Marine benthic flora and fauna of Gourdon Bay and the Dampier Peninsula in the Kimberley region of north-western Australia

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Abstract

Surveys undertaken to characterise the marine benthic habitats along the Dampier Peninsula and further south at Gourdon Bay in the Kimberley region of Western Australia were augmented with epibenthic sled sampling of soft and hard bottom habitats. This paper describes the species collected, their biomass and relative abundance for the main groups of marine macrophytes and invertebrates. Five localities were surveyed; Gourdon Bay, Quondong Point to Coulomb Point, Carnot Bay to Beagle Bay, Perpendicular Head and Packer Island. Sampling was limited to fifteen epibenthic dredge operations from a range of habitat types and was designed to target the most common habitat types and to obtain species identifications of the most important species and those which typified different habitat types. Surveys covered a total of 1,350 m^2 of seabed in depths between 11 and 23m. We identified 415 taxa comprising: 1 seagrass, 43 algae, 52 sponges, 30 ascidians, 10 hydroids, 14 scleractinian corals, 52 other cnidarians, 69 crustaceans, 73 molluscs and 71 echinoderms. Despite the limited nature of the sampling, a significant number of new species, range extensions and new records for Western Australia and Australia were recorded. Within the algae, one range extension (*Halimeda* cf. *cuneata* f. *digitata* not previously recorded in Western Australia) and one possible new species of *Areschougia* were recorded. Two range extensions were present in the ascidians; the solitary ascidian *Polycarpa* cf. *intonata* has previously only been recorded in Queensland and *Cnemidocarpa* cf. *radicosa* only in temperate Australian waters. There were several range extensions for the crustacea, for example, the sponge crab, *Tumidodromia dormia*, has only been recorded in Queensland. One species of holothurian of the genus *Phyllophorus* could not be identified from the literature available and may represent a new species. Similarly, a small species of the echinoid *Gymnechinus* could possibly be a new species. The collections of hydroids, hard corals, crinoids and molluscs contained no new species or range extensions. There was difficulty in identification of some groups to species level due to the status of the current taxonomic literature (*e.g.* Cnidaria, Porifera and ascidians) and there may be a number of new species among the material collected. Among the anthozoa, there is at least one new species of *Chromonephthea* and potentially 10 range extensions to Western Australia. *Sinularia* cf. *acuta* and *Chromonephthea curvata* are both new records for Australia with both previously recorded in Indonesia only. Among the better known taxa (*e.g.* molluscs, echinoderms, corals), most of the taxa identified to species level have been recorded to occur throughout north-western Australia, however the diversity recorded in this study is less than other parts of the Kimberley and this is almost certainly a result of the small overall area sampled and the single method of collection utilised. The most important species on soft bottom habitats in terms of biomass was the heart urchin *Breynia desorii* (up to 326 $g.m^{-2}$). Sponges were the dominant fauna by biomass (up to 620 $g.m^{-2}$) on hard bottom habitats and biomass was dominated a by a few large cup and massive sponge species (*e.g. Pione velans* and two unidentified *Spheciospongia*). The biomass of other filter feeders, especially ascidians (*e.g. Aplidium* cf. *crateriferum*), soft corals (*e.g. Chromonephthea* spp.), gorgonians (*e.g. Junceella fragilis* and *Dichotella gemmacea*) was also high, indicating the importance of these groups in characterising hard bottom habitats. Although low in biomass, crinoids such as *Comaster multifidus* and *Comatula pectinata* were abundant in samples that included a high biomass of other filter feeders.

Keywords: marine, benthic flora, benthic fauna, Kimberley, Gourdon Bay, Dampier Peninsula

Introduction

The marine environment of the Kimberley coastline in north-western Australia is very poorly documented, few studies having been conducted there due mainly to its remoteness (Masini *et al*. 2009). Although it is one of the few marine domains on earth largely unaffected by human impacts (Halpern *et al*. 2008), the Kimberley region is currently undergoing a revolution of increasing economic importance as a tourist destination and coastal developments of a significant scale are planned associated with exploitation of oil and gas reserves in the region. As a result of the likely increase in human usage and impacts in the region there is an imperative to gain an understanding of the distribution of marine habitats and the biodiversity these habitats support. There have been a limited number of expeditions which have documented the flora and fauna of different parts of the Kimberley coastal and marine environment including the southern Kimberley islands (Wells *et al*. 1995), the eastern Kimberley (Walker *et al*. 1996), the central Kimberley (Walker 1997). A survey covering the whole of the Kimberley region (Morgan 1992) did not include any coastal section of the Dampier Peninsula. This study is the first to report on the subtidal benthic marine flora and fauna of Gourdon Bay and the Dampier Peninsula, areas situated in the most southerly part of the Kimberley. The specimens sampled for this study were collected during an extensive video survey of benthic habitats conducted by Fry *et al.* (2008).

Materials and Methods

Surveys were undertaken in the Kimberley region of Western Australia between 9 and 25 June 2008 at locations both north and south of Broome (Fig. 1). Five localities were surveyed; Gourdon Bay, Quondong Point to Coulomb Point, Carnot Bay to Beagle Bay, Perpendicular Head and Packer Island. Fifteen epi-benthic dredge operations were undertaken to collect benthic flora and fauna from a variety of bio-habitat types identified from underwater video footage obtained using a towed video camera. A galvanised steel frame dredge, with an opening measuring 1.5 m wide by 0.5 m high and steel meshed sides of 1.0 m depth, was towed by *FV Eylandt Pearl* at 1–1.5 knots. A nylon codend (25 mm stretched mesh) was attached to the back of the dredge to collect the sample. The operations ranged in depth from 11–23m and were from 45 to 280m in distance

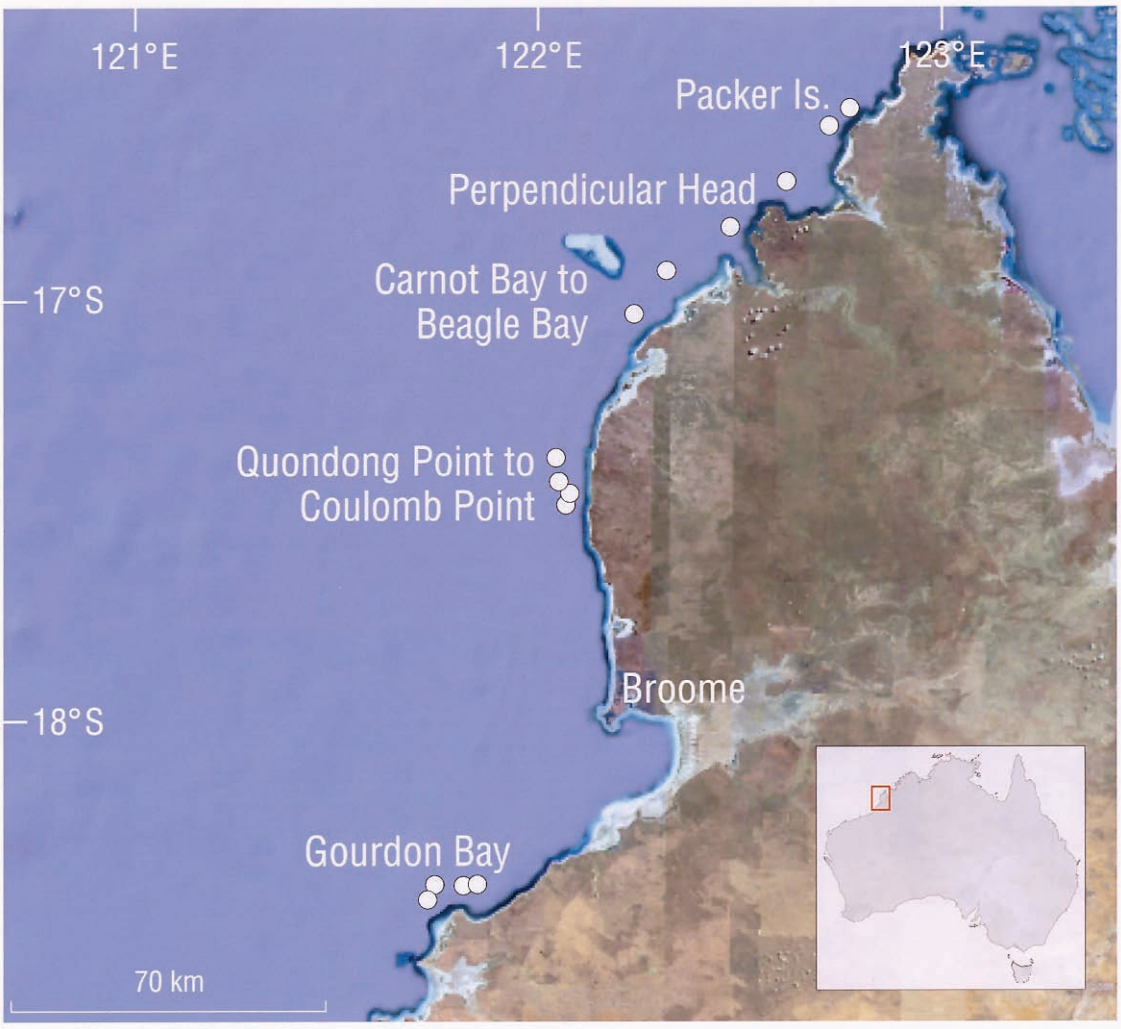

Figure 1. Location of the epi-benthic dredge towns in the Kimberley region.

