus binotatus Schultz, 1953	Twospot Lizardfish		+	+
Synodus dermatogenys Fowler, 1912	Banded Lizardfish	+	+	+
Synodus jaculum Russell and Cressey, 1979	Tailspot Lizardfish		+	

Chanidae	**Milkfishes**			
Chanos chanos (Forsskål, 1775)	Milkfish	+		
Gobiesocidae	**Clingfishes**			
Diademichthys lineatus (Sauvage, 1883)	Striped Clingfish	+	+	+
Antennariidae	**Frogfishes**			
Antennarius maculatus (Desjardins, 1840)	Warty Anglerfish		+*	
Exocoetidae	**Flyingfishes**			
Cheilopogon intermedius Parin, 1961	Intermediate Flyingfish	+o	+o	
Cheilopogon spilopterus (Valenciennes, 1847)	Manyspot Flyingfish	+o	+o	
Parexocoetus mento Valenciennes, 1847	African Flyingfish	+o	+o	
Belonidae	**Longtoms**			
Tylosurus sp.	Longtom	+		
Holocentridae	**Squirrelfishes**			
Myripristis adusta Bleeker, 1853	Shadowfin Soldierfish	+	+	+
Myripristis murdjan (Forsskål, 1775)	Crimson Soldierfish	+	+	+
Myripristis pralinia Cuvier, 1829	Bigeye Soldierfish	+		
Neoniphon sammara (Forsskål, 1775)	Slender Squirrelfish	+	+	
Sargocentron caudimaculatum (Rüppell, 1838)	Whitetail Squirrelfish	+	+	+
Sargocentron diadema (Lacépède, 1802)	Crown Squirrelfish	+	+	
Sargocentron spiniferum (Forsskål, 1775)	Sabre Squirrelfish	+	+	+
Aulostomidae	**Trumpetfishes**			
Aulostomus chinensis (Linnaeus, 1766)	Trumpetfish	+	+	
Fistulariidae	**Flutemouths**			
Fistularia commersonii Rüppell, 1838	Smooth Flutemouth	+	+	
Syngnathidae	**Pipefishes**			
Corythoichthys haematopterus (Bleeker, 1851)	Reeftop Pipefish	+	+	
Coryithoichthys schultzi Herald, 1953	Schultz's Pipefish	+		
Pteroidae	**Lionfishes**			
Dendrochirus zebra (Cuvier, 1829)	Zebra Lionfish		+	
Pterois antennata (Bloch, 1787)	Spotfin Lionfish		+	
Pterois volitans (Linnaeus, 1758)	Common Lionfish		+	
Scorpaenidae	**Scorpionfishes**			
Parascorpaena mossambica (Peters, 1855)	Mozambique Scorpionfish		+*	+*
Scorpaenodes guamensis Quoy & Gaimard, 1824	Guam Scorpionfish		+*	
Scorpaenopsis venosa (Cuvier, 1829)	Raggy Scorpionfish	+		
Serranidae	**Rockcods**			
Aethaloperca rogaa (Forsskål, 1775)	Redmouth Rockcod	+	+	+
Anyperodon leucogrammicus (Valenciennes, 1828)	Whitelined Rockcod	+	+	+
Cephalopholis argus Bloch and Schneider, 1801	Peacock Rockcod	+	+, +*	+

Scientific name	Common name	Mermaid	Scott	Seringapatam
Cephalopholis microprion (Bleeker, 1852)	Dot-head Rockcod		+	
Cephalopholis miniata (Forsskål, 1775)	Coral Rockcod	+	+	+
Cephalopholis sexmaculata (Rüppell, 1830)	Sixband Rockcod	+		
Cephalopholis urodeta (Forster, 1801)	Flagtail Rockcod	+	+	+
Epinephelus caeruleopunctatus (Bloch, 1790)	Whitespottted Grouper		+	
Epinephelus fuscoguttatus (Forsskål, 1775)	Flowery Rockcod	+	+	+
Epinephelus maculatus (Bloch, 1790)	Highfin Grouper		+	+
Epinephelus merra Bloch, 1793	Birdwire Cod	+	+, +*	+
Epinephelus ongus (Bloch, 1790)	Specklefin Rockcod		+	+
Epinephelus polyphekadion (Bleeker, 1849)	Camouflage Grouper	+	+	+
Epinephelus tukula Morgans, 1959	Potato Rockcod	+		
Gracila albomarginata (Fowler and Bean, 1930)	Thinspine Grouper	+	+	+
Plectropomus areolatus (Rüppell, 1830)	Passionfruit Coral Trout	+	+	+
Plectropomus laevis (Lacépède, 1801)	Bluespotted Coral Trout	+	+	+
Plectropomus leopardus (Lacépède, 1802)	Common Coral Trout	+	+	
Plectropomus oligacanthus (Bleeker, 1854)	Vermicular Cod		+	+
Pseudanthias huchtii (Bleeker, 1857)	Pacific Basslet			+
Pseudanthias lori (Lubbock and Randall, 1976)	Lori's Basslet			+
Pseudanthias sheni Randall and Allen 1989	Shen's Basslet		+	
Pseudanthias squamipinnis (Peters, 1855)	Orange Basslet		+	
Pseudanthias tuka (Herre and Montalban, 1927)	Purple Queen	+	+	+
Variola albimarginata Baissac, 1953	White-edge Coronation Trout		+	+
Variola louti (Forsskål, 1775)	YellowedgeCoronation Trout	+	+	
Grammistidae	**Soapfishes**			
Belonoperca chabanaudi Fowler and Bean, 1930	Arrowhead Soapfish	+		
Pseudochromidae	**Dottybacks**			
Pictichromis paccnagellae (Axelrod, 1973)	Royal Dottyback	+	+	
Pseudochromis bitaeniatus (Fowler, 1931)	Slender Dottyback		+	+
Pseudochromis cyanotaenia Bleeker, 1857	Yellowhead Dottyback		+*	
Pseudochromis fuscus Müller and Troschel, 1849	Dusky Dottyback	+	+	+
Plesiopidae	**Prettyfins**			
Plesiops verecundus Mooi, 1995	Redtip Longfin		+*	
Apogonidae	**Cardinalfishes**			
Apogon coccineus Rüppell, 1838	Little Red Cardinalfish		+*	
Apogon compressus (Smith and Radcliffe, 1911)	Blue-eye Cardinalfish	+	+	
Apogon cyanosoma (Bleeker, 1853)	Orangelined Cardinalfish		+	+
Apogon exostigma (Jordan and Starks, 1906)	Oneline Cardinalfish	+	+	
Apogon kallopterus Bleeker, 1856	Spinyhead Cardinalfish		+	

