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Loisette

RESEARCH IN SHARK BAY
Report of the France-Australe Bicentenary Expedition Committee

Hermatypic corals of Shark Bay, Western Australia

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Abstract

Shark Bay, lying between latitudes 24° and 26°S, has a depauperate coral fauna compared with the Ningaloo Reef to the north and the Houtman Abrolhos to the south. Intensive collecting has yielded only 80 species of 28 genera in scattered coral communities. No coral reefs occur in the bay nor around its margin. Strong, permanent salinity and seasonal temperature gradients either directly or indirectly restrict the occurrence of corals to areas of near normal salinity in the western half of the bay; a few species occur in the metahaline areas but none in the hypersaline waters. The exposed coasts of Dirk Hartog Island and Steep Point also have a very limited coral fauna.

Résumé

La Baie des Chiens Marins, se situant entre 24° et 26° de latitude sud, possède une faune corallienne imparfaitement développée en comparaison du récif de Ningaloo au nord et de Houtman Abrolhos au sud. Le ramassage intensif n'a produit que 80 espèces de 28 genres dans les communautés coralliennes éparses. Aucun récif corallien n'apparait dans la Baie ni autour de son bord. Une salinité élevée et permanente, et des gradients saisonniers de température restreignent soit directement ou indirectement l'apparition de coraux à des régions de salinité quasi normale dans la moitié occidentale de la Baie; quelques espèces apparaissent dans les régions métahalines mais aucune dans les régions hypersalines. Les côtes exposées de l'ile Dirk Hartog et de Steep Point ont également une faune corallienne très limitée.

Introduction

Some of the corals described by Lamarck from "Nouvelle Hollande" may have been collected in Shark Bay by the Baudin Expeditions (1801 and 1803) but without precise locality data it is not possible to be sure. The first reference to hermatypic corals in Shark Bay is by Saville-Kent (1897) who remarked on the predominance of *Turbinaria* species and noted that this genus was an important component of the coral fauna of extra-tropical areas in Australia. He also remarked on the large number of species and large size of coralla of *Turbinaria* in Shark Bay and figured specimens of *T. peltata* and *T. conspicua*. Shark Bay is the type locality of *T. conspicua* Bernard 1896 and of *T. magna* Bernard 1896, a junior synonym of *T. frondens* (Dana, 1846), both collected by Saville-Kent. No publications on corals resulted from the Hamburg Expedition (1905) which collected other taxa extensively in Shark Bay.

The Western Australian Museum collection of corals from Shark Bay began with a donation from the University of Western Australia of specimens collected by E.P. Hodgkin and B.R. Wilson at South Passage in 1957. Apart from a few trawled specimens, the next collection, again from the South Passage area, but

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including sampling stations outside the bar, off Steep Pt and off the S.W. end of Dirk Hartog Island, was made by the author in 1979. Cape Ransonnet, the south end of Dirk Hartog Island, Sunday Island and Egg Island were also sampled at this time (a total of 19 stations).

In 1980 S. Slack-Smith collected from Bernier and Dorre Islands (21 stations) and in 1981 Slack-Smith and Marsh collected corals from Turtle Bay and Louisa Bay (on the north and east sides of Dirk Hartog Island), Cape Peron North, Herald Bight, Eagle Bluff and Denham Channel (in Freycinet Reach). Other sites sampled, where no corals were found, include Useless Inlet, Faure Island, Freycinet Harbour and Hamelin Pool. Eleven stations were sampled by SCUBA and snorkelling while 63 were sampled by dredging and trawling. A comparison of the distribution of sampling sites at which corals were found with those where corals were absent (figure 1) indicates the pattern of coral distribution in the bay.

Physical features

Shark Bay stretches from the north end of Bernier Island (24°45′S, 113°10′E) to the south end of Freycinet Harbour (26°36′S, 113°41′E). It is a large shallow embayment approximately 13,000 km^2 in area with an average depth of 9 m and a greatest depth of c. 29 m. The bay is enclosed by Bernier, Dorre and Dirk Hartog islands and is subdivided internally by dune ridges and submerged banks or sills into numerous inlets, gulfs and basins. This resulted from marine transgression into a terrain composed mainly of Pleistocene dunes; the flooding created a series of broad gulfs and narrow inlets, which are partly cut off from the Indian Ocean. Influx of oceanic water is through the wide northern Geographe Channel, the Naturaliste Channel between Dorre and Dirk Hartog Islands and South Passage between Dirk Hartog Island and Steep Point.