Table 1

Location, date tow distance, area covered and depth of epi-benthic dredge operations

Location	Site ID	Date	Start Location	Tow Distance (m)	Area Covered (m^2)	Start Depth (m)
Gourdon Bay	2873	9/06/2008	-18.37945, 121.87140	171.4	257.1	16.8
Gourdon Bay	2898	9/06/2008	-18.38482, 121.81413	45.4	68.1	18.6
Gourdon Bay	2904	11/06/2008	-18.38633, 121.84475	280.8	421.2	14.6
Gourdon Bay	3144	9/06/2008	-18.42075, 121.76002	120.3	180.5	11.9
Quondong-Coloumb Pt	1811	17/06/2008	-17.36437, 122.06283	100.9	151.4	13.8
Quondong-Coloumb Pt	2037a	15/06/2008	-17.42017, 122.07507	86.8	130.2	11.4
Quondong-Coloumb Pt	2037b	15/06/2008	-17.42025, 122.07508	81.4	122.1	11.5
Quondong-Coloumb Pt	2132	16/06/2008	-17.45342, 122.10032	185.5	278.3	12.5
Quondong-Coloumb Pt	2200	15/06/2008	-17.47582, 122.08982	163.7	245.6	14.6
Perpendicular Head	714	20/06/2008	-16.70150, 122.62322	214.7	322.1	16.1
Perpendicular Head	1391	21/06/2008	-16.81005, 122.49002	85.7	128.6	19.2
Packer Island	278	25/06/2008	-16.52520, 122.77970	96.7	145.1	23.4
Packer Island	487	25/06/2008	-16.56675, 122.72845	151.0	226.5	16.6
Carnot Bay–Beagle Bay Line 4	5411	23/06/2008	-17.02107, 122.25362	131.1	196.7	15.7
Carnot Bay–Beagle Bay Line 5	5515	22/06/2008	-16.91575, 122.33305	117.7	176.6	12.3

depending on the density of the biohabitat targeted (Table 1). Biota collected by the dredge was sorted into species or higher level taxonomic groups, weighed (fresh wet weight to nearest gram) and photographed. Entire samples or representative subsamples of each species were retained and frozen. Some were subsequently preserved in ethanol prior to being identified to species level at a later date. Only the following groups of taxa were identified to species level (initials in brackets denote author responsible for identifications): macrophytes (JH; JP), sponges (JF), ascidians (GC), cnidarians (PA; except corals, DT and hydroids, JW), crustaceans (AH), molluscs (SS) and echinoderms (LM; except crinoids, KN).

Results

Species diversity

Among the taxonomic groups identified, we found 415 species: 43 algae, 1 seagrass, 52 sponges, 30 ascidians, 10 hydroids, 14 scleractinians, 49 alcyonarians, 3 other cnidarians, 69 crustaceans, 73 molluscs (including 37 bivalves and 33 gastropods) and 71 echinoderms (15 crinoids, 12 asteroids,18 ophiuroids, 2 regular echinoids, 12 irregular echinoids and 12 holothuroids. A species list is provided in Table 2 along with a relative abundance based on the biomass per m^2 of tow area. Table 2 also denotes the new records for Australia (2) and Western Australia (13, including two algae, one ascidian, one crustacean and 10 alcyonarians) and the likely new species discovered (3, including one each of Alcyonaria, Echinoidea and Holothuroidea). It should be noted that because of the absence of previous sampling of some taxa from anywhere in north-western Australia and the poor status of taxonomic knowledge for some taxa (*e.g.* Porifera, Cnidaria, Crustacea and ascidians) further new species and new records are likely to be included in the samples collected which have been or will be lodged with the Western Australian Museum.

Diversity- by site

For most flora and fauna groups, the greatest diversity was recorded at either the Gourdon Bay or the Quondong to Coulomb Point locations. This is certainly the result of increased sampling effort on both hard and soft bottom types at these two locations, with 926m^2 and 927m^2 surveyed for Quondong to Coulomb Point and Gourdon Bay respectively, compared to 451m^2 at Perpendicular Head and 372m^2, at Packer Island and 373m^2 between Carnot Bay and Beagle Bay. Further, only soft sediment habitats were surveyed at Perpendicular Head and Packer Island and only hard bottom was sampled between Carnot Bay and Beagle Bay (Table 3). For these reasons we have not attempted to contrast the diversity between sites, however the data recording the number of species in each taxonomic group at each location is shown in Table 3.

Biomass

Sponges were the dominant fauna by biomass (up to 620 $g.m^{-2}$) in the dredge samples where hard substrate existed (Table 4). A large number of species was collected (52) although the biomass was dominated by a few large cup and massive sponge species (*e.g. Pione velans* and two unidentified *Spheciospongia*). The genus *Pione* belongs to a group of obligate bioeroders of calcium carbonate. The bulk of this species was the calcium carbonate substratum the sponge had eroded and overgrown. Non-hard coral cnidarians were also an important component of the filter feeder biomass with many species of soft coral (*e.g. Chromonephthea* spp.); and gorgonains (*e.g. Junceella fragilis* and *Dichotella gemmacea*) present in the samples. Non hard coral cnidaria comprised up to 68 $g.m^{-2}$ (Table 4). Ascidians (both colonial and solitary) were an important component of the fauna dredged at all five locations with 8 of the 15 dredge samples having ascidian biomass greater than 40 $g.m^{-2}$. Dominant ascidians in terms of biomass were *Aplidium* cf. *crateriferum* (up to 66 $g.m^{-2}$) (Table 2). Although low in

Table 2

List of species identified from each of the five locations (GB: Gourdon Bay, QC: Quondong Point to Coulomb Point, PH: Perpendicular Head, PI: Packer Island) and BB: Carnot Bay to Beagle Bay). Relative biomass indicated as *<0.1g.m^2, **0.1– 1 g.m^2, ***1– 10 g.m^2, ****10 – 100g.m^2, *****>100g.m^2. Species underlined are probable new species, Species with suffix (A) or (WA) are new records for Australia or Western Australia.