Apogon leptacanthus Bleeker, 1856	Longspine Cardinalfish	+		
Apogon nigrofasciatus Lachner, 1953	Blackstriped Cardinalfish		+	
Apogon sealei (Fowler, 1918)	Cheekbar Cardinalfish			+
Apogon taeniophorus Regan, 1908	Pearly-line Cardinalfish		+, +*	+
Apogon timorensis Bleeker, 1854	Timor Cardinalfish		+	
Apogonichthys ocellatus? Weber, 1913	Ocellate Cardinalfish		+*	
Archamia fucata (Cantor, 1849)	Painted Cardinalfish		+	+
Archamia zosterophora (Bleeker, 1856)	Girdled Cardinalfish	+	+	
Cercamia eremia (Allen, 1987)	Glassy Cardinalfish		+*	
Cheilodipterus artus Smith, 1961	Wolf Cardinalfish	+	+	+
Cheilodipterus macrodon (Lacépède, 1801)	Tiger Cardinalfish		+	+
Cheilodipterus quinquelineatus Cuvier, 1828	Fiveline Cardinalfish	+	+	+
Rhabdamia cypselurus Weber, 1909	Schooling Cardinalfish		+	
Rhabdamia gracilis (Bleeker, 1856)	Slender Cardinalfish	+	+	+
Malacanthidae	**Tilefishes**			
Malacanthus brevirostris Guichenot, 1848	Flagtail Blanquillo		+	+
Malacanthus latovittatus (Lacépède, 1801)	Blue Blanquillo		+	
Echeneidae	**Remoras**			
Echeneis naucrates Linnaeus, 1758	Sharksucker	+	+	
Carangidae	**Trevallies**			
Carangoides fulvoguttatus (Forsskål, 1775)	Turrum	+		
Carangoides orthogrammus (Jordan and Gilbert, 1882)	Thicklip Trevally	+	+	
Carangoides plagiotaenia Bleeker, 1857	Barcheek Trevally		+	+
Caranx ignobilis (Forsskål, 1775)	Giant Trevally	+		+
Caranx lugubris Poey, 1860	Black Trevally	+	+	+
Caranx melampygus Cuvier, 1833	Bluefin Trevally	+	+	+
Caranx sexfasciatus Quoy and Gaimard, 1825	Bigeye Trevally	+	+	
Elegatis bipinnulata (Quoy and Gaimard, 1825)	Rainbow Runner		+	
Scomberoides commersonnianus Lacépède, 1801	Giant Queenfish	+		
Scomberoides lysan (Forsskål, 1775)	Lesser Queenfish	+		
Trachinotus blochii (Lacépède, 1801)	Snubnose Dart	+		
Lutjanidae	**Tropical Snappers**			
Aphareus rutilans Cuvier, 1830	Rusty Jobfish	+	+	+
Aprion virescens Valenciennes, 1830	Green Jobfish	+	+	+
Lutjanus biguttatus (Valenciennes, 1830)	Twospot Snapper			+
Lutjaus bohar (Forsskål, 1775)	Red Bass	+	+	+
Lutjanus decussatus (Cuvier, 1828)	Checkered Snapper	+	+	+
Lutjanus gibbus (Forsskål, 1775)	Paddletail	+	+	+
Lutjanus kasmira (Forsskål, 1775)	Bluestriped Snapper	+	+	+

Scientific name	Common name	Mermaid	Scott	Seringapatam
Lutjanus rivulatus (Cuvier, 1828)	Maori Snapper	+	+	
Lutjanus russellii (Bleeker,1849)	Moses Seaperch	+	+	+
Macolor macularis Fowler, 1931	Midnight Snapper	+	+	+
Macolor niger (Forsskål, 1775)	Black-and-White Snapper	+	+	+
Symphorichthys spilurus (Günther, 1874)	Sailfin Snapper	+	+	+
Caesionidae	**Fusiliers**			
Caesio caerulaurea Lacépède, 1801	Goldband Fusilier		+	
Caesio cuning (Bloch, 1791)	Yellowtail Fusilier	+		
Caesio lunaris Cuvier, 1830	Lunar Fusilier	+	+	
Caesio teres Seale, 1906	Blue Fusilier	+	+	+
Pterocaesio pisang (Bleeker, 1853)	Banana Fusilier		+	+
Pterocaesio tile (Cuvier, 1830)	Neon Fusilier	+	+	+
Pterocaesio trilineata Carpenter, 1987	Threestripe Fusilier		+	+
Nemipteridae	**Threadfin Breams**			
Parascolopsis tosensis (Kamohara, 1938)	Yellowstripe Monocle Bream		+	
Scolopsis affinis Peters, 1877	Bridled Monocle Bream			+
Scolopsis bilineata (Bloch, 1793)	Two-line Monocle Bream	+	+, +*	+
Scolopsis margaritifer (Cuvier, 1830)	Pearly Monocle Bream		+	+
Haemulidae	**Grunter Breams**			
Plectorhinchus chaetodonoides (Lacépède, 1801)	Spotted Sweetlips	+	+	+
Plectorhinchus lineatus (Linnaeus, 1758)	Oblique-banded Sweetlips		+	
Lethrinidae	**Emperors**			
Gnathodentex aureolineatus (Lacépède, 1802)	Goldspot Seabream	+	+	+
Lethrinus atkinsoni Seale, 1910	Yellowtail Emperor		+	
Lethrinus erythropterus Valenciennes, 1830	Longfin Emperor	+	+	+
Lethrinus obsoletus (Forsskål, 1775)	Orangestriped Emperor	+	+	
Lethrinus olivaceus Valenciennes, 1830	Longnose Emperor	+	+	+
Lethrinus rubrioperculatus Sato, 1978	Spotcheek Emperor	+		
Lethrinus xanthochilus Klunzinger, 1870	Yellowlip Emperor		+	+
Monotaxis grandoculis (Forsskål, 1775)	Bigeye Seabream	+	+	+
Mullidae	**Goatfishes**			
Parupeneus barberinus (Lacépède, 1801)	Dot-and-Dash Goatfish	+	+	+
Parupeneus crassilabris (Valenciennes, 1831)	Doublebar Goatfish	+	+	+
Parupeneus cyclostomus (Lacépède, 1801)	Goldsaddle Goatfish		+	+
Parupeneus multifasciatus (Quoy and Gaimard, 1825)	Banded Goatfish	+	+	+
Parupeneus pleurostigma (Bennett, 1831)	Sidespot Goatfish	+	+	+
Pempheridae	**Bullseyes**			
Pempheris oualensis Cuvier, 1831	Oualan Bullseye	+	+	+