Salinity

The embayment is adjacent to a hinterland of low relief in an arid to semi-arid climate (evaporation exceeds precipitation). Two rivers drain into Shark Bay, but their flow is intermittent and runoff influx is small. Climatic factors combined with low runoff and restricted circulation result in an increase of salinity values from normal oceanic in the northern and western parts of the bay to hypersaline in the southern extremities (Logan and Cebulski 1970).

The inner parts of Shark Bay were first inundated by the rise of the postglacial sea about 8000 years BP. The bay had an oceanic - metahaline salinity regime from 8,000 to 4,500 yr BP and the hypersaline salinity regime of Hamelin Pool and Lharidon Bight has developed during the past 3000-4000 years (Logan 1974).

At present the salinity gradient (figure 1) ranges from oceanic (salinity 35-40‰) in the northern and western parts of the bay through metahaline (salinity 40-56‰) to hypersaline in Hamelin Pool and Lharidon Bight (salinity 56-70‰) (Logan and Cebulski 1970).

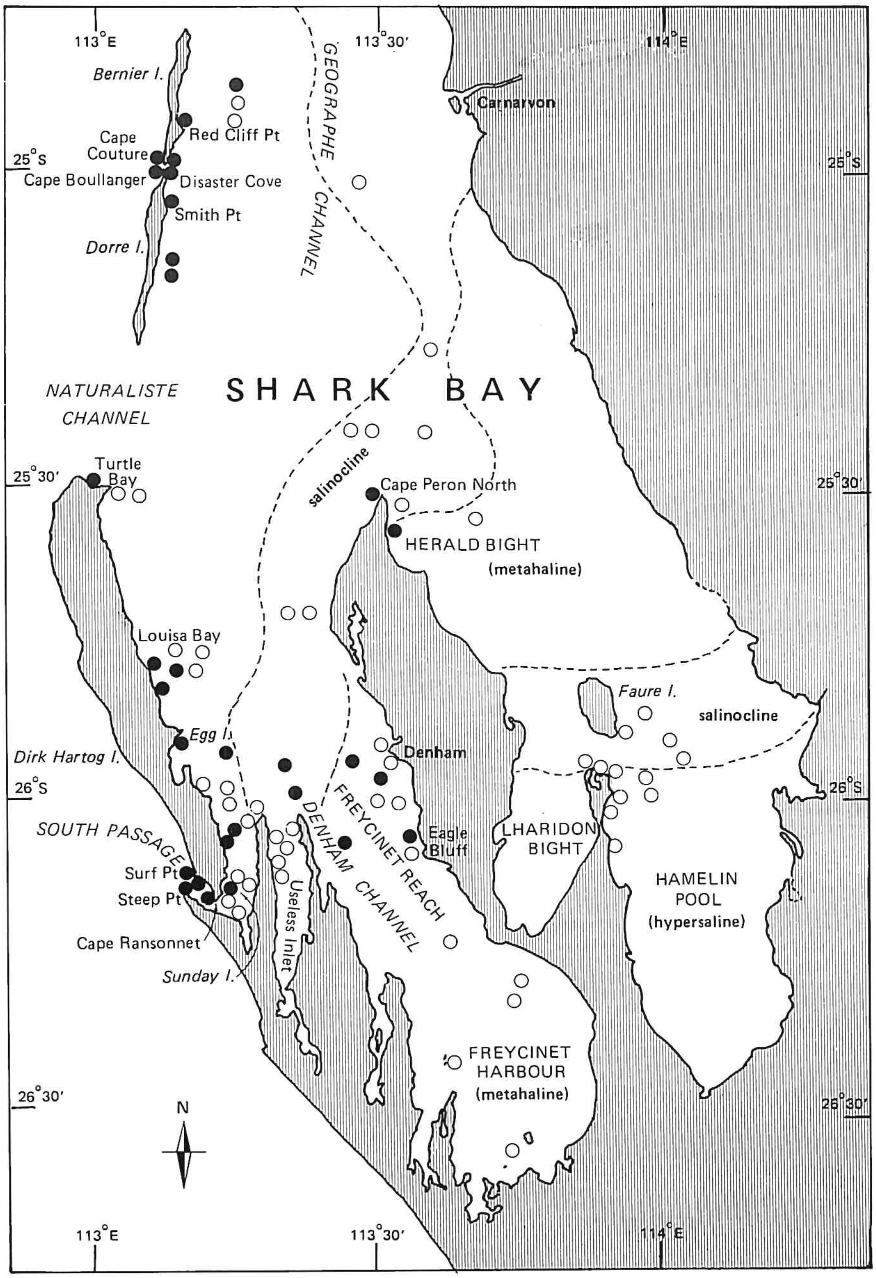

Figure 1. Map of Shark Bay with station locations indicating the presence (●) or absence (○) of corals. Salinity contours after Logan and Cebulski (1970).

Hermatypic corals are, with a few exceptions confined to the waters of near normal ocean salinity barely extending into the metahaline zone in Freycinet Reach.

Temperature

Sea surface temperature outside Shark Bay varies from 20.9°C (August-September) to 26°C (February-March) (Pearce 1986). Surface and bottom temperatures within the bay (1965 data, Logan and Cebulski 1970) have a greater range than the open sea temperature; the inner parts of the bay, including Freycinet Reach, fall to 17-18°C in August and to 19-22°C in the zone of oceanic salinity. In February a maximum of 27°C was recorded in Hamelin Pool, 24-26°C in Freycinet Reach and 22-24°C in the oceanic salinity zone. There is little difference between bottom and surface temperature either in summer or winter.

The Leeuwin Current (Cresswell and Golding 1980), an intrusion of warm low-salinity tropical water that flows southward near the Western Australian continental slope, occasionally meanders into Shark Bay but more often bypasses it. The current flows largely in autumn and winter but is very variable from month to month and year to year.

