

HARD CORALS OF THE DARWIN REGION, NORTHERN TERRITORY, AUSTRALIA.

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ABSTRACT

A species list of hard corals recorded in subtidal and reef flat habitats of the Darwin region is presented. This is the first published list of the species of corals from the Darwin area, with a total of 125 scleractinian and non-scleractinian calcareous coral species belonging to 17 families and 47 genera, including one hydrozoan and one octocoral. The Faviidae is the family represented by the highest number of genera and species while relatively high numbers of species from the families Acroporidae and Poritidae are also present in the Darwin region. Similar numbers of species are recorded from the reef flat and the subtidal zone. Fewer species, but similar proportions of all major genera, are recorded from each family in Darwin compared with the east and west coasts of Australia.

KEYWORDS: Corals, Australia, Darwin, Cnidaria, check list.

INTRODUCTION

Darwin Harbour is a relatively shallow tropical estuarine system which is naturally turbid with a high rate of sedimentation and a large diurnal tidal amplitude of 8 m maximum spring tidal range (Michie 1987). The high levels of suspended sediment in Darwin Harbour are derived from wet season runoff, and wind and wave resuspension (Wrigley *et al.* 1990). The major coral beds in this region are sparsely distributed across the extensive intertidal reef flats, to a depth of 10 metres within the Harbour, and to greater depths in subtidal regions outside the Harbour (Hooper 1987). The increasing depth of the distribution of corals is probably related to the increasing depth of the photic zone as water moves through the middle Harbour to the ocean (Wrigley *et al.*

1990). The distribution of deep water hermatypic corals is restricted by the low levels of light penetration through the turbid waters (Hooper 1987). The substratum of habitats in which corals live is composed of dead coral, calcareous sand with clasts of coral rubble, and some terrestrially derived mud (Michie 1987). Very few nearshore reefs have been investigated biologically in north-west Australia (Hooper 1987). The only published estimate of the number of coral species occurring in Darwin Harbour records 30 species of hard corals from Channel Island to Lee Point (Low Choy 1983 in Hooper 1987).

The aim of this study was to prepare a checklist of the hard corals present in Darwin Harbour in preparation for a handbook which will provide full descriptions of the species that occur in the region.

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MATERIALS AND METHODS

The list of species presented in this paper is based on corals collected in subtidal and reef flat habitats in or near Darwin Harbour. The Harbour refers to all sites within Port Darwin, and extends from West Point to Lee Point. Collection sites are listed for each sample in the species list (see Results) and locations of sites are indicated by triangles in Figure 1. Two sites north of the Harbour, North West Vernon Island and the reef off Gunn Point Beach, were also sampled. Subtidal corals were collected during ten dives conducted during the Sixth International Marine Biological Workshop, in Darwin, in July 1993. Dive sites were chosen to sample the full range of coral habitats in the Darwin region, to maximise the number of species collected. The majority of specimens collected on reef flats were sampled during extensive surveys at extreme low tides in November/December 1982. All corals collected were photographed prior to their removal, with the exception of the fungiid *Heliofungia actiniformis*, which was photographed but not collected.

Specimens were identified, using Veron and Pichon (1976, 1980, 1982), Veron 1985, Veron 1986, Veron, *et al.* (1977), Veron and Wallace (1984), Hoeksema (1989), Koh and Chou (1989), Lamberts (1982), Nemenzo (1981) and Veron (1990). Specimens which are apparently a distinct species but are not described in these references are listed as *Porites* sp. 1, *Montipora* sp. 1, *Montipora* sp. 2, *Montipora* sp. 3 and *Acropora* sp. 1. Specimens which were unidentifiable to species are listed using the genus, *e.g.* *Millepora* sp.

All samples are lodged at the Museum and Art Gallery of the Northern Territory (NTM), Darwin (registration numbers prefixed NTM C) or at the Museum of Tropical Queensland (MTQ), Townsville (registration numbers prefixed QM G). Collectors, habitat, and registration details for the specimens are listed in Table 1. Thirty-six specimens are lodged at MTQ with ten specimens being portions of specimens lodged at NTM. For specimens lodged in both museums, both registration numbers are listed in the Results section and the collection details listed in Table 1, corresponding to the NTM registration number.

RESULTS

As a result of the field surveys of the hard corals of the Darwin region, we found 123 species from 45 genera and 15 families of scleractinian corals, one hydrozoan, *Millepora* sp. and the octocoral *Tubipora musica*. This record includes all common species and many less common species, although it is unlikely that the list is exhaustive because some rarer species may have been overlooked or not present at the sites surveyed. The full species list, including museum registration numbers of each specimen and collection sites is given below.

DESCRIPTION OF CORAL HABITATS IN THE DARWIN REGION

The intertidal and subtidal substrata around Darwin on which corals are living mainly consist of rocks, unconsolidated and consolidated rubble, sand and mud. The intertidal reef flats are a mixture of low profile, silty, aggregations or rock and coral rubble, and elevated rock platforms with pools and lagoons that never dry. Dudley Point was the most extensively surveyed intertidal region. The coral cover here is noticeably richer on the outer parts of the reef and in the shallow channel between the reef and the headland. The dry areas are dominated by large *Symphyllia* heads and numerous faviids. Although some colonies of *Acropora* are often exposed, most occur in the rock pools and the channel, as do corals of many other genera such as *Porites*, *Goniopora* and *Turbinaria*. The latter is most common in the areas that are only uncovered at the lowest tides, on the reef margins and the channel entrance.

The substratum at the dive sites within the Harbour carried the highest sediment loads and had less rubble or other solid substratum. Large colonies of *Symphyllia* and medium to large colonies of faviids were the dominant coral types at the dive sites within the Harbour, except at Weed Reef where corals were sparse and the substratum very silty. From East Point to Lee Point, the water was somewhat clearer and the substratum less muddy, compared with more southerly study sites within the Harbour. Large colonies of *Porites*, *Symphyllia* and *Galaxea* (to 4 m diameter) were seen at the dive sites at Lee