Location	PI	PH	QC	GB	BB	Location	PI	PH	QC	GB	BB
ALGAE						*Axinella* sp. K1			***		
Amphiroa sp.				*		*Axinella* sp. K2					***
***Areschougia* sp.**					*	*Axinella* sp. K3			**		
Asteromenia exanimans			**	*		*Axinella* sp. K4	***		***	****	
Botryocladia leptopoda			**			*Axinella* sp. K5				***	
Caulerpa lentillifera			**			*Axos flabelliformis*		***	***		
Caulerpa racemosa var. *lamourouxii*			**			*Callyspongia* sp. K1	**		***		***
Caulerpa serrulata				*		*Cinachyra* cf. isis	***	***			
Champia parvula			**			*Cinachyra* sp. K1			***		
Chondria sp.			*			*Cinachyrella?* sp. K1			***		
Chondrophycus sp.1					*	*Ciocalypta* sp. SS3		***	****		
Chondrophycus sp.2			**			*Clathria (Thalysias) abietina*			***	***	
Cladophora herpestica				*		*Clathria (Thalysias)* cf. *lendenfeldi*			**		
Coelarthrum opuntia			*		*	*Clathria cactiformis*	**				
Cystoseira trinodis					*	*Cliona* sp. K1					***
Dasya sp.					*	*Cymbastela* cf. *vespertina*	*	***	***		
Dichotomaria marginata		**		**	*	Cymbastela sp. K1			**		
Dictyopteris woodwardia					***	*Discodermia discifera*	***				***
***Dictyota ceylanica* (WA)**				*		*Echinochalina* sp. K1			****		
Dictyota dichotoma var. *intricata*				*		*Echinodictyum* cf. *cancellatum*			***		
Digenea simplex					*	*Echinodictyum* cf. *clathrioides*			***		
Gelidiopsis intricata				*		*Echinodictyum clathrioides*	***		***	***	
Gelidiopsis scoparia				*		*Ectyoplasia tabula*	**		***	***	***
Gelidiopsis sp.				*		*Halichondria* sp. K1				****	***
Griffithsia metcalfii			**			*Higginsia* sp. K1	***				
***Halimeda* cf. *cuneata* f. *digitata* (WA)**			**			*Hippospongia* sp. SS1			**		
Halimeda discoidea			**	*		*Iotrochota* cf. baculifera	***			***	
Halimeda opuntia				*	***	*Luffariella* sp. K1			***		
Halymenia floresii			**		*	*Oceanapia* cf. *macrotoxa*	***		****		
Hypnea cervicornis					*	*Phakellia* sp. K1				****	
Hypnea sp.				*		*Pione velans*				*****	
Jania cf. *adhaerens*				*		*Raspailia* cf. *clathrata*			**		
Laurencia sp.				*		*Raspailia* cf. *nuda*			**		
Lobophora variegata				**		*Raspailia phakellopsis*				****	
Peyssonnelia sp.1				*		*Raspailia vestigifera*				****	
Peyssonnelia sp.2				*		*Reniochalina* cf. sp. 1	***				
Polysiphonia sp.			**			*Reniochalina* cf. *stalagmitis*	***	***	***		
Sargassum sp. juv.				*		*Reniochalina* sp. 1	***	***	****		
Sargassum sp.1			**			*Reniochalina* sp. 2	**	***	***	***	
Scinaia tsinglanensis			**		*	*Sarcotragus* sp. SS8		***	****	****	*****
Sebdenia flabellata					*	*Spheciospongia* sp. K1		***	*****	*****	
Solieria robusta			**			*Spheciospongia* sp. K2		***	****	*****	
Spirocladia barodensis				*		*Spheciospongia* sp. K3			****		
Udotea flabellum				*		*Theonella levior*				****	
SEAGRASS						*Thorecta* sp. K1	**		*****		****
Halophila decipiens	**		**			*Thrinacophora* cf. *cervicornis*	*				**
PORIFERA:						*Trikentrion flabelliforme*	***		***		
Aka sp. K1	**					*Xestospongia testudinaria*			****		
Aka sp. K2		***		****		ASCIDIA: Colonial					
Anthotethya fromontae	***		***	***		*Aplidium* cf. *crateriferum*			****		
Aplysinidae sp. K1			***			*Aplidium* sp. 1			****		
Arenosclera sp. K1			***			*Aplidium* sp. 2	***				**

Location	PI	PH	QC	GB	BB	Location	PI	PH	QC	GB	BB
Aplidium sp. 3	****		***			*Alertigorgia orientalis*			**	**	
Aplidium sp. 4		***	***	***	***	*Alertigorgia* sp. 1				**	
Aplidium sp. 5			**			*Carijoa* sp. 1	**			***	
Didemnum sp. 1	**		***	***		***Chromonephthea curvata* (A)**	**		***		***
Didemnum sp. 2			***	**	**	*Chromonephthea* cf. *curvata*			***		
Didemnum sp. 3			***			***Chromonephthea fruticosa* (WA)**			***		
Didemnum sp. 4				***		***Chromonephthea ostrina* (WA)**					***
Didemnum sp. 5		*		**		*Chromonephthea* sp. 1			****		
Didemnum sp. 6				**		*Chromonephthea* sp. 2			***		
Didemnum sp. 7	**		****			*Chromonephthea* sp. 3				**	
Didemnum sp. 8	**					*Chromonephthea* sp. 4			***		
Distaplia cf. *stylifera*		****		***		*Chromonephthea* sp. 5			**		
Eudistoma sp.				***		***Chromonephthea* cf. sp. 5**			**		
Nepthesis fasacicularis	***					*Chromonephthea* sp. 6					
Pseudodistoma sp.1	****		****	**		*Chromonephthya* sp. 7					**
Pseudodistoma sp.2		****	****	****		*Ctenocella pectinata*	**	**			**
Pseudodistoma sp.3		****	****	****		*Dendronephthya* sp. 1				**	**
ASCIDIA: Solitary						*Dendronephthya* sp. 2	**				**
Cnemidocarpa cf. *radicosa*		****	*	***	**	*Dendronephthya* sp. 3	**				
Phallusia obesa				**		*Dendronephthya* sp. 4					**
Phalusia cf. *arabica*				**		*Dendronephthya* sp. 5					**
Phalusia cf. *millari*	***		***	**		*Dendronephthya* sp. 6					**
***Polycarpa* cf. *intonata* (WA)**	****	***			****	*Dendronephthya* sp. 7					**
Polycarpa cf. *papillata*	**				***	*Dendronephthya spinosa*				**	
Polycarpa chinensis		*			***	*Dichotella gemmacea*	*	***		**	**
Polycarpa clavata	**	**		***		*Echinogorgia reticulata*			***		
Polycarpa sp.					**	*Echinogorgia* sp. A		**			
Polycarpa sp. 2					**	*Echinogorgia* sp. B		**			
CNIDARIA: Hydrozoa						*Echinogorgia* sp. C		**			
Gymnangium longicorne					***	*Euplexaura* sp. 1		**		**	
Idiellana pristis	***					*Euplexaura* sp. 2					**
Macrorhynchia philippina				*		***Junceella fragilis* (WA)**	**	**	**	****	**
Macrorhynchia phoenicia				*		***Lobophytum crassum* (WA)**			***		
Plumularia badia	***					*Melithaea albitincta*				***	
Plumularia scabra					****	*Melithaea* sp. 1					***
Polyplumaria cornuta	****					*Melithaea* sp. 2			***	**	
Sertularella diaphana	**			**		*Menella simplex*		**			
Sertularella decipiens	**			**		*Menella* sp. 1				**	
Thyroscyphus fruticosus				**		*Nephthea* sp. 1				***	
CNIDARIA: Scleractinia						*Nephthyigorgia kukenthali*			**		
Balanophyllia cf. *generatrix*		**				*Paraplexaura* cf. *mikrodentata*	*	**			
Cycloseris cyclolites	**	*		**		*Paraplexaura* cf. *rigida*				**	
Goniastrea aspera				****		*Paraplexaura multispinosa*	*	**			
Heterocyathus hemispherica		*		*		***Pseudopterogorgia australiensis* (WA)**					*
Montastrea curta			****			***Rumphella aggregata* (WA)**				**	
Moseleya latistellata			****			*Rumphella* sp. 1				**	
Porites australiensis	***					***Sinularia* cf. *acuta* (A)**			***		
Porites lutea				****		***Subergorgia suberosa* (WA)**		**		***	*
Porites solida				****		CNIDARIA: Zoanthiniaria anemone					
Psammocora contigua	***					*Sphenopus marsupialis*		**		**	
Truncatoflabellum cf. *spheniscus*	**			**		CNIDARIA: *Black Coral* (unidentified)		***			**
Tubastrea sp.			***			CNIDARIA: Sea Pen					
Turbinaria patula			****	****		*Sea Pen* (unidentifed)					**
Turbinaria reniformis		**		****		CRUSTACEA: *Decapoda*					
Turbinaria sp. (no sample)					****	*Achaeus brevirostris*	*				
CNIDARIA: Alcyonaria						*Actaea tuberculosa*			*		
Acabaria sp. 1	**					*Actumnus* sp. 1			*		

Table 2 (cont.)