Kyphosidae	**Drummers**			
Kyphosus vaigiensis (Quoy and Gaimard, 1825)	Brassy Drummer	+		+
Ephippidae	**Batfishes**			
Platax pinnatus (Linnaeus, 1758)	Longfin Batfish	+	+	
Platax teira (Forsskål, 1775)	Roundface Batfish	+	+	
Chaetodontidae	**Butterflyfishes**			
Chaetodon adiergastos Seale, 1910	Philippine Butterflyfish	+	+	
Chaetodon auriga Forsskål, 1775	Threadfin Butterflyfish	+	+, +*	+
Chaetodon baronessa Cuvier, 1831	Triangular Butterflyfish		+	
Chaetodon bennetti Cuvier, 1831	Eclipse Butterflyfish	+	+	
Chaetodon citrinellus Cuvier, 1831	Citron Butterflyfish	+	+	+
Chaetodon ephippum Cuvier, 1831	Saddle Butterflyfish	+	+	+
Chaetodon kleinii Bloch, 1790	Klein's Butterflyfish	+	+	+
Chaetodon lineolatus Cuvier, 1831	Lined Butterflyfish	+	+	
Chaetodon lunula (Lacépède, 1803)	Racoon Butterflyfish	+	+	
Chaetodon lunulatus Quoy & Gaimard, 1824	Pinstripe Butterflyfish	+	+	+
Chaetodon melannotus Schneider, 1801	Blackback Butterflyfish		+	+
Chaetodon meyeri Bloch and Schneider, 1801	Meyer's Butterflyfish	+	+	
Chaetodon ornatissimus Cuvier, 1831	Ornate Butterflyfish	+	+	+
Chaetodon oxycephalus Bleeker, 1853	Spotnape Butterflyfish		+	+
Chaetodon punctatofasciatus Cuvier, 1831	Spotbanded Butterflyfish	+	+	+
Chaetodon rafflesi Bennett, 1830	Lattice Butterflyfish		+	
Chaetodon semeion Bleeker, 1855	Dotted Butterflyfish	+	+	+
Chaetodon speculum Cuvier, 1831	Ovalspot Butterflyfish	+	+	+
Chaetodon trifascialis Quoy and Gaimard, 1824	Chevron Butterflyfish	+	+	+
Chaetodon ulietensis Cuvier, 1831	Doublesaddle Butterflyfish	+	+	+
Chaetodon unimaculatus Bloch, 1787	Teardrop Butterflyfish	+	+	
Chaetodon vagabundus Linnaeus, 1758	Vagabond Butterflyfish	+	+	+
Coradion chrysozonus (Cuvier, 1831)	Orangebanded Coralfish		+	
Forcipiger flavissimus Jordan and McGregor, 1898	Forceps Fish	+	+	+
Forcipiger longirostris (Broussonet, 1782)	Longnose Butterflyfish	+	+	
Hemitaurichthys polylepis (Bleeker, 1857)	Pyramid Butterflyfish		+	
Heniochus acuminatus (Linnaeus, 1758)	Longfin Bannerfish	+		
Heniochus chrysostomus Cuvier, 1831	Pennant Bannerfish	+	+	+
Heniochus singularis Smith and Radcliffe, 1911	Singular Bannerfish	+	+	+
Heniochus varius (Cuvier, 1829)	Horned Bannerfish	+	+	+
Pomacanthidae	**Angelfishes**			
Apolemichthys trimaculatus (Cuvier, 1831)	Threespot Angelfish	+	+	+
Centropyge bicolor (Bloch, 1787)	Bicolor Angelfish	+	+	+

Scientific name	Common name	Mermaid	Scott	Seringapatam
Centropyge bispinosa (Günther, 1860)	Coral Beauty	+	+	+
Centropyge eibli Klausewitz, 1963	Eibel's Angelfish	+		
Centropyge flavicauda Fraser-Brunner, 1933	Whitetail Angelfish		+	+
Centropyge tibicen (Cuvier, 1831)	Keyhole Angelfish		+	+
Centropyge vroliki (Bleeker, 1853)	Pearlscale Angelfish		+	+
Chaetodontoplus mesoleucus (Bloch, 1787)	Vermiculate Angelfish		+	
Pomacanthus imperator (Bloch, 1787)	Emperor Angelfish	+	+	+
Pomacanthus navarchus (Cuvier, 1831)	Bluegirdle Angelfish	+	+	+
Pomacanthus semicircularis (Cuvier, 1831)	Blue Angelfish	+		
Pomacanthus sexstriatus (Cuvier, 1831)	Sixband Angelfish	+	+	+
Pygoplites diacanthus (Boddaert, 1772)	Regal Angelfish	+	+	+
Pomacentridae	**Damselfishes**			
Abudefduf septemfasciatus (Cuvier, 1830)	Banded Sergeant		+	
Abudefduf vaigiensis (Quoy and Gaimard, 1825)	Indo-Pacific Sergeant	+	+, +*	+
Acanthochromis polyacanthus (Bleeker, 1855)	Spiny Puller	+		
Amblyglyphidodon aureus (Cuvier, 1830)	Golden Damsel		+	+
Amblyglyphidodon curacao (Bloch, 1787)	Staghorn Damsel	+	+	+
Amblyglyphidodon leucogaster (Bleeker, 1847)	Whitebelly Damsel	+	+	+
Amphiprion clarkii (Bennett, 1830)	Clark's Anemonefish	+	+	+
Amphiprion melanopus Bleeker, 1852	Blackback Anemonefish	+		
Amphiprion ocellaris Cuvier, 1830	Western Clown Anemonefish		+	
Amphiprion perideraion Bleeker, 1855	Pink Anemonefish	+		
Amphiprion sandracinos Allen, 1972	Orange Anemonefish		+	+
Chromis amboinensis (Bleeker, 1873)	Ambon Puller	+	+	+
Chromis atripectoralis Welander and Schultz, 1951	Blackaxil Chromis	+		
Chromis atripes Fowler and Bean, 1928	Darkfin Puller	+	+	+
Chromis fumea (Tanaka, 1917)	Smoky Puller		+	
Chromis lepidolepis Bleeker, 1877	Scaly Puller	+	+	
Chromis margaritifer Fowler, 1946	Whitetail Puller	+	+	+
Chromis opercularis (Günther, 1867)	Doublebar Chromis		+	+
Chromis ternatensis (Bleeker, 1856)	Swallowtail Puller	+	+	+
Chromis viridis (Cuvier, 1830)	Blue-green Puller	+	+	+
Chromis weberi Fowler and Bean, 1928	Weber's Puller	+	+	+
Chromis xanthochira (Bleeker, 1851)	Yellow-axil Puller	+	+	
Chromis xanthura (Bleeker, 1854)	Pale-tail Puller	+	+	+
Chrysiptera biocellata (Quoy and Gaimard, 1824)	Twospot Demoiselle	+	+, +*	+
Chrysiptera brownriggii (Bennett, 1828)	Surge Demoiselle	+	+, +*	+*
Chrysiptera cyanea (Quoy and Gaimard, 1824)	Blue Demoiselle	+	+, +*	