Hard corals of the Darwin region

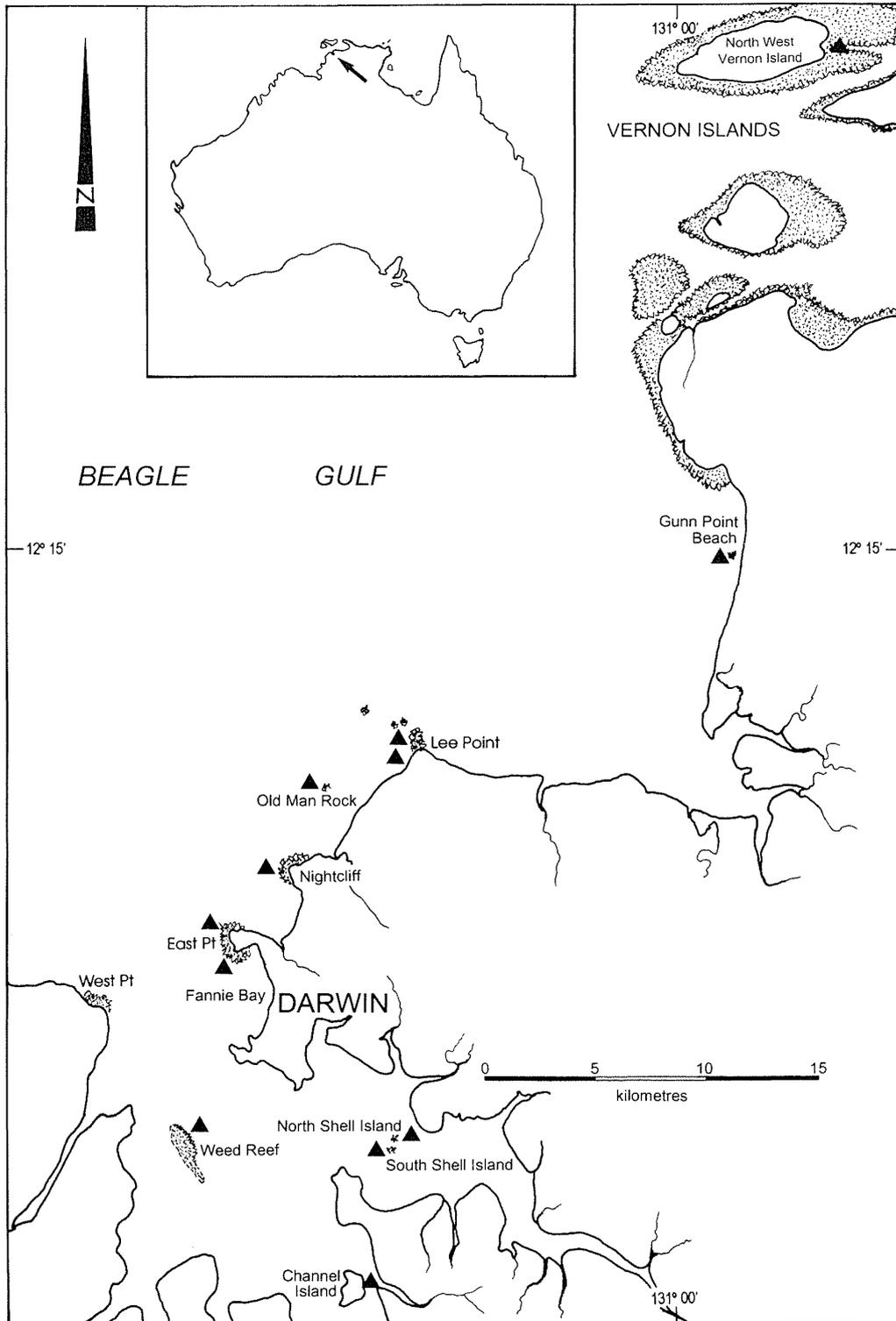


Fig. 1. Collection sites.

Table 1: Registration details of specimens recorded in this paper.

Registration number	Habitat	Collectors ¹	Identification ¹
NTM C3084-3085	Subtidal	PA	PA
NTM C5409	Reef flat	PA	PA
NTM C5423-5424			
NTM C6000-6071	Reef flat	PA, ZD, PH	ZD
NTM C6073-6183			
NTM C6244-6252			
NTM C6948-6949			
NTM C6072	Subtidal	PA	ZD
NTM C6945	Subtidal	PA	BH
NTM C7795-7808	Subtidal	JW	JW
NTM C7819-7959			
NTM C7809	Reef Flat	PA, SH	JW
NTM C7811			
NTM C7814-7817			
NTM C11973	Reef Flat	PA	PA
QM G specimens	Subtidal	JW	JW

¹ PA: P. Alderslade, ZD: Z. Dinesen, BH: B. Hoeksema, PH: P. Homer, SH: S. Homer, JW: J. Wolstenholme.

Point, Old Man Rock and Nightcliff. The highest diversity of coral species for Darwin Harbour appeared to be at the latter two sites, with smaller colonies of most other families being present between the large colonies. East Point differed from all other dive sites in having less suspended sediment in the water column and less sediment coating the substratum. No large colonies were present at East Point, with *Turbinaria* being the most common genus growing amongst many colonies of the sea whip *Junceella fragilis*. Arborescent and corymbose species of *Acropora* were the most common corals at the North West Vernon Island site. This site was also silty, with the substratum consisting largely of rubble of *Acropora* branches coated in a film of sediment.

DISTRIBUTION

Table 2 is compiled from two independent collections of the intertidal and subtidal zones. The presence of all species seen was recorded for each zone. Colonies of *Symphyllia* in the subtidal zone and possibly some rarer species in both zones may have been undersampled due to time constraints. Further surveys may show that some rarer species only recorded in one zone may occur in both environments.

Hard corals were found to be present across the reef flats and to a depth of 8 m (low water neap). A slightly greater number of species was

recorded subtidally (87 species) than intertidally (79 species) (Table 2). The genus contributing most to these differences is *Montipora*, with two species occurring in the intertidal zone and an additional eight species occurring subtidally. A total of 53 species was recorded intertidally and subtidally. Species from most families were recorded in both zones. However, the families Milleporidae (*Millepora* sp.), Astrocoeniidae (*Stylocoeniella guentheri*) and Agariciidae (*Pachyseris speciosa*) were only found in the intertidal zone and were only represented by one species each. These species may also be present subtidally but were either absent or rare at the sites surveyed in this project.

SPECIES LIST

Class Hydrozoa Order Milleporina Family Milleporidae

Millepora sp.
NTM C11973 (Dudley Pt).

Class Anthozoa Order Alcyonacea Family Tubiporidae

Tubipora musica Linnaeus, 1758
NTM C5409, NTM C5423, NTM C5424 (Lee Pt); NTM C7805 (Channel I.).

Hard corals of the Darwin region

Table 2. The species recorded from the reef flat and subtidal environments.