Location	PI	PH	QC	GB	BB	Location	PI	PH	QC	GB	BB
Actumnus sp. 2		*	*		*	*Synalpheus tumidomanus*			*		
Actumnus sp. 3				*		*Thalamita annulipes*				*	
Alpheus pareuchirus	*		*	*		***Tumidodromia dormia* (WA)**				**	
Alpheus villosus			*	*	*	*Upogebia darwini*			*		
Anacinetops stimpsoni	*					***Vellumnus labyrinthicus* (WA)**				*	
Calappa capellonis			*			CRUSTACEA: Sessilia					
Calappa clypeata	*	*				***Solidobalanus* socialis (WA)**		*			
Ceratocarcinus longimanus	*					*Striatobalanus amaryllis*		*			
Charybdis helleri			*		*	CRUSTACEA: *Stomatopoda*					
Charybdis jaubertensis				*		*Carinosquilla carita*			*		
Charybdis sp.				*		*Gonodactylaceus graphurus*			*	*	
Cryptopodia fistulosa		*		*		*Haptosquilla corrugata*				*	
Dardanus imbricatus		*	*			MOLLUSCA: Bivalvia					
Dardanus setifer			*			*Acrosterigma* cf. *wilsoni*			**		
Dardanus squarrosus			*			*Annachlamys flabellata*				**	
Dorrippe quadridens				*		*Antigona chemnitzii*					**
Etisus anaglyptus				*		*Antigona lamellaris*				*	**
Gomeza bicornis					*	*Barbatia* cf. *helblingii*			**	**	
Gonatonotus pentagonus	*					Barbatia cf. *lima*	*				
Halimede ochtodes			*			*Barbatia* sp.			*		
Heteropanope sp. 1			*	*		cf. *Lithophaga* sp. (damaged)				*	
Huenia heraldica			*		*	*Chama* cf. *fibula*					**
Hyastenus sebae			*		*	*Chama* cf. *lazarus*				***	
Izanami inermis	**	**		*	*	*Chama* sp.			***		
Leucosia haswelli	*	*				*Circe* cf. *scripta*	*				
Liomera pallida				*		*Circe scripta*		**			
Lissoporcellana spinuligera				*		*Dosinia* sp. (juv)					**
Lophopilumnus globosus			**			*Eucrassatella pulchra*					**
Menaethius monoceros				*		*Fulvia* cf. *australe*	*				
Metapenaeopsis mogiensis		*			*	*Gastrochaena* cf. *philippinensis*					*
***Metapenaeopsis sinuosa* (WA)**	*					*Glycymeris* cf. *crebriliratus*	*				
Metapenaeus sp. 1	**		*			*Glycymeris dampierensis*	**	***			
Micippa excavata	*					*Glycymeris persimilis*				*	**
Myra australis	*	*				*Hiatella* cf. *australis*			**		
Myra cf. *affinis*		*	*			*Laevicardium biradiatum*				*	
Nodolambrus nodosus	*	*	*			*Laevicardium* cf. *biradiatum*					**
Pachycheles sculptus		*	*	*		*Lima vulgaris*	*			**	
Petrolisthes militaris	*		*	*	*	*Mactra incarnata*	*			*	**
Philyra platycheir			*			*Mimachlamys* cf. *funebris*				**	
Pilodius sp. 1					*	*Mimachlamys funebris*				*	
Pilumnopeus sp. 1	*	*	*	*	*	*Modiolus phillipinarum*	*				
Pilumnopeus sp. 2			*	*		*Paphia semirugata*	*				
Pilumnus pulcher			**	**		*Pinctada maxima*	***				
Pilumnus vespertilio			*	*		*Pinna deltodes*				**	
Polyonyx biunguiculatus				*		*Pinna* sp. (juv).				*	
Polyonyx triunguiculatus			*			*Placamen tiara*			*		
Portunus curvipenis		*				*Pteria* cf. *lata*				**	
Portunus rubromarginatus	**		*			*Pteria penguin*				***	
Pseudolambrus harpax	*					*Semele* cf. *zebuensis*	*				
Pseudopaguristes sp. 1			*			*Spondylus* cf. *violascens*				**	
Schizophrys dama	*		*	**	**	*Spondylus victoriae*	**			*	
Seulocia laevimana			*			*Trisidos semitorta*	*				
Stimdromia lateralis				*		MOLLUSCA: Cephalopoda					
Synalpheus comatularum				*	**	*Sepia papuensis*				*	
Synalpheus pococki			**			*Octopus* sp. A				*	
Synalpheus stimpsoni			*	*		*Octopus* sp. B	**				

Location	PI	PH	QC	GB	BB
MOLLUSCA: Gastropoda					
Ancillista muscae				**	
Cantharus erythrostomus				**	*
cf. *Calthalotia* sp.			*		
Chicoreus banksii					**
Clanculus atropurpureus				*	
Clanculus bicarinatus			*		*
Conus cf. reductaspiralis			*		
Conus novaehollandiae			*		
Cronia avellana			**	**	**
Cymatium cf. vespaceum			*		
Cypraea subviridis dorsalis			*		
Diadora cf. singaporensis			*		
Engina cf. *curtisiana*				*	
Fasciolariidae			*		
Gyrineum cf. *lacunatum*			*		
Herpetopoma atrata		*		*	
Hexaplex stainforthi			**	**	
Latirus sp.				*	
Morula? sp.				*	
Murex acanthostephes	*		**		
Natica euzona					
Phos senticosus	*		*		
Scutus unguis					
Strombus campbelli	*			*	
Syrinx aruanus	**				
Tectus fenestratus					
Thais echinata			*	**	
Turris cf. *crispa*			*		
Vexillum vulpeculum	*	*			
MOLLUSCA: Opisthobranchia					
Bornella anguilla					**
Moridilla brockii			*		**
Nembrotha purpureolineata	*		**		
Platydoris sp.			*		
ECHINODERMATA: Crinoidea					
Capillaster multiradiata	*				***
Clarkcomanthus littoralis		*	**		*
Clarkcomanthus luteofuscum				*	
Comanthus wahlbergii				***	
Comaster multifidus			***	***	***
Comaster schlegelii	*		**	**	**
Comatella maculata				**	***
Comatula pectinata	*	***	**	***	***
Comatula rotalaria	**	***		***	
Heterometra crenulata	***	**			
Heterometra sarae				*	
Zygometra cf. *comata*				*	
Zygometra comata	*			*	*
Zygometra microdiscus				*	
Zygometra punctata			*		
ECHINODERMATA: Asteroidea					
Anthenea conjungens			***		
Astropecten monacanthus			*	*	
Astropecten vappa	**				
Astropecten velitaris			**	**	

Location	PI	PH	QC	GB	BB
Astropecten zebra	**	**	*	**	
Echinaster varicolor				**	
Goniodiscaster acanthodes			**		
Gymnanthenea globigera				**	
Metrodira subulata	**			*	
Nepanthia belcheri				**	**
Pseudoreaster obtusangulus			***		
Stellaster childreni	**	**		***	
ECHINODERMATA: Ophiuroidea					
Dictenophiura stellata			*		
Macrophiothrix caenosa				*	
Macrophiothrix callizona				*	
Macrophiothrix cf. *megapoma*					*
Macrophiothrix megapoma			**	**	*
Macrophiothrix microplax				*	
Ophiactis savignyi				*	
Ophiochasma stellata		*		*	
Ophioconis cincta				*	
Ophiomaza cacaotica		*	*	*	***
Ophiothrix (Keystonea) martensi				*	
Ophiothrix (Keystonea) smaragdina		*	*	*	*
Ophiothrix (Placophiothrix) lineocaerulea			*	**	*
Ophiothrix (Placophiothrix) striolata				*	
Ophiothrix ciliaris	*	*	*	**	*
Ophiothrix ciliaris/exigua		*	*		
Ophiothrix exigua		*	*		
Ophiothrix sp.1			*	*	
ECHINODERMATA: Echinoidea					
Breynia desorii	***	****	*****	****	***
Brissopsis sp.					***
cf. *Gymnechinus* sp.				*	**
Clypeaster (Coronanthus) telurus					**
Clypeaster latissimus				*	
Clypeaster (Stolonoclypus) virescens		**		**	
Echinolampas ovate					***
Lovenia elongate				****	***
Peronella lesueuri	**	**	**	***	
Peronella macroproctes	*	**			*
Peronella orbicularis	*	**			
Peronella tuberculata	*		*		
Prionocidaris bispinosa	***			**	**
Temnopleurus alexandri				**	**
ECHINODERMATA: Holothuroidea					
Actinocucumis typica					**
Cercodemas anceps	**	*	**	*	
Cladolabes schmeltzii			***		
Colochirus crassus			**		
Colochirus quadrangularis			***	***	**
Holothuria (Halodeima) atra					**
Holothuria (Theelothuria) michaelseni	**			*	
Phyllophorus (Urodemella) proteus					***
Phyllophorus sp.					**
cf. *Phyllophorus* sp.					*
Stolus buccalis				***	*
Synaptula recta			***		***

Table 3

Summary of the dredge area and number of species within functional groups recorded in each epi-benthic dredge tow (PI – Packer Island; PH – Perpendicular Head; QC – Quondong Point to Coulomb Point; GB – Gourdon Bay; BB – Carnot Bay to Beagle Bay).