Chrysiptera glauca (Cuvier, 1830)	Grey Demoiselle		+*	
Chrysiptera hemicyanea (Weber, 1913)	Azure Demoiselle	+	+	+
Chrysiptera rex (Snyder, 1909)	Pink Demoiselle		+	+
Chrysiptera rollandi (Whitley, 1961)	Bluehead Demoiselle	+		
Dascyllus aruanus (Linnaeus, 1758)	Banded Humbug	+	+	+
Dascyllus reticulatus (Richardson, 1846)	Headband Humbug	+	+	+
Dascyllus trimaculatus (Rüppell, 1829)	Threespot Humbug	+	+	+
Dischistodus perspicillatus (Cuvier, 1830)	White Damsel	+	+	+
Dischistodus prospotaenia (Bleeker, 1852)	Honeyhead Damsel	+	+	+
Hemiglyphidodon plagiometapon (Bleeker, 1852)	Lagoon Damsel	+	+	+
Lepidozygus tapeinosoma (Bleeker, 1856)	Fusilier Damsel			+
Neoglyphidodon melas (Cuvier, 1830)	Black Damsel		+	+
Neoglyphidodon nigroris (Cuvier, 1830)	Scarface Damsel		+	
Neopomacentrus azysron (Bleeker, 1877)	Yellowtail Demoiselle	+	+*	
Neopomacentrus cyanomos (Bleeker, 1856)	Regal Demoiselle	+		
Plectroglyphidodon dickii (Liénard, 1839)	Dick's Damsel	+	+	+
Plectroglyphidodon johnstonianus Fowler and Ball, 1924	Johnston Damsel	+	+	
Plectroglyphidodon lacrymatus (Quoy and Gaimard, 1824)	Jewel Damsel	+	+	+
Plectroglyphidodon leucozonus (Bleeker, 1859)	Whiteband Damsel	+		+*
Pomacentrus adelus Allen, 1991	Obscure Damsel	+	+	
Pomacentrus amboinensis Bleeker, 1868	Ambon Damsel		+	+
Pomacentrus auriventris Allen, 1991	Goldbelly Damsel		+	+
Pomacentrus bankanensis Bleeker, 1853	Speckled Damsel	+	+, +*	+
Pomacentrus chrysurus Cuvier, 1830	Whitetail Damsel	+	+	+
Pomacentrus coelestis Jordan and Starks 1901	Neon Damsel	+	+	+
Pomacentrus grammorhynchus Fowler, 1918	Bluespot Damsel	+		
Pomacentrus lepidogenys Fowler and Bean,1928	Scaly Damsel		+	+
Pomacentrus moluccensis Bleeker, 1853	Lemon Damsel	+	+	+
Pomacentrus nigromanus Weber, 1913	Goldback Damsel		+	
Pomacentrus nigromarginatus Allen, 1973	Blackmargin Damsel	+	+	+
Pomacentrus philippinus Evermann and Seale, 1907	Philippine Damsel	+	+	+
Pomacentrus vaiuli Jordan and Seale, 1906	Princess Damsel	+	+	+
Stegastes fasciolatus (Ogilby, 1889)	Pacific Gregory	+	+	+
Stegastes nigricans (Lacépède, 1801)	Dusky Gregory	+	+	+
Cirrhitidae	**Hawkfishes**			
Cirrhitichthys oxycephalus (Bleeker, 1855)	Spotted Hawkfish	+	+	+
Cirrhitus pinnulatus (Bloch & Schneider, 1801)	Whitespotted Hawkfish		+	
Oxycirrhitus typus Bleeker, 1857	Longnose Hawkfish		+	
Paracirrhites arcatus (Cuvier, 1829)	Ringeye Hawkfish	+	+	+