	Intertidal	Subtidal		Intertidal	Subtidal
CLASS Hydrozoa			<i>Montastrea curta</i>		*
ORDER Milleporina			<i>Montastrea annuligera</i>		*
Family Milleporidae			<i>Montastrea valenciennesi</i>	*	*
<i>Millepora</i> sp.	*		<i>Plesiastrea versipora</i>	*	
CLASS Anthozoa			<i>Leptastrea purpurea</i>	*	
ORDER Stolonifera			<i>Leptastrea transversa</i>		*
Family Tubiporidae			<i>Cyphastrea serailia</i>		*
<i>Tubipora musica</i>	*	*	<i>Cyphastrea chalcidicum</i>	*	
			<i>Cyphastrea microphthalma</i>	*	*
			<i>Moseleya latistellata</i>	*	*
ORDER Scleractinia			Family Agariciidae		
Family Thamnasteriidae			<i>Pachyseris speciosa</i>	*	
<i>Psammocora contigua</i>	*	*			
<i>Psammocora superficialis</i>		*	Family Siderastreidae		
<i>Psammocora profundacella</i>	*	*	<i>Pseudosiderastrea tayamai</i>	*	*
Family Astrocoeniidae			<i>Coscinaraea columna</i>		*
<i>Stylocoeniella guentheri</i>	*		Family Fungiidae		
Family Pocilloporidae			<i>Heliofungia actiniformis</i>		*
<i>Stylophora pistillata</i>	*		<i>Fungia fungites</i>	*	*
<i>Pocillopora damicornis</i>	*	*	<i>Herpolitha limax</i>	*	*
			<i>Polyphyllia talpina</i>	*	*
Family Faviidae			<i>Lithophyllon undulatum</i>	*	*
<i>Favia stelligera</i>	*		<i>Podabacia crustacea</i>	*	*
<i>Favia fava</i>	*	*			
<i>Favia pallida</i>	*	*	Family Oculinidae		
<i>Favia speciosa</i>	*	*	<i>Galaxea astreata</i>		*
<i>Favia matthaii</i>	*		<i>Galaxea fascicularis</i>	*	*
<i>Favia maritima</i>		*	<i>Archohelia rediviva</i>	*	*
<i>Barabattoia amicornum</i>	*	*			
<i>Favites chinensis</i>		*	Family Merulinidae		
<i>Favites abdita</i>	*	*	<i>Merulina ampliata</i>	*	*
<i>Favites halicora</i>		*			
<i>Favites flexuosa</i>	*	*	Family Mussidae		
<i>Favites complanata</i>	*		<i>Cynarina lacrymalis</i>		*
<i>Favites pentagona</i>	*	*	<i>Acanthastrea echinata</i>	*	*
<i>Goniastrea retiformis</i>	*		<i>Acanthastrea hillae</i>		*
<i>Goniastrea aspera</i>	*	*	<i>Lobophyllia hemprichii</i>	*	*
<i>Goniastrea pectinata</i>	*	*	<i>Symphyllia recta</i>	*	*
<i>Platygyra daedalea</i>	*	*	<i>Symphyllia radians</i>	*	
<i>Platygyra lamellina</i>		*	<i>Symphyllia agaricia</i>	*	
<i>Platygyra sinensis</i>	*	*			
<i>Platygyra verweyi</i>	*		Family Pectiniidae		
<i>Leptoria phrygia</i>	*		<i>Echinophyllia aspera</i>	*	*
<i>Hydnophora exesa</i>	*	*	<i>Oxypora lacera</i>	*	

Table 2 (continued). The species recorded from the reef flat and subtidal environments

	Intertidal	Subtidal		Intertidal	Subtidal
Family Pectiniidae (cont.)			Family Caryophylliidae (cont)		
<i>Mycedium elephantotus</i>	*	*	<i>Alveopora verrilliana</i>	*	
<i>Pectinia paeonia</i>	*	*	<i>Alveopora spongiosa</i>	*	
Family Caryophylliidae			Family Acroporidae		
<i>Euphyllia glabrescens</i>	*	*	<i>Montipora hoffmeisteri</i>		*
<i>Euphyllia paraancora</i>	*	*	<i>Montipora mollis</i>	*	
Family Dendrophylliidae			<i>Montipora turtlensis</i>	*	
<i>Turbinaria peltata</i>	*	*	<i>Montipora spongodes</i>		*
<i>Turbinaria patula</i>		*	<i>Montipora spumosa</i>		*
<i>Turbinaria mesenterina</i>	*	*	<i>Montipora grisea</i>		*
<i>Turbinaria reniformis</i>		*	<i>Montipora stellata</i>		*
<i>Turbinaria stellulata</i>	*	*	<i>Montipora aequituberculata</i>		*
<i>Turbinaria cf. bifrons</i>		*	<i>Montipora sp. 1</i>		*
<i>Turbinaria cf. conspicua</i>	*		<i>Montipora sp. 2</i>		*
<i>Duncanopsammia axifuga</i>	*	*	<i>Montipora sp. 3</i>		*
Family Poritidae			<i>Acropora brueggemanni</i>	*	*
<i>Porites lobata</i>	*	*	<i>Acropora digitifera</i>	*	*
<i>Porites australiensis</i>	*	*	<i>Acropora robusta</i>	*	*
<i>Porites mayeri</i>		*	<i>Acropora nobilis</i>		*
<i>Porites cylindrica</i>	*	*	<i>Acropora cf. formosa</i>	*	*
<i>Porites annae</i>	*		<i>Acropora millepora</i>	*	*
<i>Porites sp. 1</i>	*	*	<i>Acropora tenuis</i>		*
<i>Goniopora lobata</i>		*	<i>Acropora donei</i>		*
<i>Goniopora somaliensis</i>	*	*	<i>Acropora nasuta</i>	*	
<i>Goniopora minor</i>	*		<i>Acropora valida</i>		*
<i>Goniopora palmensis</i>	*	*	<i>Acropora solitaryensis</i>	*	
<i>Goniopora stutchburyi</i>	*	*	<i>Acropora cf. wallaceae</i>	*	*
<i>Goniopora cf. calicularis</i>		*	<i>Acropora sp. 1</i>	*	*
			<i>Astreopora cucullata</i>		*

Order Scleractinia
Family Thamnasteriidae

Psammocora contigua (Esper, 1797)
NTM C6158 (Dudley Pt); NTM C7803 (Channel I.); NTM C7804 (NW Vernon I.); NTM C7811/QM G48138 (Gunn Pt).

Psammocora superficialis Gardiner, 1898
NTM C7822 (Old Man Rock), NTM C7823 (East Pt).

Psammocora profundacella Gardiner, 1898
NTM C6041 (Dudley Pt); NTM C7824 (South Shell I.).

Family Astrocoeniidae

Stylocoeniella guentheri Bassett-Smith, 1890
NTM C6153 (Dudley Pt).

Family Pocilloporidae

Pocillopora damicornis Linnaeus, 1758
NTM C7961 (Dudley Pt).

Stylophora pistillata Esper, 1797
NTM C7819 (Nightcliff); NTM C7820 (NW Vernon I.); NTM C7821 (South Shell I.); NTM C7960 (Dudley Pt).

Family Faviidae

Favia stelligera (Dana, 1846)
NTM C6096 (Dudley Pt).