Location	Transect #	Habitat	Area Sampled (m^2)	Algae	Sea-grass	Pori-fera	Asci-dia	Cnid-aria	Crust-acea	Moll-usca	Echino-dermata
PI	278	Soft	145	0	0	2	4	5	10	12	13
PI	487	Soft	227	0	1	23	9	14	11	9	9
PH	714	Soft	322	0	0	0	3	2	9	2	11
PH	1391	Soft	129	1	0	11	6	16	7	3	9
QC	1811	Soft	151	13	1	26	5	6	14	12	14
QC	2037a	Hard	130	0	0	0	0	0	4	1	8
QC	2037b	Hard	122	5	1	6	6	3	6	5	10
QC	2132	Soft	278	4	1	20	6	13	18	9	12
QC	2200	Soft	245	0	0	0	2	0	7	2	6
GB	2873	Soft	257	0	0	3	2	2	10	7	28
GB	2898	Hard	68	2	0	9	3	7	11	2	15
GB	2904	Soft	421	1	0	0	2	4	2	9	19
GB	3144	Hard	181	18	0	11	12	20	16	15	16
BB	5411	Hard	197	10	0	4	9	14	4	6	9
BB	5515	Hard	177	6	0	8	3	11	10	12	23

biomass, crinoids such as *Comaster multifidus* and *Comatula pectinata* (up to 18 $g.m^{-2}$) were abundant in samples that included a high biomass of other filter feeders (Table 4).

Benthic primary producers had a low biomass in the samples collected. Few hard corals were caught with the most dominant species being *Turbinaria patula and T. reniformis*. The highest coral biomass recorded was at Gourdon Bay (up to 426 $g.m^{-2}$). Other areas of high coral cover were observed in the surveys conducted by Fry *et al* (2008) however it is thought the type of dredge used did not adequately sample some massive and encrusting growth forms efficiently. In addition no hard bottom was sampled in the Perpendicular Head and Packer Island locations. Algae and seagrass had low biomass at all sites, with the exception of the site nearest Carnot Bay (5411) where algae comprised about 13 $g.m^{-2}$ (Table 4).

Echinoderms were well represented in the samples and comprised the highest biomass of any taxa on soft bottom habitats. Three of the dredge tows at Gourdon Bay and Quondong-Coulumb (2200, 2873, and 2904) caught a large number of the heart urchins (*Breynia desorii* and *Lovenia elongata*) with a biomass of between 55 and 326 $g.m^{-2}$ (Table 4). The biomass of asteroids was highest on soft sediment habitats (up to 3.36 $g.m^{-2}$) of which most was *Stellaster childreni* but few other types of organisms were caught in the dredge at these transects as the substratum was observed to be nearly 100% bioturbated fine sand or bare coarse sand. Molluscs were common in the samples but made up a low biomass due to their small size. The sampling gear would have been ineffective in sampling small molluscs as a result of the 25mm mesh size. The biomass of other taxa not included in the taxonomic analysis is included in Table 4, the highest biomass of which was bryozoa (up to 294 $g.m^{-2}$) at Gourdon Bay.

Discussion

Previous surveys of the Kimberley region (Wells *et al*. 1995; Walker *et al*. 1996; Walker 1997; Morgan 1992) have not covered the Dampier Peninsula and Gourdon Bay regions so this study contributes to a gap in our knowledge of the biodiversity of an important part of the Kimberley coast where development pressure is expected to increase. In addition, previous surveys have not examined some of the taxonomic groups covered here (*e.g.* non-coral cnidarians, porifera and ascidians). These filter feeder taxa dominate much of the biomass of benthic habitats in this region (*e.g.*, Table 4 this study; Fry *et al*. 2008). Elsewhere in Western Australia, where more extensive studies have been undertaken, such as in the south-west (McEnnulty *et al*. in press) and in the north-west at Ningaloo (Fromont unpublished) and the Dampier archipelago (Fromont *et al*. 2006), filter feeders such as sponges also dominate benthic animal biomass. Further research in the Kimberley is likely to reveal that filter feeders play an important role in the ecosystem and thus these groups warrant more attention in biodiversity surveys in the region. Below we discuss the findings of this study for each of the taxonomic groups examined.

Algae and Seagrass

A total of 43 species of macroalgae from 22 families were identified. The greatest diversity of marine flora was recorded at the Quondong to Coulomb Point location (24 species), followed by Gourdon Bay (21 species). *Halophila decipiens* was the only seagrass species collected. This species was identified in four tow samples from Packer Island and Quondong-Coulumb.

Of the 43 species of algae, 14 could not be identified further than genus level, although they were recognised as discrete entities. In some instances (*e.g. Laurencia* sp.,

Chondrophycus sp.1 and sp.2) this was due to specimens being infertile, as reproductive material is necessary to confirm the placement of such species. Certain other species (*e.g. Peyssonnelia* sp.1 and sp.2) require a detailed examination of the internal structure, aided by appropriate taxonomic keys. Specimens of some smaller species (*e.g. Hypnea* sp., *Dasya* sp., *Polysiphonia* sp.) were damaged by the freezing and thawing process and could not be identified beyond genus level.

Among the green algae (Chlorophyta), *Caulerpa* and *Halimeda* were most diverse with three species from each genus collected. One species of *Halimeda* had a distinctive appearance of large lower segments giving rise to numerous chains of narrow, elongated segments and was assigned to *Halimeda* cf. *cuneata* f. *digitata*. This species has not been recorded in WA although more detailed internal examination and/or genetic sequencing would be required to confirm its placement within this species.

The brown algae (Phaeophyceae) were represented by seven species belonging to the families Dictyotaceae and Sargassaceae. Several juvenile *Sargassum* plants (*Sargassum* sp.) were also collected in the samples. These juvenile plants may have been different species, but due to their small size (to ca. 2 cm high) could not be identified further. A large, reproductively mature *Sargassum* specimen (*Sargassum* sp.1) could not be identified to species level due to the lack of detailed taxonomic information available for *Sargassum* occurring in north-west Australia. The taxonomy of the north-west *Sargassum* species is currently under investigation (Dixon & Huisman 2010) and the voucher specimen from the current survey will be revisited at a later date. The distribution of *Dictyota ceylanica* in Western Australia is unknown at present, however it is reported to occur worldwide in tropical and subtropical waters (Abbott and Huisman, 2004; Huisman *et al.,* 2007).

The red algae were the most diverse group among the collection, with 28 species recorded. Families were represented by only 1–3 species, with the exception of the Rhodomelaceae with seven species. The widely distributed but rarely collected (Huisman, 2000) *Asteromenia exanimans* was identified from two tow samples from Quondong-Coulumb and Gourdon Bay. A specimen identified as *Areschougia* sp. may possibly be a new species, but fertile (reproductive) material or genetic sequencing would be required to confirm this. Within Western Australia, *Gelidiopsis scoparia* has currently only been reported from Ningaloo and Dampier Archipelago.

The marine flora of north-western Australia is relatively poorly known and a comprehensive flora list has yet to be published for the region (Huisman *et al*., 2009). Huisman and Borowitzka (2003) reported 210 species from the Dampier Archipelago, while an earlier survey of the eastern Kimberley region by Walker (1996) recorded 93 species from the intertidal zone alone. A survey of the marine flora of the region's offshore atolls (Rowley Shoals, Scott Reef and Seringapatam Reef, Huisman *et al*. 2009) recorded 210 species, and gave an estimate of the north-western Australian flora as > 350 species. The present study recorded 44 species of macroalgae and seagrass from the dredge tows in waters of between 11.4 and 23.4 depth. The lower species diversity in this study was due to this limited depth range, the method of collection and the targeted nature of the sampling design. A detailed examination of microscopic and epiphytic algae would have increased the number of species identified, but would still not fully account for the apparent low biodiversity. For example, the genus *Sargassum* in particular appears to be under-represented in the collection. This algae genus is among the most common macroalgae in tropical regions (Huisman 2000), yet only one adult species and several unidentifiable juveniles were collected. Macroalgae with certain morphologies, *e.g.* small, delicate or fragile thalli, are also likely to be under-represented in the collection. This is also likely attributed to the collection method and dredging equipment used. Walker & Prince (1987) visited 4 sites within the region of our study and recorded a total of 6 species of seagrass however their surveys were limited to intertidal areas.

Porifera

A total of 154 sponge specimens were examined for further identification. Of these, there were 52 species of Demospongiae from 18 families identified. A number of other sponge samples were caught in the dredges but not retained. These were only identified to the broad Porifera group. Of the identified taxa, the greatest sponge diversity was recorded at the Quondong to Coulomb Point location (52 species). This was followed by the Packer Island location (25 species) and Gourdon Bay location (23 species), with only 11 species recorded at the Perpendicular Head location and nine from the Carnot Bay to Beagle Bay location.

Due to complications with historic literature and the current classification for the Porifera group, just over half of the 52 species (29) were not identified to species. These have been identified as discrete species and given a species number which is consistent with all Porifera identification from the Western Australian Museum. It was therefore not possible to determine if these unidentified taxa have been previously described or are new species. Of the 23 species that were identified, nine species have been previously reported from Western Australia and the Northern Territory. A further seven species appear to be endemic to the west coast of Australia. Most of these species have previously been reported from north Western Australia, around the Dampier Archipelago due to the significant amount of sponge research that has been undertaken in that area. Three additional species are known to occur in tropical Australia and four are widespread Indo-Pacific. This suggests that the Kimberley has a few Indo-Pacific sponge species but the majority are more restricted in their distribution to the north and northwest of Australia, or are Western Australian endemics.