An infrared satellite image of 30 April 1980 shows a slight intrusion into the northern part of the bay (between Bernier Island and Carnarvon), between Dorre Island and the north end of Dirk Hartog Island and into South Passage (Legeckis and Cresswell 1981). An image of 22 October 1979 (Legeckis and Cresswell 1981) shows a complete absence of the Leeuwin Current while one of 18 October 1984 (Pearce 1985) shows a fairly well developed current penetrating well into Shark Bay.

Oxygen

Bottom waters within Shark Bay generally are saturated with oxygen although large diurnal fluctuations occur in proximity to seagrass stands (Logan and Cebulski 1970).

Tides

Tide is the major factor causing water movement in Shark Bay. The tides are mixed diurnal with a spring range of 1.70 m and a neap range of 0.61 m at Carnarvon (Logan and Cebulski 1970).

Wind

Shark Bay is in the belt of south-east trade winds which are locally reinforced by a strong sea-breeze system during summer and by winds associated with depressions in the Southern Ocean during winter. Winds are predominantly southerly with a mean velocity of 10-15 knots in summer (October to April) with a mean maximum velocity of 25 knots in January and February. Southerly winds also prevail during winter (May to September) but with a lower velocity in a range of 5-8 knots with periods of calm. Strong northerly winds can occur in association with depressions in the Southern Ocean and cyclonic disturbances from the north occasionally affect Shark Bay with severe winds.

The interaction of wind drift with tidal currents leads to a circulation in which net movement is from west to south-east, then east and finally north-west. This movement is probably along the density (salinity) trend lines (Logan and Cebulski 1970). The prevailing southerly winds generate substantial seas predominantly on shores with a south-easterly and south-westerly aspect. Sustained wave action mobilises fine sediments causing turbid conditions in the bay for much of the time.

Coral habitats in Shark Bay

The three elongate, narrow, north-south trending islands, (Bernier, Dorre and Dirk Hartog Islands) provide the principal coral habitats in Shark Bay. The islands are composed of Pleistocene coastal limestone (Tamala Eolianite) overlying Cretaceous limestone (Logan and Cebulski 1970). Bernier Island (24°45′S, 113°10′E to 24°59′S, 113°08′E) is 26.5 km long by 2.8 km wide, at its widest point; Dorre Island (24°59′S, 113°07′E to 25°16′S, 113°05′E) is 30.6 km long by 3.2 km wide at its widest point.