Favia fava (Forskål, 1775)
NTM C6053, NTM C6059 (Vesteys Beach);
NTM C6104, NTM C6105, NTM C6112, NTM C6114 (Dudley Pt); NTM C7904 (Channel I.).

- Favia pallida* (Dana, 1846)**
NTM C6009, NTM C6013, NTM C6014, NTM C6113 (Dudley Pt); NTM C7902 (Nightcliff).
- Favia speciosa* (Dana, 1846)**
NTM C6017, NTM C6050, NTM C6101, NTM C6102, NTM C6103 (Dudley Pt); NTM C7903 (Channel I.).
- Favia matthaii* Vaughan, 1918**
NTM C6015 (Dudley Pt).
- Favia maritima* (Nemenzo, 1971)**
NTM C7905 (Lee Pt).
- Barabattoia amicorum* (Edwards and Haime, 1850)**
NTM C6111 (Dudley Pt), NTM C7906 (NW Vernon Is), NTM C7907 (Weed Reef)
- Favites chinensis* (Verrill, 1866)**
NTM C7911 (Channel I.).
- Favites abdita* (Ellis and Solander, 1786)**
NTM C6057 (Vesteys Beach).
- Favites halicora* (Ehrenberg, 1834)**
NTM C7908 (East Pt).
- Favites flexuosa* (Dana, 1846)**
NTM C6012, NTM C6016 (Dudley Pt); NTM C7909 (Old Man Rock); NTM C7910 (Weed Reef).
- Favites complanata* (Ehrenberg, 1834)**
NTM C6130 (Dudley Pt).
- Favites pentagona* (Esper, 1794)**
NTM C6007, NTM C6027, NTM C6033, NTM C6035, NTM C6080, NTM C6081, NTM C6089, NTM C6095, NTM C6122, NTM C6123, NTM C6124 (Dudley Pt); NTM C7912 (Old Man Rock); NTM C7913 (Lee Pt); NTM C7914 (East Pt).
- Favites* sp.**
NTM C6004, NTM C6028 (Dudley Pt).
- Goniastrea retiformis* (Lamarck, 1816)**
NTM C6018, NTM C6127, NTM C6128, NTM C6129 (Dudley Pt).
- Goniastrea aspera* (Verrill, 1865)**
NTM C6131, NTM C6132, NTM C6133, NTM C6134, NTM C6136 (Dudley Pt); NTM C7915 (North Shell Is); NTM C7916 (Channel I.).
- Goniastrea pectinata* (Ehrenberg, 1834)**
NTM C6119, NTM C6120, NTM C6121 (Dudley Pt); NTM C7917 (Nightcliff).
- Goniastrea* sp.**
NTM C7918 (Old Man Rock).
- Platygyra daedalea* (Ellis and Solander, 1786)**
NTM C6038, NTM C6135, NTM C6137, NTM C6138, NTM C6139, NTM C6140, NTM C6141, NTM C6142, NTM C6143, NTM C6144, NTM C6145 (Dudley Pt); NTM C7919, NTM C7920, NTM C7921 (Channel I.); NTM C7922 (Weed Reef); NTM C7923 (South Shell I.).
- Platygyra* c.f. *daedalea* (Ellis and Solander, 1786)**
NTM C7924 (Channel I.).
- Platygyra lamellina* (Ehrenberg, 1834)**
NTM C79225 (Lee Pt).
- Platygyra sinensis* (Edwards and Haime, 1849a)**
NTM C6005, NTM C6024, NTM C6075, NTM C6076, NTM C6077 (Dudley Pt); NTM C7926 (North Shell I.); NTM C7927 (Channel I.).
- Platygyra verweyi* Wijsman-Best, 1976**
NTM C6092, NTM C6094 (Dudley Pt).
- Leptoria phrygia* (Ellis and Solander, 1786)**
NTM C6047, NTM C6090 (Dudley Pt).
- Hydnophora exesa* (Pallas, 1766)**
NTM C6088, NTM C6093 (Dudley Pt); NTM C7898 (Lee Pt); NTM C7899 (East Pt); NTM C7900 (Nightcliff).
- Montastrea curta* (Dana, 1846)**
NTM C7928 (Lee Pt).
- Montastrea annuligera* (Edwards and Haime, 1849a)**
NTM C7929 (Old Man Rock).
- Montastrea valenciennesi* (Edwards and Haime, 1848a)**
NTM C6040, NTM C6100 (Dudley Pt); NTM C7930 (Old Man Rock); NTM C7931 (East Pt); NTM C7932 (Nightcliff).
- Plesiastrea versipora* (Lamarck, 1816)**
NTM C6049, NTM C6073, NTM C6074 (Dudley Pt).
- Leptastrea purpurea* (Dana, 1846)**
NTM C6021, NTM C6037, NTM C6082, NTM C6083 (Dudley Pt).
- Leptastrea transversa* Klunzinger, 1879**
NTM C7933 (NW Vernon I.).

***Cyphastrea serailia* (Forskål, 1775)**

NTM C7934 (Old Man Rock); NTM C7935,
NTM C7936 (East Pt).

***Cyphastrea chalcidicum* (Forskål, 1775).**

NTM C6025, NTM C6043, NTM C6098
(Dudley Pt).

***Cyphastrea microphthalma* (Lamarck, 1816)**

NTM C6086, NTM C6087, NTM C6091
(Dudley Pt); NTM C7937 (Old Man Rock).

***Moseleya latistellata* Quelch, 1884**

NTM C6072 (NW Vernon I.); NTM C6107, NTM
C6108 (Dudley Pt); NTM C7938 (Channel I.).

Family Agariciidae

***Pachyseris speciosa* (Dana, 1846)**

NTM C6036 (Dudley Pt).

Family Siderastreidae

***Pseudosiderastrea tayamai* Yabe and
Sugiyama, 1935**

NTM C6058 (Vesteys Beach); NTM C6151
(Dudley Pt); NTM C7866 (Weed Reef).

***Coscinaraea columna* (Dana, 1846)**

NTM C7867 (Lee Pt); NTM C7868 (Nightcliff).

Family Fungiidae

***Heliofungia actiniformis* (Quoy and Gaimard,
1833)**

NTM C6945 (NW Vernon I.).

***Fungia fungites* (Linnaeus, 1758)**

NTM C6948 (Vesteys Beach); NTM C6949
(Dudley Pt); NTM C7869, NTM C7870, NTM
C7872, NTM C7873 (NW Vernon I.), NTM
C7871 (South Shell I.).

***Herpolitha limax* (Esper, 1797)**

NTM C6154 (Dudley Pt); NTM C7874 (North
Shell I.).