North Western Australia is known to have a high diversity of sponges. Hooper *et al.* (2002) considered the North-West Shelf of Western Australia to be one of three sponge biodiversity hotspots in Australia, containing more than 600 species. Bergquist and Kelly-Borges (1995) found more species of the Indo-Pacific family Ianthellidae in the Dampierian province (mid-west to north-west Australia), with two apparently endemic species, than anywhere else in the Indo-Pacific region. Furthermore, a study in the Dampier Archipelago recorded 275 sponge species collected by both dredge and diver expeditions (Jones 2004). However, the sponge fauna of the coastal

Table 4

Biomass (g.m^{-2}) of benthic catch from each dredge operation within the five locations (GB: Gourdon Bay, QC: Quondong Point to Coulomb Point, PH: Perpendicular Head, PI: Packer Island and BB: Carnot Bay to Beagle Bay).

		PI	**PI**	**PH**	**PH**	**QC**	**QC**	**QC**	**QC**	**QC**	**GB**	**GB**	**GB**	**GB**	**BB**	**BB**
	Transect Number	**278**	**487**	**714**	**1391**	**1811**	**2037a**	**2037b**	**2132**	**2200**	**2873**	**2898**	**2904**	**3144**	**5411**	**5515**
	Area Sampled (m^2)	145	227	322	129	151	130	122	278	245	257	68	421	181	197	177
Algae	*Halimeda*													0.10		
	Other Chlorphytes												0.01		2.03	
	Chlorophyte/Rhodophyte															
	Mix				0.28	2.58		<0.01	0.57			0.53		0.93	6.53	0.43
	Phaeophyte	0.10										0.26		0.09	3.38	0.01
Seagrass	*Halophila*		0.18			0.19		0.01	0.29							
Cnidaria	Hydrozoa	15.27	2.69		4.46							0.53		0.20	18.37	1.81
	Anemone				0.31											
	Soft corals					41.64			65.94			0.71		3.26	6.27	
	Gorgonians (branched)		0.95	0.34	20.60	2.18		1.64	2.34			0.85		11.88	1.04	0.75
	Gorg. (unbranched)		0.19		3.65	4.76			0.54			3.03		16.93	0.79	0.39
	Hard Coral		5.76	0.01	0.34	38.34		26.21				426.07		199.43	58.30	3.14
	Solitary Coral										0.76		0.31			
Cnidaria	Unspecified		4.30			32.06						4.35			5.31	0.63
Porifera	Demospongiae														3.05	
	Cup					165.24			58.57					37.73	40.51	
	Massive					227.44			39.17		36.85	251.08		369.52	88.64	
	Mixed				37.35							226.40		67.22		
	Unspecified	0.85	77.06	0.11		229.82		126.55	71.62	0.12					6.41	362.49
Crustacea	Decapoda	0.37		0.25	0.12	1.12	0.20	0.25	0.58	0.06	0.90	1.18	0.04	0.31	0.16	0.72
	Unspecified	0.73	0.57													0.11

Echinodermata	Asteroidea			0.68	0.12	1.32			1.65	0.24	1.21	0.26	3.36	1.09		0.74
	Echinoidea	7.76		24.22	0.34	0.97	0.23	0.17		325.91	92.62	0.97	55.70		0.81	9.38
	Holothuroidea	0.21	0.12	0.09		0.13	0.05	1.05	3.59	0.12	0.06	6.20	0.03		1.87	5.40
	Crinoidea	3.93	0.38	3.26	0.16	3.79	1.07	0.13	0.28		5.11	18.19	3.06	1.16	7.45	1.47
	Ophiuroidea			0.09	0.19	0.25	0.08	0.08	0.21		0.71	0.94	0.08	0.66		0.18
	Unspecified	4.12	1.58	0.59									17.82			
Mollusca	Gastropoda			0.09	0.36	0.70		0.03	0.27	0.01		0.29	0.15	0.51	0.71	
	Bivalvia			0.06	1.52	9.52		0.23	0.36	<0.01	1.07	0.29	0.37	12.28	0.31	2.19
	Cephalopoda												0.04			
	Octopoda													0.03		
	Opisthobranchia		0.04			0.40	0.00		0.01						0.16	0.11
Mollusca	Unspecified	81.21	12.98								0.10					0.11
Ascidia	Solitary Tunicates			0.09	1.76			1.64		0.07	0.49		0.83	17.31	30.24	3.85
	Colonial Tunicates	77.21	42.93		118.62	80.04		49.47	91.63		1.08	99.55	0.10	83.96		
	Didemnidae											5.44		2.14		
Bryozoa	Unspecified	1.38	0.36	0.06	0.87							293.84		1.35	1.95	1.83
Annelida	Polychaeta			0.02				0.49						0.02		0.26
Nemerteans	Unspecified		0.19													
Sipuncula	Unspecified				0.08						0.51					
Teleosts	Unspecified	1.86	0.59		0.75	0.62	1.31	1.64	0.18	0.24	0.30	0.73	0.38	0.04	0.10	0.23
Biol. Conglomerates	Excl Sponge		3.91				17.66	13.10								6.39
	Incl Sponge					165.24	92.13	343.97								
Other	Rocks / Rubble				147.73						116.67	550.95	49.85	421.02	864.77	116.09
Total Catch		195	155	30	340	1008	113	567	338	327	258	1893	132	1249	1149	519

Kimberley region of Australia has been poorly studied and requires a significant amount of research. The collection of 52 species does not appear to reflect the extent of the sponge biodiversity expected within the Kimberley region but does give an indication of the high sponge diversity recorded from this limited area and the low number of dredge tows which targeted hard bottom habitats. That the diversity and biomass of sponges in the study region should be high, is not surprising and is consistent with other tropical locations along the Western Australian coast, such as Ningaloo Reef (Fromont pers. obs.) and the Dampier Archipelago (Fromont *et al*. 2006). Although it is likely that some sponge species in the area are new records or species for Western Australia, confirmation must await detailed taxonomic assessment. Nonetheless the sponge collection also contained examples of species that, based on gross morphology and skeletal characters, are widely distributed along the Western Australian coast and were also collected in deeper waters off Ningaloo (Fromont unpublished).

Ascidiacea

Thirty separate taxa of ascidians were sampled but only eleven of these species could be identified to species level, in part due to freezing before preservation. The remainder were identified to genus. Nineteen species of ascidians were identified from each of the Quondong to Coulomb Point and Gourdon Bay locations. Thirteen species were recorded at the Packer Island location and nine at the Perpendicular Head and Carnot Bay to Beagle Bay locations. Ascidians can be divided into two distinct morphologies, 'solitary species' where there is only a single individual or 'colonial species' where there are numerous, often small, individuals within a common colonial body or test. There were 20 species from six families that were colonial forms and 10 species from two families that were solitary forms. Colonial species were relatively abundant and three genera; *Aplidium, Didemnum* and *Pseudodistoma* represented the majority of the samples. These comprised six species of *Aplidium,* eight species of *Didemnum* and three species of *Pseudodistoma.* There was also one species representing each of the *Distaplia, Eudistoma* and *Nepthesis* genera. *Aplidium, Didemnum* and *Pseudodistoma* are widespread throughout Australia and species from these genera are found in most tropical and temperate waters (Kott 1990, 1992). Of the less common colonials, *Nepthesis fasacicularis* has previously been recorded across tropical Australia, including at Broome and *Distaplia stylifera* has a wide distribution through temperate and tropical Australia (Kott 1990, 1992).

The most common solitary ascidians were from the genera *Polycarpa* (six species) and *Phallusia* (three species). The most abundant of the solitary ascidians was *Polycarpa* cf. *intonata,* a small (3–5cm) round species heavily encrusted with sand and found buried in sandy sediments. This species has previously only been recorded in Queensland (Kott 1985). *Polycarpa* and *Phallusia* are common throughout Australia in both tropical and temperate waters. *Polycarpa chinensis* was also common in the samples and has a wide distribution including the Dampier Archipelago, Cockburn Sound, Queensland, Victoria, Vietnam and China and *Polycarpa* cf. *papillata* which also has a wide distribution from the Dampier Archipelago, Shark Bay, Queensland, Victoria, the Arafura Sea, Indonesia and Ceylon (Kott 1985). Of the less common genera in the samples *Cnemidocarpa* closely resembling *C. radicosa* was recorded, which has previously only been observed in temperate Australian waters (Kott 1985).