Bernier and Dorre islands are predominantly flat topped masses girt by cliffs which rise abruptly from the sea on their western side and reach an elevation of about 46 metres at Quoin Bluff North on Dorre Island (Ride 1962). Limited areas around Bernier and Dorre Islands have been sampled, to a depth of c. 5 metres, but they probably include those most favourable for coral growth. These are principally the southern end of Bernier Island (Cape Couture) where there is a coral covered platform, on the western side, at 1-2 m, with 'gardens' of staghorn and tabular Acroporas, and the northern end of Dorre Island (Cape Boullanger) where reefs extending northwards from the Cape support a diverse coral fauna.

The two islands are separated by a narrow channel 3-4 m deep through which there is considerable water movement.

Other areas with a fair diversity of corals are the eastern side of Cape Couture where there is 20-30% cover of living coral, principally *Montipora* spp, tabular Acroporas and faviids; Disaster Cove (N.E. side of Dorre Island) which has a coral community on rock substrate near the entrance to the bay, with 10-20% coral cover, principally *Turbinaria* spp, *Montipora* spp. and faviids. A few kilometres to the south near Smith Point is a fairly diverse coral community dominated by *Turbinaria* spp. Red Cliff Pt on the south-east side of Bernier Island has less than 5% coral cover, principally *Turbinaria* spp and faviids.

The western sides of Bernier and Dorre Islands are subjected to heavy wave action and have not been investigated. The principal coral areas appear to be those with some shelter from wave action but with close proximity to the open sea. Species richness drops, the diversity of *Acropora* species decreases and the diversity of *Turbinaria* species increases on the more sheltered eastern sides of the islands. Fifty-five species of 23 genera of hermatypic corals have been found at Bernier and Dorre Islands, very similar to the numbers for the South Passage area, however there are apparent differences in the species composition of the fauna (Table 1).

Table 1. Hermatypic corals of Shark Bay. Data from the Western Australian Museum collection; registration numbers of specimens are given in Veron and Marsh (1988). Symbols: + = present, - = not found, V = visual record.

Hermatypic corals of Shark Bay	**Bernier and Dorre Islands**	**Inside South Passage**	**Outside South Passage**	**Turtle Bay**	**Louisa Bay/Egg Island**	**Sunday Island**	**Cape Peron/Herald Bight**	**Freycinet Reach**
Family Pocilloporidae								
Pocillopora damicornis (Linnaeus, 1758)	+	+	V	V	-	-	V	-
P. verrucosa (Ellis & Solander, 1786)	-	+	+	-	-	-	-	-
P. eydouxi Edwards & Haime, 1860	-	-	+	-	-	-	-	-
Stylophora pistillata (Esper, 1797)	+	+	-	-	-	-	-	-
Family Acroporidae								
Montipora monasteriata (Forskål 1775)	+	-	-	-	-	-	-	-
M. tuberculosa (Lamarck, 1816)	+	-	-	-	-	-	-	-
M. mollis Bernard, 1897	+	-	-	-	-	-	-	-
M peltiformis Bernard, 1897	+	-	+	-	-	-	-	-
M. turgescens Bernard, 1897	+	+	+	-	-	-	-	-
M. capricornis Veron, 1985	+	-	-	-	-	-	-	-
M. spongodes Bernard, 1897	+	-	-	-	-	-	-	-
M. spumosa (Lamarck, 1816)	+	-	-	-	-	-	-	-
M. foveolata (Dana, 1846)	-	-	+	-	-	-	-	-
M. angulata (Lamarck, 1816)	+	-	-	-	-	-	-	-
M. hispida (Dana, 1846)	+	+	+	-	-	-	-	-
M. aequituberculata Bernard, 1897	+	-	-	-	-	-	-	-
M. spp.	-	-	-	V	-	-	-	-
Acropora digitifera (Dana, 1846)	+	+	-	-	-	-	-	-
A. verweyi Veron & Wallace, 1984	-	+	+	-	-	-	-	-
A. robusta (Dana, 1846)	+	+	+	-	-	-	-	-
A. bushyensis Veron & Wallace, 1984	-	-	+	-	-	-	-	-
A. aspera (Dana, 1846)	+	-	+	-	-	-	-	-
A. pulchra (Brook, 1891)	-	+	+	-	-	-	-	-
A. millepora (Ehrenberg, 1834)	+	+	+	-	-	-	-	-
A. hyacinthus (Dana, 1846)	+	-	-	-	-	-	-	-
A. spicifera (Dana, 1846)	-	-	+	-	-	-	-	-