Scientific name	Common name	Mermaid	Scott	Seringapatam
Paracirrhites forsteri (Schneider, 1801)	Freckled Hawkfish	+	+	+
Sphyraenidae	**Pikes**			
Sphyraena barracuda (Walbaum, 1792)	Great Barracuda	+		
Labridae				
Anampses caeruleopunctatus Rüppell, 1829	Diamond Wrasse		+	
Anampses meleagrides Valenciennes, 1840	Speckled Wrasse	+	+	
Anampses twistii Bleeker, 1856	Yellowbreast Wrasse	+	+	+
Bodianus axillaris (Bennett, 1832)	Coral Pigfish	+	+	+
Bodianus diana (Lacépède, 1801)	Diana's Pigfish	+	+	+
Bodianus mesothorax (Bloch and Schneider, 1801)	Eclipse Pigfish	+		+
Cheilinus chlorurus (Bloch, 1791)	Floral Maori Wrasse	+	+	+
Cheilinus fasciatus (Bloch, 1791)	Redbreast Maori Wrasse	+	+	+
Cheilinus trilobatus Lacépède, 1801	Tripletail Maori Wrasse	+	+	+
Cheilinus undulatus Rüppell, 1835	Humphead Maori Wrasse	+	+	+
Cheilio inermis (Forsskål, 1775)	Sharpnose Wrasse		+	
Cirrhilabrus cyanopleura (Bleeker, 1851)	Blueside Wrasse	+	+	
Cirrhilabrus exquisitus Smith, 1957	Exquisite Wrasse		+	+
Cirrhilabrus randalli Allen, 1995	Randall's Wrasse	+	+	+
Conniella apterygia Allen, 1983	Connie's Wrasse	+	+	
Coris aygula Lacépède, 1801	Redblotched Wrasse	+	+	+
Coris caudimacula (Quoy and Gaimard, 1834)	Spot-tail Wrasse		+	+
Coris gaimard (Quoy and Gaimard, 1824)	Clown Wrasse	+	+	+
Coris batuensis (Bleeker, 1857)	Variegated Wrasse		+	+
Cymolutes praetextus (Quoy and Gaimard, 1834)	Knife Wrasse	+		
Epibulus insidiator (Pallas, 1770)	Slingjaw Wrasse	+	+	+
Gomphosus varius Lacépède, 1801	Birdnose Wrasse	+	+	+
Halichoeres biocellatus Schultz, 1960	False-eye Wrasse	+	+	
Halichoeres chrysus Randall, 1981	Golden Wrasse		+	+
Halichoeres hortulanus (Lacépède, 1801)	Checkerboard Wrasse	+	+, +*	+
Halichoeres margaritaceus (Valenciennes, 1839)	Pearly Wrasse		+*	+*
Halichoeres marginatus Rüppell, 1835	Dusky Wrasse	+	+	+
Halichoeres melanurus (Bleeker, 1851)	Hoeven's Wrasse	+	+	+
Halichoeres nebulosus (Valenciennes, 1839)	Cloud Wrasse			+
Halichoeres ornatissimus (Garrett, 1863)	Ornamental Wrasse	+		
Halichoeres prosopeion (Bleeker, 1853)	Twotone Wrasse		+	+
Halichoeres scapularis (Bennett, 1832)	Zigzag Wrasse			+
Halichoeres trimaculatus (Quoy and Gaimard, 1834)	Threespot Wrasse	+	+, +*	+
Hemigymnus fasciatus (Bloch, 1792)	Fiveband Wrasse	+	+	+

Hemigymnus melapterus (Bloch, 1791)	Thicklip Wrasse	+	+	+
Hologymnosus doliatus (Lacépède, 1801)	Pastel Slender Wrasse		+	+
Labrichthys unilineatus (Guichenot, 1847)	Oneline Wrasse	+	+	+
Labroides bicolor Fowler and Bean, 1928	Bicolor Cleanerfish	+	+	+
Labroides dimidiatus (Valenciennes, 1839)	Common Cleanerfish	+	+	+
Labroides pectoralis Randall and Springer, 1975	Breastspot Cleanerfish	+	+	+
Labropsis manabei Schmidt, 1931	Tailblotch Tubelip		+	
Labropsis xanthonota Randall, 1981	Yellowback Tubelip	+	+	+
Macropharyngodon meleagris (Valenciennes, 1839)	Leopard Wrasse	+	+	+
Macropharyngodon negrosensis Herre, 1932	Black Leopard Wrasse	+		
Macropharyngodon ornatus Randall, 1978	Ornate Leopard Wrasse	+	+	
Novaculichthys taeniourus (Lacépède, 1801)	Carpet Wrasse	+	+, +*	
Oxychelinus celebicus (Bleeker, 1853)	Slender Maori Wrasse	+	+	+
Oxycheilinus diagrammus (Lacépède, 1801)	Violetline Maori Wrasse	+	+	+
Oxycheilinus unifasciatus (Streets, 1877)	Ringtail Maori Wrasse	+	+	
Paracheilinus flavianalis Kuiter and Allen, 1999	Yellowfin Flasher Wrasse		+	
Pseudocheilinus evanidus Jordan and Evermann, 1903	Pinstripe Wrasse	+	+	+
Pseudocheilinus hexataenia (Bleeker, 1857)	Sixline Wrasse	+	+	+
Pseudocheilinus octotaenia Jenkins, 1901	Eightline Wrasse	+	+	+
Pseudodax moluccanus (Valenciennes, 1840)	Chiseltooth Wrasse	+	+, +*	+
Pterogogus cryptus Randall, 1981	Cryptic Wrasse		+	+
Stethojulis bandanensis (Bleeker, 1851)	Redspot Wrasse	+	+, +*	+
Stethojulis interrupta (Bleeker, 1851)	Brokenline Wrasse	+	+	
Stethojulis strigiventer (Bennett, 1832)	Silverstreak Wrasse	+	+	+
Thalassoma amblycephalum (Bleeker, 1856)	Bluehead Wrasse	+	+, +*	+
Thalassoma hardwicke (Bennett, 1829)	Sixbar Wrasse	+	+	+
Thalassoma janseni (Bleeker, 1856)	Jansen's Wrasse		+	
Thalassoma lunare (Linnaeus, 1758)	Moon Wrasse	+	+	+
Thalassoma quinquevittatum (Lay and Bennett, 1839)	Red-ribbon Wrasse	+	+	+
Thalassoma trilobatum? (Lacépède, 1801)	Ladder Wrasse			+*
Wetmorella albofasciata Schultz and Marshall, 1954	Doubleline Wrasse		+	
Pinguipedidae	**Grubfishes**			
Parapercis clathrata Ogilby, 1910	Spothead Grubfish		+	+
Parapercis hexophtalma (Cuvier, 1829)	Blacktail Grubfish		+	
Parapercis millepunctata (Günther, 1860)	Thosand-spot Grubfish		+	+
Parapercis multiplicata Randall, 1984	Doublestitch Grubfish	+	+	
Parapercis sp.	Grubfish			+
Trichonotidae	**Sand Divers**			
Trichonotus elegans Shimada and Yoshino, 1984	Elegant Sand Diver			+
Blenniidae	**Blennies**			