The species present in this collection indicate that both sandy sediment and some harder substrates were sampled with the dredge as taxa of both communities were represented. The ascidian fauna of the Kimberley region is not well known and there are no other collections known from this area. It is therefore difficult to make any direct comparisons of the expected diversity of species or to their known distributions in relation to other studies.

Cnidaria – Hydrozoa

Hydroids collected comprised ten species, from four families. Five of the species were collected at the Gourdon Bay location, four at the Packer Island location and one at each of the stations between Carnot Bay and Beagle Bay. These species form large colonies attached to shallow-water reef and rubble bottom and are adapted to fairly turbid conditions and mild to strong current flows. The samples comprised a suite of common tropical species with known distributions across much of tropical Australia (see Watson 2000). Some of these species have also been recorded from Indonesia and are circumglobal-tropical in distribution. No previous surveys of the Kimberley- Pilbara region have reported species compositions for the hydroids. However, diversity may be considered low, reflecting low sampling frequency at each site and coarse sampling methods by dredging rather than more selective scuba diving.

Cnidaria – Anthozoa – Scleractinia

Hard coral samples collected comprised 6 families, 11 genera and 14 species. Eight species were collected at the Gourdon Bay location and four species at each of the other four locations. Azooxanthellate scleractinian colonies were the most abundant group, comprising 44 of the 58 colonies identified. In comparison, colonies of zooxanthellate scleractinian species were less abundant (14 of the 58 colonies) but were more diverse in species (9 of the 14 species identified). The most abundant azooxanthellate species was *Cycloseris cyclolites* (31 colonies), while the two most abundant zooxanthallete species were *Turbinaria reniformis* (3 colonies) and *Turbinaria patula* (3 colonies). Eight of the 14 species recorded were represented by only one colony. The most represented family was Dendrophyllidae (5 species) followed by Faviidae (3 species) and Poritidae (3 species). In dredge samples where hard corals were recorded, diversity was generally low with usually only 2 or 3 species present. All 14 species of corals identified have widespread distributions and are common throughout the Indo-Pacific region (Cairns 1998; Veron & Marsh 1988) and north-western Australia, (Veron & Marsh 1988). None of these new records represent range extensions.

However, very few coral collections exist for the inshore waters of the Kimberley coast with accounts of hard coral diversity being available from only a limited number of studies. Veron and Marsh (1988) stated that 102 species of hard corals have been recorded from the

Kimberley coast and nearshore reefs; while more recently, Cairns (1998) recorded 87 species of azooxanthellate hard coral species from north-western Australian waters. However a recent survey by Griffith (2004) increased the number of hard coral species identified from the nearby Dampier Archipelago to 229.

Limited coral surveys conducted at Broome (15 species) and the Lacepede Islands (10 species) (Veron & Marsh 1988) suggest the species diversity observed in this study (14 species) may be representative of the local area. However, the low species diversity observed in this study may reflect low sampling frequency, limited depth range (11–23 m) or inadequate sampling in habitats considered favourable for the proliferation of hard corals (hard substrate).

Cnidaria – other Anthozoans

Forty-eight (48) species of other anthozoans from 11 families were sampled. Seventeen of these species were collected at the Gourdon Bay location, 16 at the Quondong to Coulomb Point location, 11 at the Perpendicular Head location and 10 at the Packer Island location. Of the 48 species only 21 were able to be identified to species level. The remainder were identified to genus level. The nomenclature for these genera needs revision as the current classification literature does not account for the high level of intra-colony and intra-species variability. It was therefore not possible to determine whether these anthozoan species constitute new previously undescribed species. There is, however, at least one new species of *Chromonephthea.*

There are potentially 10 species collected that now show range extensions into Western Australian waters (see Table 2). However, most are known to occur in other tropical coastal areas of northern Australia. Exceptions are *Sinularia* cf. *acuta* and *Chromonephthea curvata* which have both only been previously recorded only in Indonesia. Further, the only published record of *Paraplexaura* cf. *rigida* is from Shark Bay, WA. Nephtheidae and Plexauridae were well represented with 19 and 13 species from each family, respectively. The remaining nine families had less than four species present in the dredge samples, with five of these only having one species. As there is no other published literature on non-scleractinian cnidaria diversity in the Kimberley region, no conclusions can be made about the representativeness of this collection to expected species diversity of the region.

Crustacea

A total of 69 crustacean species from 21 families were identified from the dredge samples. The greatest crustacean diversity was recorded at the Quondong to Coulomb Point location (49 species), followed by the Gourdon Bay location (39 species), Packer Island (21 species) and Perpendicular Head (16 species). Of the 69 total species, ten could not be confidently identified to species level using current descriptions in the literature-six Pilumnidae hairy crabs (three *Actumnus*, two *Pilumnopeus*, one *Heteropanope*), one Portunidae swimming crab (*Charybdis*), one Xanthidae stone crab (*Pilodius*), one Diogenidae hermit crab (*Psueodopaguristes*) and one Penaeidae prawn (*Metapenaeus*).Most of the specimens collected belong to the order Decapoda, which contains the most familiar groups of crustaceans – the Anomura (Hermit crabs and false crabs) Brachyura (crabs), Caridea (shrimp), Gebiidea (ghost shrimp and mud lobsters), Penaeoidea (prawns).

The anomuran species present in this collection comprise only a small component of that group's diversity in tropical Australian waters, with only the Diogenidae (left-handed' hermit crabs) and Porcellanidae (porcelain crabs) represented.

The major families of the Brachyura were represented by at least one species each. The Pilumnidae was the most common brachyuran family in the collection, represented by 13 species. This family is very diverse and the species are very difficult to identify owing to a lack of comprehensive systematic accounts, resulting in a high proportion of specimens identified to morphospecies. The Xanthid crabs are typically the most speciose decapod family in areas where coral rubble/reef systems are present (*e.g.* Hewitt 2004; Hewitt *et al.* 2009), which contrasts with the four taxa present in the current collection. The two species of the pilumnid subfamily Eumedoninae identified, *Ceratocarcinus longimanus* and *Gonatonotus pentagonus*, are notable for their lifestyle as obligate commensals on crinoids and echinoids respectively. Such echinoderm associations are a common feature of this crustacean subfamily (Davie 2002b).

The only species in the Caridea group to be recorded from the dredge samples was the snapping shrimps of the family Alpheidae. Of these, two species are known to form associations with crinoids, *Synalpheus comatularum* and *S. stimpsoni*. A single bopyrid isopod was found as a parasite on a specimen of *Alpheus pareuchirus*.

There was also only one gebiid species collected, *Upogebia darwini*. Like other members of its group, this species burrows in soft sediments. However, it has also been found in close association with sponges. One of the specimens of *U. darwini* was found to be host to a rhizocephalan barnacle, an aberrant group which parasitises other crustaceans.

The non-decapod specimens identified belong to the Cirripedia (barnacles) and Stomatopoda (mantis shrimp) orders. Apart from the unidentified rhizocephalan, only two other specimens of barnacles were present, both being attached to the same gastropod shell inhabited by the hermit crab *Dardanus imbricatus*. The three species of stomatopods identified, *Carinosquilla carita, Haptosquilla corrugata* and *Gonodactylaceus graphurus* are common in tropical Australian waters (Ahyong 2001).

The majority of crustacean species recorded in the dredge samples have an extensive tropical Indo-West Pacific distribution (78%), in that most can be found across northern Australia and in south-east Asian waters. Only three species – *Dardanus squarrosus, Portunus curvidens* and *Thalamita annulipes* – are Western Australian endemics. Four of the species represented have not been collected during previous surveys in the region with *Metapenaeopsis sinuosa, Vellumnus labyrinthicus, Solidobalanus socialis* and *Tumidodromia dormia* newly recorded from Western Australian fauna (decapods not listed in Davie 2002a,b), This trend in the biogeographical affinity of decapod crustaceans is consistent with previous surveys of tropical Western

Australia (Morgan 1990; Hewitt 2004; Hewitt *et al*. 2009). The Kimberley subtidal decapod crustacean fauna can be summarised as being dominated by wide ranging Indo-Pacific species, with a low number of species being endemics to Australia. The majority of the species collected can be considered as exclusively tropical species, with only a few, such as *Stimdromia lateralis*, having a significant temperate distributional range (Davie 2002b).

While the decapod collection from this survey is quite diverse, there are several major groups not represented. No members of the Infraorder Palinura (crayfish, slipper lobsters) were collected although the shallow waters sampled should have been an ideal habitat for them. Specimens of the family Alpheidae were the only members of the Caridea (shrimp) collected, although the Caridea is the second largest infraorder of decapods, with approximately 600 species recorded from Australian waters (Davie 2002a).