Hermatypic corals of Shark Bay	Bernier and Dorre Islands	Inside South Passage	Outside South Passage	Turtle Bay	Louisa Bay/Egg Island	Sunday Island	Cape Peron/Herald Bight	Freycinet Reach
A. latistella (Brook, 1892)	+	–	–	–	–	–	–	–
A. valida (Dana, 1846)	–	–	+	–	–	–	–	–
A. solitaryensis Veron & Wallace, 1984	+	–	–	–	–	–	–	–
A. florida (Dana, 1846)	+	+	+	–	–	–	–	–
A. spp.	–	–	–	V	+	–	–	–
Family Poritidae								
Porites lobata Dana, 1846	–	+	+	–	–	–	–	–
P. lutea Edwards & Haime, 1860	–	+	–	–	–	–	–	–
P. sp.	+	–	–	–	–	+	–	–
Goniopora lobata Edwards & Haime, 1860	–	+	–	–	–	–	–	+
G. tenuidens Quelch, 1886	–	+	–	–	–	–	–	–
G. stutchburyi Wells, 1955	–	+	–	–	–	–	–	–
G. sp.	+	–	–	–	–	–	–	–
Alveopora allingi Hoffmeister, 1925	–	+	–	–	–	–	–	–
A. spongiosa Dana, 1846	–	+	–	–	–	–	–	–
A. tizardi Bassett-Smith, 1890	–	–	+	–	–	–	–	–
A. sp.	+	–	–	–	–	–	–	–
Family Siderastreidae								
Psammocora contigua (Esper, 1797)	+	+	–	–	V	+	–	–
P. superficialis Gardiner, 1898	–	–	–	–	–	–	+	–
Coscinaraea columna (Dana, 1846)	–	–	+	–	–	–	–	–
Family Agariciidae								
Pavona explanulata (Lamarck, 1816)	+	–	–	–	–	–	–	–
P. minuta Wells, 1954	+	+	V	–	–	–	–	–
Leptoseris mycetoseroides Wells, 1954	–	+	+	–	–	–	–	–
Family Fungiidae								
Cycloseris cyclolites (Lamarck, 1801)	+	+	–	–	+	–	+	+
Diaseris fragilis Alcock, 1893	–	–	–	–	–	–	–	+
Family Pectiniidae								
Echinophyllia aspera (Ellis & Solander, 1786)	+	+	–	–	–	–	–	–
E. orpheensis Veron & Pichon, 1980	+	–	–	–	–	–	–	–
Oxypora lacera (Verrill, 1864)	–	–	+	–	–	–	–	–
Family Mussidae								
Acanthastrea echinata (Dana, 1846)	+	–	–	–	–	–	–	–
A. hillae Wells, 1955	+	+	–	–	–	–	–	–
Symphyllia wilsoni Veron, 1985	+	+	+	–	–	+	–	–