Scientific name	Common name	Mermaid	Scott	Seringapatam
Aspidontus dussumieri (Valenciennes, 1836)	Lance Blenny			+
Atrosalarias sp.	Blenny		+*	
Atrosalarias fuscus (Rüppell, 1835)	Dusky Blenny			+
Blenniella periophthalmus (Valenciennes, 1836)	Bluestreaked Rockskipper		+*	+*
Cirripectes sp.	Tidepool Blenny	+	+	
Cirripectes filamentosus (Alleyne & Macleay, 1877)	Filamentous Blenny		+*	
Ecsenius alleni Springer, 1988	Allen's Combtooth Blenny	+	+	+
Ecsenius bicolor (Day, 1888)	Bicolor Combtooth Blenny	+	+	
Ecsenius schroederi McKinney and Springer, 1976	Schroeder's Combtooth Blenny	+	+*	+
Ecsenius sp.	Combtooth Blenny	+		
Meiacanthus atrodorsalis (Günther, 1877)	Eyelash Fangblenny	+	+	+
Meiacanthus grammistes (Valenciennes, 1836)	Linespot Fangblenny	+	+	+
Petroscirtes breviceps (Valenciennes, 1836)	Shorthead Sabretooth Blenny	+		
Plagiotremus rhinorhynchos (Bleeker, 1852)	Bluestriped Fangblenny	+	+	+
Plagiotremus tapeinosoma (Bleeker, 1857)	Piano Fangblenny	+	+	+
Rhabdoblennius sp.	Rockskipper Blenny			+*
Salarias sp.	Blenny	+		
Salarias fasciatus (Bloch, 1786)	Banded Blenny	+	+, +*	
Salarias cf. *patzneri* Bath,1992	Patzner's Blenny		+*	
Salarias sinuosus? Snyder, 1908	Fringelip Blenny		+*	+*
Trypterygiidae	**Triplefins**			
Enneapterygius larsonae Fricke, 1994	Blackhead Threefin		+*	
Enneapterygius nanus? Schultz, 1960	Pygmy Threefin		+*	
Helcogramma chica? Rosenblatt, 1960	Little Hooded Threefin			+*
Callionymidae	**Dragonets**			
Neosynchiropus ocellatus (Pallas, 1770)	Marble Dragonet		+*	
Gobiidae	**Gobies**			
Amblyeleotris guttata (Fowler, 1938)	Blackchest Shrimpgoby		+	
Amblyeleotris steinitzi (Klausewitz, 1974)	Steinitz' Shrimpgoby	+	+	
Amblyeleotris wheeleri (Polunin and Lubbock, 1977)	Burgundy Shrimpgoby	+	+	+
Amblygobius decussatus (Bleeker, 1855)	Crosshatch Goby			+
Amblygobius nocturnus (Herre, 1945)	Pyjama Goby		+	+
Amblygobius rainfordi (Whitley, 1940)	Old Glory Goby	+	+	+
Amblygobius phalaena (Valenciennes, 1837)	Whitebarred Goby	+	+	+
Asterropteryx semipunctatus Rüppell, 1830	Starry Goby		+	
Bryaninops natans Larson, 1985	Purple-eye Goby		+	
Bryaninops sp.?	Sea Whip Goby		+	+
Cabillus sp.	Cabillus Goby		+*	

Fusigobius signipinnis Hoese and Obika, 1988	Flasher Sandgoby	+	+	
Cryptocentrus caeruleomaculatus (Herre, 1933)	Bluespotted Shrimpgoby			+
Cryptocentrus cinctus (Herre, 1936)	Yellow Shrimpgoby		+	
Cryptocentrus fasciatus (Playfair and Günther, 1867)	Y-bar Shrimpgoby			+
Ctenogobiops maculosus (Fourmanoir, 1955)	Silverspot Shrimpgoby	+	+	
Ctenogobiops feroculus Lubbock and Polunin, 1977	Fierce Shrimpgoby			+
Ctenogobiops tangaroai Lubbock and Polunin, 1977	Tangaroa Shrimpgoby		+	
Eviota prasites Jordan and Seale, 1906	Hairfin Eviota			+
Eviota queenslandica Whitley, 1932	Queensland Eviota		+*	+*
Eviota sp.	Eviota		+*	
Fusigobius sp.	Sandgoby		+	+
Gnatholepis sp.	Sandgoby		+*	
Gnatholepis anjerensis (Bleeker, 1851)	Shoulderspot Sandgoby		+	+
Gobiodon okinawae Sawada, Arai and Abe, 1972	Yellow Coralgoby	+	+	+
Gobiodon quinquestrigatus (Valenciennes, 1837)	Fiveline Coralgoby	+		
Gobiodon spilophthalmus Fowler, 1944	Whitelined Coralgoby	+		
Istigobius rigilius (Herre, 1953)	Orangespotted Sandgoby	+	+	+
Lotilia graciliosa Klausewitz, 1960	Whitecap Shrimpgoby		+	
Paragobiodon echinocephalus (Rüppell, 1830)	Redhead Stylophora Goby		+*	
Pleurosicya sp.	Ghostgoby		+	
Priolepis semidoliata (Valenciennes, 1837)	Halfbarred Reefgoby		+*	
Signigobius biocellatus Hoese and Allen, 1977	Crab-eye Goby		+	
Trimma okinawae (Aoyagi, 1949)	Orange-red Pygmygoby		+*	
Valenciennea longipinnis (Lay and Bennett, 1839)	Ocellate Glidergoby		+	
Valenciennea sexguttata (Valenciennes, 1837)	Sixspot Glidergoby		+	
Valenciennea strigata (Broussonet, 1782)	Blueband Glidergoby	+	+	+
Xenisthmidae	**Wrigglers**			
Xenisthmus clarus (Jordan & Seale, 1906)	Clear Wriggler		+*	
Microdesmidae	**Dartfishes**			
Nemateleotris magnifica Fowler, 1938	Red Firegoby	+	+	+
Ptereleotris evides (Jordan and Hubbs, 1925)	Arrow Dartgoby	+	+	+
Ptereleotris heteroptera (Bleeker, 1855)	Tailspot Dartgoby		+	+
Ptereleotris microlepis (Bleeker, 1856)	Greeneye Dartgoby	+		+
Ptereleotris zebra (Fowler, 1938)	Zebra Dartgoby	+	+	
Acanthuridae	**Surgeonfish**			
Acanthurus blochii Valenciennes, 1835	Dark Surgeonfish	+	+	+
Acanthaurus dussumieri Valenciennes, 1835	Pencil Surgeonfish	+	+	
Acanthurus leucosternon Bennett, 1832	Powder-blue Surgeonfish		+	
Acanthurus lineatus (Linnaeus, 1758)	Bluelined Surgeonfish	+	+	+