***Polyphyllia talpina* (Lamarck, 1801)**

NTM C6160 (Dudley Pt); NTM C7875 (Lee
Pt); NTM C7876 (NW Vernon I.).

***Lithophyllon undulatum* Rehberg, 1892**

NTM C6045 (Dudley Pt); NTM C7877
(Nightcliff); NTM C7878, NTM C7879 (Weed
Reef).

***Podabacia crustacea* (Pallas, 1766)**

NTM C6156 (Dudley Pt); NTM C7816 (Gunn
Pt); NTM C7880 (Old Man Rock); NTM C7881
(Weed Reef).

Family Oculinidae

***Galaxea astreata* (Lamarck, 1816)**

NTM C7796 (Nightcliff).

***Galaxea c.f. astreata* (Lamarck, 1816)**

NTM C6078, NTM C6079 (Dudley Pt); NTM
C7801 (Old Man Rock).

***Galaxea fascicularis* (Linnaeus, 1767)**

NTM C6084, NTM C6085 (Dudley Pt); NTM
C7798 (Weed Reef)

***Galaxea c.f. fascicularis* (Linnaeus, 1767).**

NTM C7799 (Weed Reef), NTM C7800 (Old
Man Rock).

***Archohelia rediviva* Wells and Alderslade,
1979**

NTM C3084 (South Shell I.); NTM C7802 (East Pt).

Family Merulinidae

***Merulina ampliata* (Ellis and Solander, 1786)**

NTM C6106 (Dudley Pt); NTM C7901
(Nightcliff).

Family Mussidae

***Cynarina lacrymalis* (Edwards and Haime,
1848c)**

NTM C7806 (North Shell I.); NTM C7807,
NTM C7808 (Weed Reef).

***Acanthastrea echinata* (Dana, 1846)**

NTM C6097, NTM C6099 (Dudley Pt); NTM
C7891 (Old Man Rock).

***Acanthastrea hillae* Wells, 1955**

NTM C7892 (Old Man Rock); NTM C7893
(Lee Pt).

***Acanthastrea* sp.**

NTM C7894 (Lee Pt).

***Lobophyllia hemprichii* (Ehrenberg, 1834)**

NTM C6110, NTM C6115, NTM C6116, NTM
C6117 (Dudley Pt); NTM C7895 (Channel I.);
NTM C7896 (Weed Reef).

***Symphyllia recta* (Dana, 1846)**

NTM C6003, NTM C6118 (Dudley Pt); NTM
C7897 (Lee Pt).

***Symphyllia radians* Edwards and Haime,
1849b**

NTM C6109 (Dudley Pt).

***Symphyllia agaricia* Edwards and Haime,
1849b**

NTM C6055 (Vesteys Beach).

Family Pectiniidae

Echinophyllia aspera (Ellis and Solander, 1786)

NTM C6175, NTM C6176, NTM C6177, NTM C6178 (Dudley Pt); NTM C7882, NTM C7884 (Nightcliff); NTM C7883 (South Shell I.).

Oxypora lacera (Verrill, 1864)

NTM C6048 (Dudley Pt).

Mycedium elephantotus (Pallas, 1766)

NTM C6173, NTM C6174 (Dudley Pt); NTM C7885 (North Shell I.); NTM C7886, NTM C7888 (Nightcliff); NTM C7887 (South Shell I.).

Pectinia paeonia (Dana, 1846)

NTM C6031 (Dudley Pt); NTM C7889 (Weed Reef); NTM C7890 (NW Vernon I.).

Family Caryophylliidae

Euphyllia glabrescens (Chamisso and Eysenhardt, 1821)

NTM C6183 (Dudley Pt); NTM C7939 (Lee Pt); NTM C7940 (South Shell I.).

Euphyllia paraancora Veron, 1990

NTM C3085 (NW Vernon I.); NTM C6152, NTM C6182 (Dudley Pt); NTM C7941 (Lee Pt); NTM C7942 (Nightcliff).

Family Dendrophylliidae

Turbinaria peltata (Esper, 1794)

NTM C6171, NTM C6172 (Dudley Pt); NTM C7943 (Lee Pt).

Turbinaria patula (Dana, 1846)

NTM C7944 (Lee Pt); NTM C7945 (Old Man Rock).

Turbinaria mesenterina (Lamarck, 1816)

NTM C6006, NTM C6052 (Dudley Pt); NTM C7946 (South Shell I.); NTM C7947, NTM C7948 (Old Man Rock).

Turbinaria reniformis Bernard, 1896

NTM C7949 (North Shell I.).

Turbinaria stellulata (Lamarck, 1816)

NTM C6044 (Dudley Pt), NTM C7797 (Lee Pt).

Turbinaria c.f. *bifrons* Bruggemann, 1877

NTM C7795 (Nightcliff).

Turbinaria c.f. *conspicua* Bernard, 1896

NTM C6026 (Dudley Pt).

Turbinaria sp.

NTM C6179, NTM C6180 (Dudley Pt).

Duncanopsammia axifuga (Edwards and Haime, 1848b)

NTM C6159 (Dudley Pt); NTM C7951 (East Pt).

Family Poritidae

Porites lobata Dana, 1846

NTM C6030, NTM C6051, NTM C6148 (Dudley Pt); NTM C7839 (East Pt); NTM C7840 (North Shell I.).

Porites australiensis Vaughan, 1918

NTM C6008 (Dudley Pt); NTM C7841, NTM C7842 (Old Man Rock); NTM C7843 (Nightcliff).

Porites mayeri Vaughan, 1918

NTM C7844 (Channel I.); NTM C7845 (Old Man Rock).

Porites cylindrica Dana, 1846

NTM C6010, NTM C6019 (Dudley Pt); NTM C7846 (NW Vernon I.); NTM C7847 (North Shell I.).

Porites annae Crossland, 1952

NTM C6149, NTM C6150, NTM C6155 (Dudley Pt).

Porites sp. 1

NTM C6000, NTM C6054, NTM C6146, NTM C6147 (Dudley Pt); NTM C7848, NTM C7850 (Nightcliff); NTM C7849 (NW Vernon I.).

Goniopora lobata Edwards and Haime, 1860

NTM C7851, NTM C7853, NTM C7854 (Lee Pt); NTM C7852, NTM C7855, NTM C7856 (Channel I.); NTM C7857 (North Shell I.); NTM C7858 (Weed Reef).

Goniopora somaliensis Vaughan, 1907

NTM C6066, NTM C6067 (Dudley Pt); NTM C7859 (East Pt).

Goniopora minor Crossland, 1952

NTM C6065, NTM C6069 (Dudley Pt).

Goniopora palmensis Veron and Pichon, 1982

NTM C6002, NTM C6060, NTM C6064 (Dudley Pt); NTM C7860 (Weed Reef).