Hermatypic corals of Shark Bay	**Bernier and Dorre Islands**	**Inside South Passage**	**Outside South Passage**	**Turtle Bay**	**Louisa Bay/Egg Island**	**Sunday Island**	**Cape Peron/Herald Bight**	**Freycinet Reach**
Family Merulinidae								
Hydnophora exesa (Pallas, 1766)	+	–	–	–	–	+	–	–
Family Faviidae								
Favia favus (Forskål, 1775)	+	–	+	–	–	–	–	–
Favia sp.	–	–	–	–	–	–	–	+
Favites abdita (Ellis & Solander, 1786)	+	–	–	–	V	–	–	–
F. chinensis (Verrill, 1866)	+	–	–	–	–	–	–	–
F. pentagona (Esper, 1794)	+	+	+	–	–	+	–	+
F. russelli (Wells, 1954)	+	–	–	–	–	–	–	–
Goniastrea edwardsi Chevalier, 1971	+	–	–	–	–	–	–	–
G. favulus (Dana, 1846)	+	–	–	–	–	–	–	–
G. aspera Verrill, 1865	+	+	V	–	+	+	+	+
G. pectinata (Ehrenberg, 1834)	+	–	V	–	–	–	–	–
G. australensis (Edwards & Haime, 1857)	+	+	+	V	–	–	–	–
Platygyra daedalea (Ellis & Solander, 1786)	–	–	+	–	–	–	–	–
P. lamellina (Ehrenberg, 1834)	–	+	–	–	–	–	–	–
P. pini Chevalier, 1975	+	–	–	–	–	–	–	–
Montastrea curta (Dana, 1846)	+	+	–	–	V	+	–	–
M. magnistellata Chevalier, 1971	+	–	–	–	–	–	–	–
M. valenciennesi (Edwards & Haime, 1848)	+	+	+	–	–	–	–	–
Plesiastrea versipora (Lamarck, 1816)	+	+	+	–	–	+	–	+
Cyphastrea serailia (Forskål, 1775)	+	+	+	–	–	+	V	+
C. microphthalma (Lamarck, 1816)	+	+	–	–	–	+	–	–
Moseleya latistellata Quelch, 1884	+	+	V	+	–	V	–	+
Family Dendrophylliidae								
Turbinaria peltata (Esper, 1794)	+	+	V	–	+	+	V	+
T. frondens (Dana, 1846)	+	+	+	+	+	+	–	+
T. mesenterina (Lamarck, 1816)	–	+	–	–	+	+	V	+
T. reniformis (Bernard, 1896)	–	–	–	+	–	–	–	+
T. bifrons Brüggemann, 1877	+	+	+	–	+	V	+	+
T. conspicua Bernard, 1896	–	+	–	–	–	–	–	–
T. sp. 1.	–	+	+	–	–	–	–	–
Duncanopsammia axifuga (Edwards & Haime, 1848)	–	+	+	–	–	–	–	–
Species	55	42	38	7	10	15	8	14
Genera	23	23	20	6	7	11	6	10

Dirk Hartog Island (25°29′S, 112°58′E to 26°10′S, 113°13′E) is the largest of the three islands, 76 km long by 12 km wide at its widest point. The exposed western side is cliffed for its entire length, while the eastern side tends to be lower and is sheltered from the ocean swell.

Localities on the north, east, south and south-west sides of Dirk Hartog island were sampled for corals.

At Turtle Bay, 1 km east of Cape Inscription, a dissected limestone reef at 3-6 m was algal covered with scattered corals. Seven species of six genera were recorded (Table 1).

Several sites on the east coast of Dirk Hartog Island were searched for corals: A point at the south end of Louisa Bay; near Egg Island; c. 10 km south of Homestead Point and Sunday Island. At all these localities the coral fauna was depauperate and dominated by *Turbinaria* species. At Louisa Bay and Egg Island Bay nine species of six genera were found but around Sunday Island the coral fauna was richer with 15 species of 11 genera (Table 1). In Egg Island Bay and at Sunday Island *Turbinaria* spp. particularly yellow and green colonies of *T. mesenterina* formed dense stands reminiscent of Saville-Kent's (1897) description of stands of *T. conspicua* at Egg Island as resembling "subaqueous plantations of Brobdingnagian, crinkle-leaved, savoy cabbages". Curiously no specimens of *T. conspicua* were found in Egg Island Bay in 1979. It is possible that Saville-Kent confused the two species in the field.

One colony of *Acropora* sp was found in Louisa Bay but only fragments of dead staghorn *Acropora* at Egg Island Bay and in the bay north of Homestead Point.

The South Passage Area

At the south end of Dirk Hartog Island the coral diversity increases from Cape Ransonnet to Surf Point and changes from a *Turbinaria* dominated community to a more diverse one including *Acropora* spp. Between Cape Ransonnet and Surf Point an area of dead *Acropora* reef was found in 1979, some in situ but mostly staghorn *Acropora* rubble with no living *Acropora* species.

On the eastern side of Surf Point a moderately sheltered rock and rubble bottom at 2-3 m supports a fairly diverse coral fauna including six species of *Acropora*. *A. robusta* and *A. digitifera* formed very large colonies and *Pocillopora damicornis* was abundant in this area.