Scientific name	Common name	Mermaid	Scott	Seringapatam
Acanthurus nigricans (Linnaeus, 1758)	Velvet Surgeonfish	+	+	+
Acanthurus nigricauda Duncker and Mohr, 1929	Eyeline Surgeonfish	+	+	+
Acanthurus nigrofuscus (Forsskål, 1775)	Dusky Surgeonfish		+	+
Acanthurus olivaceus Forster, 1801	Orangeblotch Surgeonfish	+	+	+
Acanthurus pyroferus Kittlitz, 1834	Mimic Surgeonfish	+	+	+
Acanthurus thompsoni (Fowler, 1923)	Night Surgeonfish	+	+	+
Acanthurus triostegus (Linnaeus, 1758)	Convict Surgeonfish	+	+, +*	
Ctenochaetus cyanocheilus Randall and Clements, 2001	Yelloweye Bristletooth		+	+
Ctenochaetus striatus (Quoy and Gaimard, 1825)	Lined Bristletooth	+	+	+
Naso brachycentron (Valenciennes, 1835)	Humpback Unicornfish		+	
Naso brevirostris (Valenciennes, 1835)	Spotted Unicornfish	+	+	+
Naso caesius Randall and Bell, 1992	Silverblotched Unicornfish	+	+	+
Naso hexacanthus (Bleeker, 1855)	Sleek Unicornfish		+	+
Naso lituratus (Forster, 1801)	Clown Unicornfish	+	+	+
Naso thynnoides (Valenciennes, 1829)	Onespine Unicornfish		+	
Naso tuberosus Lacépède, 1801	Humphead Unicornfish	+	+	
Naso unicormis (Forsskål, 1775)	Bluespine Unicornfish	+	+	+
Naso vlamingii (Valenciennes, 1835)	Bignose Unicornfish	+	+	+
Zebrasoma scopas (Cuvier,1829)	Brown Tang	+	+	+
Zebrasoma veliferum (Bloch, 1797)	Sailfin Tang	+	+	+
Zanclidae	**Moorish Idols**			
Zanclus cornutus (Linnaeus, 1758)	Moorish Idol	+	+	+
Siganidae	**RabbifishesRabbitfishes**			
Siganus argenteus (Quoy and Gaimard, 1825)	Forktail Rabbitfish		+	
Siganus corallinus (Valenciennes, 1835)	Coral Rabbitfish	+	+	+
Siganus doliatus Cuvier, 1830	Bluelined Rabbitfish	+	+	
Siganus puellus (Schlegel, 1852)	Masked Rabbitfish	+	+	+
Siganus punctatissimus Fowler and Bean, 1929	Finespotted Rabbitfish		+	+
Siganus punctatus (Schneider, 1801)	Spotted Rabbitfish	+	+	+
Siganus vulpinus (Schlegel and Müller, 1845)	Foxface	+	+	+
Scombridae	**Mackerels**			
Acanthocybium solandri (Cuvier,1831)	Wahoo		+^	
Grammatorcynus bilineatus (Rüppell, 1836)	Scad Mackerel		+	
Gymnosarda unicolor (Rüppell, 1836)	Dogtooth Tuna	+	+	
Thunnus albacares (Bonnaterre, 1788)	Yellowfin Tuna	+^	+^	
Istiophoridae	**Marlins**			
Istiophorus platypterus (Shaw and Nodder, 1792)	Sailfish		+^	
Bothidae	**Lefteye Flounders**			

Bothus mancus Broussonet, 1782	Flowery Flounder			+*
Balistidae	**Triggerfishes**			
Balistapus undulatus (Park ,1797)	Orangestripe Triggerfish	+	+	+
Balistoides conspicillum (Bloch and Schneider, 1801)	Clown Triggerfish		+	
Balistoides viridescens (Bloch and Schneider, 1801)	Titan Triggerfish	+	+	+
Canthidermis maculatus (Bloch, 1786)	Whitespotted Triggerfish		+	
Melichthys niger (Bloch, 1786)	Black Triggerfish	+	+	+
Melichthys vidua (Richardson, 1845)	Pinktail Triggerfish	+	+	
Odonus niger (Rüppell, 1837)	Redtooth Triggerfish		+	+
Pseudobalistes flavimarginatus (Rüppell, 1829)	Yellowmargin Triggerfish	+		
Rhinecanthus aculeatus (Linnaeus, 1758)	Hawaiian Triggerfish	+	+	
Sufflamen bursa (Bloch and Schneider, 1801)	Pallid Triggerfish	+	+	+
Sufflamen chrysopterum (Bloch and Schneider, 1801)	Eye-stripe Triggerfish		+	+
Monacanthidae	**Leatherjackets**			
Aluterus scriptus (Osbeck, 1765)	Scrawled Leatherjacket	+	+	+
Cantherhines pardalis (Rüppell, 1837)	Honeycomb Leatherjacket	+	+	
Paraluteres prionurus (Bleeker, 1851)	Blacksaddle Filefish		+	
Oxymonacanthus longirostris (Bloch and Schneider, 1801)	Harlequin Filefish	+	+	
Ostraciidae	**Boxfishes**			
Ostracion cubicus Linnaeus, 1758	Yellow Boxfish	+	+	
Ostracion meleagris Shaw, 1796	Black Boxfish	+	+	
Tetraodontidae	**Toadfishes**			
Arothron nigropunctatus (Bloch and Schneider, 1801)	Blackspotted Puffer	+	+	+
Arothron stellatus (Bloch and Schneider, 1801)	Starry Puffer	+	+	
Canthigaster valentini (Bleeker, 1851)	Blacksaddle Toby			+
Canthigaster solandri (Richardson, 1844)	Solander's Toby	+	+	+
Diodontidae	**Porcupinefishes**			
Diodon liturosus Shaw, 1804	Blackblotched Porcupinefish		+	
Total number of species per atolls		**293**	387	267
Total number of species over all atolls			**461**	

Guide to Authors

Subject Matter

Original research, reviews and observations in all branches of natural science and human studies will be considered for publication. However, emphasis is placed on studies pertaining to Western Australia and neighbouring regions. Longer papers will be considered for publication as Supplements to the *Records of the Western Australian Museum*. Such publications may attract charges to the authors to offset the costs of printing — authors should consult the editors before submitting large manuscripts. Short communications should not normally exceed three typed pages and this category of paper is intended to accommodate observations, results or new records of *significance*. All material must be original and not have been published elsewhere.

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Authors are advised to follow the layout and style in the most recent issue of the *Records of the Western Australian Museum* including headings, tables, illustrations and references. When in doubt, use a simple format that is easily edited. Please provide line numbers throughout the MS (e.g. in Word go to File » Page Setup » Layout (tab) » Line Numbers (button), add line numbers and click on "continuous" numbering).