Goniopora stutchburyi Wells, 1955

NTM C6056, NTM C6157 (Vesteys Beach); NTM C7861 (East Pt); NTM C7862 (North Shell I.).

Goniopora c.f. *calicularis* (Lamarck, 1816)

NTM C7863 (Nightcliff).

Alveopora verrilliana Dana, 1872

NTM C6042, NTM C6063 (Dudley Pt).

***Alveopora spongiosa* Dana, 1846**

NTM C6039, NTM C6068 (Dudley Pt).

***Alveopora* sp.**

NTM C7864 (Old Man Rock); NTM C7865 (Weed Reef).

Family Acroporidae

***Montipora hoffmeisteri* Wells, 1954**

NTM C7825 (Lee Pt).

***Montipora mollis* Bernard, 1897**

NTM C6001, NTM C6011, NTM C6020, NTM C6022, NTM C6029, NTM C6046, NTM C6070, NTM C6125, NTM C6126 (Dudley Pt).

***Montipora turtlensis* Veron and Wallace, 1984**

NTM C6034 (Dudley Pt).

***Montipora spongodes* Bernard, 1897**

NTM C7826 (North Shell I.).

***Montipora spumosa* (Lamarck, 1816)**

NTM C7827 (Nightcliff); NTM C7828 (NW Vernon I.).

***Montipora grisea* Bernard, 1897**

NTM C7829 (Old Man Rock); NTM C7830 (East Pt).

***Montipora stellata* Bernard, 1897**

NTM C7831 (NW Vernon I.).

***Montipora aequituberculata* Bernard, 1897**

NTM C7817 (Gunn Pt); NTM C7832 (NW Vernon I.).

***Montipora* sp. 1**

NTM C7833 (Weed Reef).

***Montipora* sp. 2**

NTM C7834, NTM C7836 (North Shell I.); NTM C7835 (Old Man Rock)

***Montipora* sp. 3**

NTM C7837 (Lee Pt).

***Acropora brueggemanni* (Brook, 1893)**

NTM C6164, NTM C6165, NTM C6166, NTM C6246/QM G48118 (Dudley Pt); QM G46240 (NW Vernon I.); QM G48119 (Channel I.).

***Acropora digitifera* (Dana, 1846)**

NTM C6170 (Dudley Pt); NTM C7950/QM G48120 (NW Vernon I.).

***Acropora robusta* (Dana, 1846)**

NTM C6250 (Dudley Pt); QM G48101 (Nightcliff).

***Acropora nobilis* (Dana, 1846)**

NTM C6251 (Dudley Pt); NTM C7952, QM G48108, QM G48109 (NW Vernon I.); QM G48105, QM G48106 (Nightcliff); QM G48107 (Channel I.); QM G48110 (South Shell I.).

***Acropora* c.f. *formosa* (Dana, 1846)**

NTM C7815(Gunn Pt); QM G48102 (Weed Reef); QM G48103 (North Shell Is); QM G48104 (Nightcliff).

***Acropora millepora* (Ehrenberg, 1834)**

NTM C6169, NTM C6245 (Dudley Pt); NTM C7953, QM G48128 (NW Vernon I.)

***Acropora* c.f. *millepora* (Ehrenberg, 1834)**

NTM C7954/QM G48124 (NW Vernon I.).

***Acropora tenuis* (Dana, 1846)**

NTM C7955/QM G48127 (NW Vernon I.)

***Acropora donei* Veron and Wallace, 1984**

NTM C7956(NW Vernon Is); QM G48129 (Nightcliff).

***Acropora* c.f. *donei* Veron and Wallace, 1984**

NTM C7957/QM G48130 (South Shell I.); NTM C7958/QM G48126 (NW Vernon I.).

***Acropora nasuta* (Dana, 1846).**

NTM C6244 (Dudley Pt).

***Acropora valida* (Dana, 1846)**

NTM C7959, QM G48125 (NW Vernon I.)

***Acropora solitaryensis* Veron and Wallace, 1984**

NTM C7809/QM G48137 (West Pt).

***Acropora* c.f. *wallaceae* Veron, 1990**

NTM C6161, NTM C6162/QM G48117, NTM C6163 (Dudley Pt); QM G48111, QM G48112, QM G48113 (South Shell I.); QM G48114, QM G48115 (Nightcliff); QM G48116 (Channel I.).

***Acropora* sp. 1**

NTM C6167, NTM C6168, NTM C6248, NTM C6249 (Dudley Pt); NTM C7814/QM G48136(Gunn Pt); QM G48131, QM G48132 (Nightcliff); QM G48133 (NW Vernon I.); QM G48134 (Weed Reef).

***Acropora* c.f. sp. 1**

NTM C6252 (Dudley Pt).

***Acropora* sp.**

NTM C6247/QM G48135 (Dudley Pt).

***Astreopora cucullata* Lamberts, 1980**

NTM C7838 (Lee Pt).

DISCUSSION

A total of 123 species from 45 genera and 15 families of scleractinian corals is recorded from Darwin Harbour and nearby areas. One hydrozoan species, *Millepora* sp., and the octocoral *Tubipora musica* were also recorded. All except four species were recorded within the Harbour. These four species *Leptastrea transversa*, *Montipora aequituberculata*, *Acropora tenuis* and *Acropora valida* were only recorded from Gunn Point or North West Vernon Island. Although there are no extensive reef systems developed in the areas explored during this study, there is a high species diversity with significantly more species recorded than the previous estimate of 30 species of hard corals from Channel Island to Lee Point.

Distribution: intertidal vs subtidal. Hard corals were found to occur across the reef flats and to a depth of 8 m, which is consistent with (previous work by) Hooper (1987) who reported that the distribution of corals of the Darwin region is between 2 to 10 m depth. In this survey, a slightly greater number of species were found subtidally (87 species) compared with the reef flats (79 species) (Table 2). Intertidal surveys, were conducted during low spring tides and thus included samples from the interface of the intertidal and subtidal zones. This may explain the higher proportion of species recorded intertidally.

Distribution: a comparison with the east and west Australian coasts. The numbers of genera and species in each family of hard corals recorded from the Darwin region, are compared to the same families for the east and west coasts of Australia in Table 3. Records from the east Australian coast include collections from the Great Barrier Reef south to the Solitary Islands on the coast, as well as Chesterfield Atoll, Elizabeth and Middleton Reefs, and Lord Howe Island, (see Veron and Wallace 1984). Records from the West Australian coast include collections from the Kimberley coast to Recherche Archipelago, as well as Ashmore Reef, Cartier Island, Seringapatam Reef, Scott Reef, and Rowley Shoals (Veron and Marsh 1988).