In contrast the southern shore, inside South Passage, is predominantly sandy with algal covered rock substrate offshore and very few corals. Dirk Hartog Island is linked to Steep Point by a limestone ridge, the outer bar, which rises to about six metres from the surface, and breaks heavily except in very calm weather. The reef top slopes seawards to 10-11 m then drops vertically to c. 18 m or is undercut by caves. The reef top is algal covered with scattered low-growing colonies of *Acropora, Montipora, Pocillopora* and faviids. The outer wall is covered mainly with alcyonaceans, sponges and ascidians with the ahermatypic corals *Tubastrea* spp under ledges. In places species of *Favia, Favites, Montipora* and *Oxypora* occur on the wall but more corals occur on boulders and as coral bommies on a gently sloping bottom at c. 20 m. In this area *Coscinaraea columna* forms large colonies and the coral fauna includes *Turbinaria, Goniastrea, Favia, Favites, Porites, Alveopora, Pavona, Moseleya, Duncanopsammia* and other genera.

On the south side of South Passage a reef connecting Monkey Rock to the mainland was examined. It slopes seaward and has scattered corals on the deeper part at c. 5 m. On the slope at c. 3 m there was 10-30% cover of living coral, predominantly *Montipora* spp with scattered colonies of *Acropora* spp, *Pocillopora damicornis, P. verrucosa* and *P. eydouxi,* a few species of Faviidae and no Turbinarias.

Two other seaward sites were examined: north of Surf Point (Dirk Hartog Island) at 10-12 m the bottom was gently sloping algal covered rock with sparse corals, mainly *Montipora* and *Acropora* spp; off the north east side of Steep Point a narrow intertidal platform drops vertically to c. 9 m then slopes to sand at 18 m. Rock towers c. 6 m diameter, rise from c. 15 m to 6-9 m from the surface. The sides are covered by sponges, ascidians, alcyonaceans and *Tubastrea* spp. No hermatypic corals were found on the towers but scattered colonies of *Turbinaria, Acropora, Montipora, Alveopora, Goniastrea, Favites* and *Moseleya* were found on the rock slope near their bases.

From these observations it seems unlikely that extensive coral areas occur on the seaward sides of Bernier, Dorre or Dirk Hartog Islands, all of which are subjected to heavy wave action on their western coasts.

A total of 53 species of 26 genera were found in the South Passage area, combining records from sheltered and exposed waters.

In Freycinet Reach islets off Eagle Bluff have a very depauperate coral fauna on rocks rising from silty sand. An isolated patch of corals yielded *Cyphastrea serailia, Goniastrea aspera, Favites pentagona, Favia* sp. *Goniopora lobata* and *Turbinaria* spp. No corals were found further south in Freycinet Reach.

Off Cape Heirisson on a silty sand and shell rubble bottom at 16.5 m, among sponges and gorgonians, colonies of *Turbinaria peltata* and *T. frondens* were common with a few colonies of *Favia* and *Moseleya.*

Cape Peron North

There is little suitable habitat for corals at the cape. The bottom is predominantly sand with some rock substrate at c. 2 m.

A few small *Turbinaria* spp and small faviids were the only corals found.

Herald Bight

This large bay on the east side of Cape Peron North has a silty sand bottom with scattered rocks and coral at 5-6 m. The water was turbid and many of the coralla were dead or partly dead. Three species of *Turbinaria* (Table 1) were the most abundant corals, particularly *T. bifrons.* No corals were found further south off Faure Island or in Hamelin Pool.

Corals of soft substrates

The solitary fungiid *Cycloseris cyclolites* has been dredged from many parts of Shark Bay except in metahaline and hypersaline areas but no *Fungia* spp have been found. *Diaseris fragilis,* from Freycinet Reach, is the only other fungiid recorded.

Cyphastrea spp form free living coralliths, often with a hollow centre inhabited by a Xanthid crab. These are occasionally found on soft substrates both in coral areas and in deeper water away from other corals e.g. at a depth of 11 m, east of Castle Pt., Dorre I., where several examples were found. Lamberts and Garth (1977) reported Xanthid commensalism with corals of seven genera, this observation adds an eighth.

Turbinaria spp often attach to small fragments of rubble or shell on soft substrates and are tolerant of silty areas such as Freycinet Reach.

The coral fauna

Overall the known hermatypic coral fauna of Shark Bay numbers 80 species of 28 genera. This is an impoverished fauna compared with the Ningaloo Reefs to the north (21°47′S to 23°38′S) where 217 species of 54 genera are recorded or the Houtman Abrolhos to the south (28°16′S to 29°S) with 184 species of 42 genera (Veron and Marsh 1988).