The title should be concise, informative and contain key words necessary for retrieval by modern searching techniques. An abridged title (not exceeding 50 character spaces) should be included for use as a running head.

An abstract must be given in full length papers but not short communications, summarizing the scope of the work and principal findings. It should normally not exceed 2% of the paper and be suitable for reprinting in reference periodicals. At the end of the abstract, provide several keywords not already included in the title.

The International System of units should be used. Spelling should follow the *Concise Oxford Dictionary*. Numbers should be spelled out from one to nine in descriptive text; figures used for 10 or more. For associated groups, figures should be used consistently (e.g. "5 to 10", not "five to 10").

Systematic papers must conform with the International Codes of Botanical and Zoological Nomenclature and, as far as possible, with their recommendations.

Synonymies should be given in the short form (taxon, author, date, page) and the full reference cited at the end of the paper. All citations, including those associated with scientific names in taxonomic works, must be included in the references.

Manuscripts

Manuscripts should be submitted electronically as PDF's or Word files to the editors (listed below). For manuscripts with large image files, submission of a CD is acceptable. Manuscripts must be 1.5 or double-spaced throughout. All margins should be at least 25 mm wide. Tables plus headings, and Figure legends should be on separate pages. Tables should be numbered consecutively, have headings which make them understandable without reference to the text, spell out generic names and be referred to in the text.

Figures

Lower resolution images can be inserted into a PDF or Word document for review. Upon acceptance, high resolution (6–10 Mb) images in TIFF or JPEG format can be e-mailed or burned to CD and posted to the editors. We prefer TIFF files for figures. For Adobe Illustrator and Sigmaplot, save in .eps (encapsulated postscript) format; for PowerPoint, save in .wmf (windows metafile format); for Excel, save as Excel 97 worksheet (must contain spreadsheet and embedded chart); and for CorelDraw, save as an .eps file that may be opened by Adobe Illustrator.

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Scale must be indicated on illustrations. Use arrows or other aids to indicate specific features mentioned in the text. All maps, line drawings, photographs and graphs should be numbered in sequence and referred to as "Figure" (no abbreviation) in the text and captions. Each figure should have a brief, fully explanatory caption.

References

In the body of the text, references should be cited as follows:

> McKenzie and colleagues (McKenzie 1999, 2000; McKenzie *et al*. 2000) found that bat frequencies were highest on full moons, contra previous workers (Smith and Jones 1982; Berman 1988; Zucker *et al*. 1992).

For citing taxonomic groups and the author, a comma occurs between them:

> The family Carphodactylidae consists of *Carphodactylus* Smith, 1999, *Nephrurus* Jones, 1999, *Orroya* Couper, Covacevich and Hoskin, 2001, *Phyllurus* Sprong, 1888 and *Saltuarius* Hammond, 1901.

All references must be cited in the text by author and date and all must be listed alphabetically at the end of the paper. The names of journals are to be given in full. Consult a recent edition of the *Records* for style. For taxonomic papers, include full references for all taxonomic groups mentioned in the text. In manuscripts dealing with historical subjects references may be cited as footnotes.

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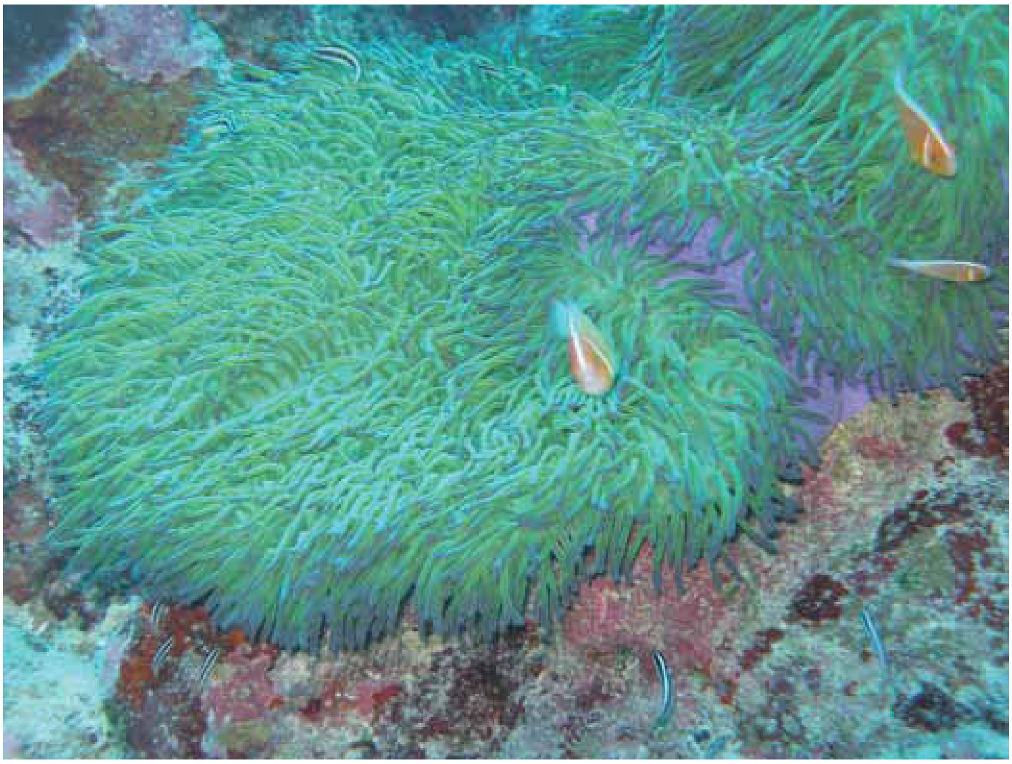
All manuscripts are reviewed by at least two referees whose reports assist the editors in making their decision whether to accept the paper. The review process usually takes from two to three months, although the review process and typesetting for longer manuscripts and supplements are usually longer.

The corresponding author is sent one set of page proofs electronically which must be returned within one week after receipt.

All authors will receive a PDF of their papers and a print copy of the entire issue.

Editors

Manuscripts can be submitted to either Paul Doughty (paul.doughty@museum.wa.gov.au; human studies [anthropology, archaeology or history] and vertebrate animals) or Mark Harvey (mark.harvey@museum.wa.gov.au; invertebrate animals).



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