Species from all scleractinian families described from the east and west coasts of Australia (Veron and Pichon 1976; Veron and Pichon 1980; Veron and Pichon 1982; Veron *et al.* 1977; Veron and Wallace 1984 and Veron

and Marsh 1988) are found in Darwin, with the exception of the monospecific family Trachyphylliidae. In terms of number of species and genera, the largest family in the Darwin region, is the Faviidae, consisting of 32 species from 12 genera (Table 3). The Faviidae also has the largest number of genera on the east and the west coasts of Australia (17 genera). The largest number of species on the east and west coasts however, occurs within the Acroporidae with 117 species on the east coast and 101 species on the west. Although the number of species is relatively high, substantially fewer species of Acroporidae, were recorded from the Darwin region compared with the records for the east and west Australian coasts. This is probably due to the turbid conditions of the Darwin region, which are not preferred by many species of *Acropora*.

The Poritidae is represented by relatively high numbers of species (35 species on the east coast, 14 species around Darwin and 36 species from the west coast) from a small number of genera (four genera from east Australia and three genera from Darwin and the west coast) in all three regions. The numbers of Fungiidae around Darwin contrast with those recorded for the east and west coasts, the most notable difference being that there was only one species of *Fungia* found compared with 15 species recorded on the east coast of Australia and 12 species on the west coast (Table 3). A second species of *Fungia* (*F. repanda*) has also been recorded from Darwin (B. Hoeksema, pers. comm.). The reason that so few species of *Fungia* have been found in the Darwin region, compared with the east and west coasts of Australia, is unknown. *Cynarina* is the only genus recorded in Darwin that is not recorded from west Australia, while all Darwin genera are recorded from east Australian reefs.

Pocillopora damicornis is extremely rare in the Darwin region (P. Alderslade, personal observation). This is noteworthy because this species is common on both east (Veron and Pichon 1976) and west (Veron and Marsh 1988) Australian reefs, and reefs in the Indian and Pacific Oceans (Richmond 1985). There are a number of factors, relating to environmental conditions, which could explain the paucity of *Pocillopora damicornis* in the Darwin region. This species has been recorded to bleach frequently and severely at Magnetic Island, Townsville (Oliver 1985) possibly indicating that this species is not

Table 3. Number of species and genera of corals in the Darwin region compared with eastern and western Australia.

	Eastern Australia*		Darwin Harbour and N.W. Vernon Island			Western Australia*			
	#genera in family	#species in family	#species in genus	#genera in family	#species in family	#species in genus	#genera in family	#species in family	#species in genus
CLASS Hydrozoa									
ORDER Milleporina									
Family Milleporidae	1	?		1	?	1	1	?	?
<i>Millepora</i> sp.			?			1			?
CLASS Anthozoa									
ORDER Stolonifera									
Family Tubiporidae	1	1		1	1	1	1	1	1
<i>Tubipora musica</i>			1			1			1
ORDER Scleractinia									
Family Thamnasteriidae	1	7		1	3		1	9	
<i>Psammocora</i>			7			3			9
Family Astrocoeniidae	1	2		1	1		1	2	
<i>Stylocoeniella</i>			2			1			2
Family Pocilloporidae	5	9		2	2		4	9	
<i>Pocillopora</i>			4			1			5
<i>Stylophora</i>			1			1			1
Family Faviidae	17	54		12	32		17	57	
<i>Favia</i>			12			6			13
<i>Barabattoia</i>			1			1			1
<i>Favites</i>			9			6			8
<i>Goniastrea</i>			7			3			8
<i>Platygyra</i>			5			4			6
<i>Leptoria</i>			1			1			1
<i>Hydnophora</i>			3			1			4
<i>Montastrea</i>			4			3			4
<i>Plesiastrea</i>			1			1			1
<i>Leptastrea</i>			6			2			6
<i>Cyphastrea</i>			4			3			4
<i>Moseleya</i>			1			1			1
Family Trachyphylliidae	1	1		0	0		2	2	
Family Agariciidae	5	2		1	1		5	2	
<i>Pachyseris</i>			2			1			2
Family Siderastreidae	2	6		2	2		2	5	
<i>Pseudosiderastrea</i>			1			1			1
<i>Coscinaraea</i>			5			1			4
Family Fungiidae	11	21		6	6		9	18	
<i>Heliofungia</i>			1			1			1
<i>Fungia</i>			15			1			12
<i>Herpolitha</i>			2			1			2
<i>Polyphyllia</i>			1			1			1
<i>Lithophyllon</i>			1			1			1
<i>Podabacia</i>			1			1			1

Hard corals of the Darwin region

Table 3 (continued). Number of species and genera of corals in the Darwin region compared with eastern and western Australia

	Eastern Australia*			Darwin Harbour and N.W. Vernon Island			Western Australia*		
	#genera in family	#species in family	#species in genus	#genera in family	#species in family	#species in genus	#genera in family	#species in family	#species in genus
Family Oculinidae	3	4		2	3		2	2	
<i>Galaxea</i>			2			2			2
<i>Archohelia</i>			1			1			-
Family Merulinidae	3	1		1	1		2	2	
<i>Merulina</i>			1			1			2
Family Mussidae	6	13		4	7		6	13	
<i>Cynarina</i>			1			1			0
<i>Acanthastrea</i>			4			2			4
<i>Lobophyllia</i>			4			1			4
<i>Symphyllia</i>			4			3			5
Family Pectiniidae	4	10		4	4		4	11	
<i>Echinophyllia</i>			4			1			3
<i>Oxypora</i>			2			1			2
<i>Mycedium</i>			1			1			2
<i>Pectinia</i>			3			1			4
Family Caryophylliidae	4	4		1	2		5	4	
<i>Euphyllia</i>			4			2			4
Family Dendrophylliidae	3	10		2	8		3	11	
<i>Turbinaria</i>			9			7			10
<i>Duncanopsammia</i>			1			1			1
Family Poritidae	4	35		3	14		3	36	
<i>Porites</i>			13			6			15
<i>Goniopora</i>			15			6			14
<i>Alveopora</i>			7			2			7
Family Acroporidae	4	117		3	25		4	101	
<i>Montipora</i>			36			11			35
<i>Acropora</i>			73			13			62
<i>Astreopora</i>			8			1			4

*East Australian records are taken from the AIMS monograph series for zooxanthellate scleractinian species; Veron (1986) for *Millepora* sp. (number of species unknown) and *Tubipora musica*; Wells and Alderslade (1979) for *Archohelia rediviva*. West Australian records are taken from Veron and Marsh (1988) for scleractinian species; Veron (1986) for *Millepora* sp. (number of species unknown) and *Tubipora musica*; no reference for *Archohelia rediviva*.