From Table 1 the pattern of distribution of coral species in the bay is evident. *Turbinaria* is the most widespread genus in the areas sampled but the presence or absence data does not indicate the dominance of this genus at all the sheltered localities whereas at the seaward sites it becomes a small component of the fauna. *Montipora, Acropora* and *Pocillopora* species dominate the fauna of the seaward sites. *Goniastrea aspera* is one of the most common and widely distributed species in Shark Bay, found in almost all the habitats sampled. The temperate Western Australian endemic species, *Symphyllia wilsoni,* reaches the northern limit of its distribution in Shark Bay.

Figure 1 shows the presence or absence of corals at the localities sampled. The distribution of corals closely follows the zone of oceanic salinity, impinging on the metahaline zone in Freycinet Reach.

Discussion

While the list of corals from Shark Bay is probably not yet complete, sufficient is known to comment on the distribution patterns. The limits of coral distribution in Shark Bay, although coinciding fairly closely with the boundary between water of oceanic salinity and metahaline water and with the winter temperature minimum of 18-19°C (although data is lacking for some of the localities) may be affected indirectly as well as directly by these factors.

Kinsman (1964) found 11 species of 11 genera of corals living in waters with an extreme temperature range and high salinity in the southern Persian Gulf. Temperatures varied seasonally from 16° to >40°C at the surface and from 20° to 36°C below 4-5 metres depth. Salinities ranged from 42 to 45‰ with 48‰ in lagoons where large *Porites* colonies occur. Kinsman found that *Porites* could not survive salinity >48‰ while *Acropora, Platygyra, Cyphastrea, Stylophora, Favia* and *Turbinaria* could not tolerate salinities much in excess of 45‰. These salinities correspond with the metahaline waters of Shark Bay.

It is generally accepted that reef corals flourish best in the temperature range 25° to 29°C and that reefs are not usually formed where the seasonal minimum falls below 19°C although many species can withstand minimum temperatures of 16° to 17°C for short periods and a maximum of 36°C (Kinsman 1964).

The initiation of the Leeuwin Current coincides approximately with the mass spawning of hermatypic corals on the Western Australian coast and is believed to be a major factor in the distribution of corals and the maintenance of coral communities on the west coast (Simpson 1985). The slight impingement of the Leeuwin Current on Shark Bay, shown by Legeckis and Cresswell (1981, figure 1) coincides with the main areas occupied by coral communities in the bay.

The question of whether hermatypic corals need to feed heterotrophically or whether they can obtain sufficient nutrients from products translocated from zooxanthellae has been debated for some years. From experimental evidence Gladfelter (1985) concluded that where light is not limiting products translocated from zooxanthellae might be sufficient to fuel a reef coral's daily metabolic expenditure but where light limits productivity heterotrophic sources of energy are required even to fulfil maintenance respiratory needs. In all environments it appears that a source of nutrition other than translocated products from zooxanthellae is required to sustain growth (i.e. net synthesis of new tissue).

Kimmerer *et al.* (1985) have shown that there is a seven fold increase in zooplankton from the ocean to the central part of Shark Bay, then a decrease of four orders of magnitude into the hypersaline basins, possibly due to nutrient limitation in the hypersaline waters. Thus the lack of zooplankton as well as effects of salinity, temperature and turbidity may restrict the distribution of corals in the high salinity parts of Shark Bay. The lack of nutrients may also affect corals directly since they are capable of taking up phosphorus ions, ammonia and dissolved organic nitrogen from the environment (Muscatine 1973). Nutrient limitation may also affect the coral's zooxanthellae. Yellowlees and Miller (in press) suggest, from experimental data, that phosphorus rather than nitrogen limitation seems more likely as a regulatory factor in the symbiotic association between corals and zooxanthellae. Smith and Atkinson (1984) report that Shark

Bay is a P - limited ecosystem with a slow exchange of materials with the ocean and residence time of water exceeding 1 yr.

Hermatypic corals in Shark Bay are further limited by the lack of hard substrate in may parts of the bay and by the limited water movement in the enclosed basins.

Taking all these factors into account it is not surprising that the distribution of corals in Shark Bay is confined to the areas of oceanic salinity where there is adequate water movement to bring zooplankton and adequate light for photosynthesis. Further ecological research may define more precisely the physical factors controlling coral distribution in Shark Bay.

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