Knowledge of the crustacean fauna of north Western Australia is patchy, but several expeditions have been carried out along the coasts of the central and northern Kimberley region focussing on the decapod crustacean fauna (*e.g.* Morgan 1992; Davie & Short 1995, 1996; Hewitt 1997). The records of the Western Australian Museum (Hosie unpublished) indicate that at least 400 species from 50 families of decapod and stomatopod crustaceans have been found in the Kimberley region as a whole and a similar number have been recorded from the Dampier Archipelago area in the Pilbara region (Hewitt 2004). Overall, the missing diversity reflects the limited range of habitat types surveyed and the limited depth range sampled. In addition it is most likely that species or groups under-represented in the samples are highly cryptic, commensal or otherwise associated with habitats that are not adequately sampled by dredge methods. The carideans in particular have a high rate of symbiotic relationships (Davie 2002a). Further species of crustaceans are perhaps still attached to their associated hosts. An increase in sampling effort and utilising multiple methods of capture would have increased the range of taxa sampled.

Mollusca

A total of 73 mollusc species were identified from the dredge samples. These comprised 3 cephalopods, 33 gastropods (including 4 opisthobranchs) and 37 bivalves. The greatest diversity of bivalves was recorded at the Gourdon Bay location (30 species), while the greatest diversity of gastropods was recorded at the Quondong to Coulomb Point location (18 species including 3 opisthobranchs).

The bivalves were represented by 16 families and 26 genera. The venus clams (Veneridae) were the most diverse group with 6 species from 5 genera identified. Many of the bivalves collected in the dredge samples are common free-living species of the soft-bottom habitats/ communities of tropical northern Australia. These included the arcid species, *Trisidos semitorta*, all of the glycymerid species, post-juvenile spondylid species *Spondylus victoriae*, the pectinid species *Annachlamys flabellatus* and species of the genus *Lima*, and all of the cardiid, semelid, mactrid, crassatellid and venerid species.

Those bivalves that were not free-living include byssate species; the arcid species of the genus *Barbatia*, the pteriid species of the genera *Pteria* and *Pinctada*, the mytilid species of the genera *Modiolus* and *Lithophaga*, the pectinid species *Mimachlamys funebris*, the pinnid species of the genus *Pinna*, and the hiatellid species of the genus *Hiatella*. The species of the genus *Pteria* commonly attach to up-standing biota such as gorgonians and seagrasses. Species of the genus *Lithophaga* burrow into dead and living corals and occasionally into soft rocks, while those of the genus *Hiatella* shelter within rock crevices or burrow into sponges, soft rock or even molluscan shells. Some non-byssate forms in this collection include the cemented species of the genus *Chama*, and the spondylid *Spondylus violascens.*

Three cephalopod species were also recorded: two from the Octopoda group, which could not be identified to species level, and one Sepiidae species. The Gastropoda in this collection consisted of 4 opisthobranchs and 30 Orthogastropoda. This latter group comprised 28 genera from 14 families with the most diverse genera being the Muricidae (7 species) and the Trochidae (5 species).

The geographic ranges of most of the mollusc species recorded in this survey are known to extend from the Central Indo-West Pacific region, along the northern coasts of Australia and southwards to the Pilbara Region of Western Australia. However, one species previously not recorded in the Kimberley region was recorded in this survey. *Acrosterigma wilsoni* was previously only known from the Muiron Islands and Ningaloo to Dampier Archipelago, WA.

The diversity of the molluscan fauna in the Kimberley area is known to be very high. Previous studies collected 292 and 232 species in western Kimberley and southern Kimberley respectively (Wells & Bryce 1995; Bryce 1997). However, there have been few detailed sampling surveys of the molluscan fauna along the mainland coasts of the Kimberley region, particularly along the western side of the Dampier Peninsula and adjacent coasts. The nearby Dampier Archipelago has also been found to be very diverse in molluscan species; a total of 695 species were recorded from intertidal and subtidal hand collection surveys in 1998–2002 (Jones 2004). More recently Bryce and Whisson (2009) found 339 species of molluscs in surveys of atolls offshore from the Kimberley at Scott and Seringapatam Reefs.

The relatively low diversity of the molluscan species taken during this survey (73 species), and the relatively high degree of variation in the species between the survey sites can be attributed to the low sampling frequency, the small size and cryptic nature of most molluscan species which are not adequately sampled by the dredging methodology used and to the limitation in data of not including dead-taken molluscan specimens. Those species that are typical of this area but are not represented in the survey samples are of small size and/ or are inhabitants of specific habitats. Their absence is probably due to constraints associated with the limited number of samples at each site, meaning few habitat types were adequately covered and the type of dredging gear employed – such as large mesh size.

Echinodermata

There were 71 species of echinoderms. These included 15 crinoids (feather stars), 12 asteroids (sea stars), 18 ophiuroids (brittle stars), 14 echinoids (urchins) and 12 holothuroids (sea cucumbers). The greatest diversity of crinoids, asteroids, ophiuroids and echinoids were all recorded at the Gourdon Bay location. The greatest diversity of holothurians was recorded at the site nearest Beagle Bay (5515).

The crinoid species represented in the dredge samples were generally typical of the crinoid communities seen in the northern WA region. There were three families represented by eight genera and fourteen species. Nine of these species are from the family Comasteridae, including two from the genus *Comatula* which is generally the dominant crinoid genus in shallow waters of central and northern Western Australia. This study did not further extend any of the species distribution ranges, nor were any new species reported. The collection is much less diverse (three families and eight genera) than samples from other regions that have been studied. However little is known of the Kimberley region specifically. This lower diversity may be due to the sampling of predominantly shallow waters or from the sampling methods employed. For example, the collection appeared to be restricted to larger specimens with none of the typically smaller groups, such as the Antedonidae or the Colobometridae, recorded in the dredge samples. In addition, no species of the Calometridae family were recorded; where the reef-dwelling *Neometra* species within this family have been present in previous tropical surveys from Western Australia.

Small species of *Ophiothrix* ophiuroids were abundant in this collection, with most being *O. ciliaris.* This species shows a high level of variability and is superficially similar to *O. exigua* which was also recorded in the dredge samples. Two specimens cut across the characters that separate the species and have been identified as *O. ciliaris*/ *exigua*. Another very small ophiuroid of the *Ophiothrix* genus was unable to be indentified. Many of the ophiotrichid species are associated with sponges while *Ophiomaza cacaotica*, another species identified from our dredge samples, is commensal on large crinoids.

One species of echinoid could not be identified to any currently described species. This was a small species from the genus *Gymnechinus.* Additionally, one species of holothurian of the genus *Phyllophorus* could not be identified to species level using the currently available literature and may represent a new species. Irregular echinoids, dominated by *B. desorii* made up the highest biomass of any mobile invertebrates in this study, had biomasses comparable to habitat defining taxa such as corals and sponges and (Table 4) are likely to be of significant ecological importance in soft sediment habitats in the Kimberley region (Keesing & Irvine, in press).

All of the asteroid species in this collection have been previously recorded in north-western Australia. While this is also the case for most of the crinoids, ophiuroids, echinoids and holothurians, one species recorded here from each group have not been previously described in the current literature.

While this collection recorded 71 species, other studies in the area have recorded many more. In comparison, 286 species of echinoderms were recorded in the Dampier Archipelago (Jones 2004) with 170 of these species collected from 100 sites using rake box dredge methods, 90 other species were collected during SCUBA diving transects and the remaining 26 species were already present in the WA Museum collection. In another study, 127 species were recorded on the North-West Shelf by a broad scale trawl survey between Barrow Island and Port Hedland (20–200m) in the early 1980s (WA Museum, unpublished). In a study by the WA Museum to collate echinoderm records (excluding holothurians) for north Western Australia, 338 species were recorded on the shelf and inshore islands north of North West Cape (Marsh & Marshall 1983). Such comparative studies show this collection underestimates the echinoderm community expected.

It is notable that this collection does not contain any species of the asteroid *Luidia,* specifically the large *L. maculata* which is a known predator of heart urchins which were found to be very abundant in some areas within the four locations sampled. Overall this collection can be regarded as a subset of those of the Dampier Archipelago and North-West Shelf. Differences may be due to the sampling methods and intensity of sampling.

Summary

This study has made a significant contribution to the knowledge of a range of plant and invertebrate taxa from north-western Australia with 415 species recorded and was the first survey of subtidal habitats in the Dampier Peninsula region. Despite the limited nature of the sampling in terms of sites and area and only one method of collection (epibenthic sled), a significant number of new species, range extensions and new records for Western Australia and Australia were recorded. For some taxa (*e.g.* hydrozoa, alcyonaria and ascidia) these are the first published records of species occurrences from the Kimberley region of Western Australia.

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