N.B. *Lithophyllon undulatum* was synonymised with *L. cf edwardsi* (Hoeksema, 1989), and *Turbinaria conspicua* was synonymised with *T. bifrons* (Veron and Pichon, 1980) and thus each of these pairs is recorded as one species in their respective tallies for the east Australian coast. Tallies include all species referred to as 'cf' and unnamed species (e.g. *Porites* sp 1). Specimens identified only to genus level are not counted.

a successful competitor under adverse conditions such as high turbidity.

The families Thamnasteriidae, Astrocoeniidae, Pocilloporidae, Agariciidae, Siderastreidae, Oculinidae, Merulinidae, Mussidae, Pectiniidae, Caryophylliidae and Dendrophylliidae are represented by relatively low numbers of genera and species for the three regions discussed and elsewhere in the Indo-Pacific region.

The only azooxanthellate coral recorded was *Archohelia rediviva*, which was found in both the intertidal and subtidal zones. The occurrence of this species is significant because this is an uncommon species previously recorded from only three locations, all in Queensland on the east coast of Australia (Wells and Alderslade 1979; MTQ unpublished records). Azooxanthellate corals are normally found on steep walls, under ledges, in deep water or in other locations where light is limited. The azooxanthellate coral, *Tubastrea* sp., has been recorded from the wreck of the SS *Zealandia* in Darwin Harbour at a depth of 22 m (NTM records). It is likely that other species or genera of azooxanthellate corals are present on wrecks and other locations in the Darwin region with restricted light levels, but such habitats were not surveyed during this study.

The skeletal morphologies of species from most families are similar in appearance to the same species on the Great Barrier Reef. However, colonies of some species of *Acropora* collected in Darwin differ in skeletal morphology. For example, in *Acropora formosa* the axial corallites are larger relative to branch size compared with colonies on the Great Barrier Reef. Three tentative species of *Montipora* (*Montipora* sp. 1, 2 and 3) collected in Darwin, have very small corallites compared with the species of *Montipora* described from the Great Barrier Reef (B. Stobart pers. comm.). Further research is necessary to determine if they are different species from those from the Great Barrier Reef (Veron and Wallace 1984) or morphological variants. Veron and Marsh (1988) also recorded several species of *Acropora* to have distinct variants several species in specific geographic regions, suggesting that they may be sibling species or geographic subspecies. More extensive surveys of the coral fauna, as well as studies of the morphological and genetic variation (DNA or electrophoretic studies) of the species in the Darwin region are necessary to confirm the taxonomic status of such colonies.

It is possible that corals in the Darwin region may exhibit morphological variation compared with the same species on the Great Barrier Reef because they are breeding within a relatively isolated gene pool or as a result of environmental stress.

Major factors determining species diversity and abundance of corals between the intertidal and subtidal zones in the Darwin area and compared with the east and west coasts of Australia appear to be restricted light availability, turbidity, high levels of sedimentation, limited availability of suitable settlement substratum for coral larvae, and the limited range of habitats present.

Irradiance is probably one of the most important abiotic factors influencing coral reef development (Falkowski *et al.* 1990). Irradiance enables the photosynthetic endosymbiotic algae (zooxanthellae) to fix carbon which the coral then uses. Although quantitative data for light levels have not been published for Darwin Harbour, it is clear that the high levels of turbidity which often reduce visibility to 0.7 m (Hooper 1987) substantially reduce light levels reaching the corals in the waters of the region. Falkowski *et al.* (1990), using *Stylophora pistillata* as a study species, reported that corals living in shaded areas must obtain up to 60% of their carbon requirements from heterotrophic feeding, in contrast with corals growing under high light conditions which can obtain all their reduced carbon needs for animal respiration from photosynthesis by their zooxanthellae. Restricted light levels reaching the corals therefore influence their rate of growth by reducing rates of photosynthesis, and affect the depth to which corals can occur, and possibly also the species which are able to survive in the Darwin region. Light levels may also influence successful recruitment sites of coral larvae (Maida *et al.* 1994; Mundy 1994).

In addition to reducing the amount of light reaching the corals, high levels of turbidity also directly affect corals through sedimentation. Corals remove sediment from their colony surface through ciliary activities, mucous entanglement, polyp tissue expansion, and tentacular action (Hubbard and Pocock 1972; Stafford-Smith and Ormond 1992). This physical removal of sediment is an energy drain for the coral and thus reduces the amount of energy available for growth (Cortes and Risk 1985). Hubbard and Pocock (1972) and Stafford-Smith and Ormond (1992) also report that species with different

colony and calyx morphologies differ in their ability to reject sediments. The strong tidal currents experienced in the Darwin region reduce the effects of sedimentation by physically removing the sediment from the surface of coral colonies (Rogers 1990), and this is possibly a factor in explaining the high number of species surviving in such a turbid environment.

High levels of sedimentation also affect recruitment of juvenile corals because coral larvae cannot successfully establish themselves in shifting sediments (Rogers 1990). Maida *et al.* (1994) and Rogers *et al.* (1984) suggest that the reduction or absence of coral recruitment on exposed settlement surfaces is due to sedimentation on these surfaces. Thus the films of sediment covering much of the bare substratum in Darwin Harbour may not be conducive to coral recruitment. Experimental evidence indicates that coral larvae preferentially settle in crevices (Wallace 1985; Harriott and Fisk 1987). Such crevices are likely to be filled with sediment and thus further reduce the availability of potential recruitment sites for coral spat.

Low variability in habitat types in the Darwin region is also a factor contributing to the smaller number of coral genera and species present, compared with the east and west Australian coasts. A major difference in the coral communities in the Darwin region is that there are no barrier reefs developed. A barrier reef system such as the Great Barrier Reef is a complex structure with many different types of habitats and biotic communities. These communities experience a range of different environmental parameters. The parameters include varying levels of wave energy, currents, light, nutrient supply, sedimentation and type of substratum (Done 1982; Rosen 1975) and are important in determining the types of coral communities and associated taxa found in a particular reef habitat or reef type. The diversity of the coral fauna in the Darwin region seems most comparable to that of the inner-shelf reefs of the GBR (Done 1982). These reefs are nearshore, silt-affected, and have relatively low diversity (Done 1982).

CONCLUSION

No clear trends are apparent in the numbers of species or genera occurring intertidally and subtidally in Darwin Harbour. All larger families and genera have species present in both

zones. Although there are fewer species of hard corals in Darwin Harbour compared to the east and west Australian coasts, the relative proportions of species in each genus and the number of species and genera in each family are similar to the east and west Australian coasts, with the exception of the Faviidae. Considering the high sediment load, strong tidal currents, and long periods of exposure for reef flat corals during low tides, the species diversity of Darwin Harbour is comparatively high. However, because of the limited range of habitat types, and therefore reduced potential for species diversity, it is not surprising that the diversity is lower than on the east and west coasts of Australia where barrier reefs with large ranges of habitat variability exist.

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