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Kimberley marine biota. Historical data: echinoderms

Alison Sampey[1*] and Loisette M. Marsh[1]

[1] Department of Aquatic Zoology, Western Australian Museum, Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

* Email: alison.sampey@hotmail.com

ABSTRACT – Australian state museums contain extensive species data and can provide baseline biodiversity information for many areas. We collated the specimen records from the Kimberley region of Australia and found 382 shallow water (<30 m) echinoderm species, comparable to available estimates of species richness from adjacent regions such as the Pilbara, 'Coral Triangle' or Great Barrier Reef. We identify and discuss taxonomic and collecting gaps, cross shelf patterns in species richness and composition, biogeography, and suggest some areas for future research on echinoderms in the region. At most locations, echinoderms have been incompletely sampled and many taxonomic gaps are apparent. Sampling to date has focused on hard substrates, yet there are extensive soft sediment areas in the region. More collections have occurred at inshore reefs and islands, which are more numerous, than at offshore atolls. Cumulative species richness is higher inshore than offshore, but at most inshore locations species richness is lower than offshore. However, this is biased by more collections having occurred intertidally inshore compared to subtidally offshore and much remains to be discovered about the inshore subtidal echinoderm fauna. Five times more endemic species are recorded inshore than offshore, with conservation implications. Further work is needed to identify specimens in existing collections.

KEYWORDS: natural history collections, species inventory, biodiversity, NW Australia, baseline

INTRODUCTION

The importance of utilising natural science collection datasets to provide baseline biodiversity information for conservation and environmental management decisions is now recognised (Pyke and Ehrlich 2010). The Kimberley region of Australia is currently of great interest for its conservation value with a number of proposed marine protected areas, and also for its oil and gas reserves, fishing and aquaculture activities, nature based tourism, and proposed development (Department of Environment and Conservation 2009). Consequently, baseline data to 'characterise the assets and values' in the region are needed (Wood and Mills 2008).

The Western Australian Museum (WAM) and other Australian natural science institutions have undertaken marine biodiversity surveys of the species present in the region, but much of these data and their interpretation is either unpublished or published in specialist taxonomic literature, so not readily accessible to researchers and managers. To address this data gap, WAM instigated an extensive data compilation of marine taxa known from an area henceforth titled the Kimberley Project Area (Project Area). Wilson (2014) has reviewed the historical and environmental background of the Project Area (defined below in the methods). Throughout this paper 'inshore' refers to locations along the coast, and the numerous islands and reefs found shoreward of the 50 m depth contour (Figure 1). 'Offshore' refers to the shelf edge atolls that rise from deeper waters (200–400 m) along the continental margin. Here, we document what is currently known about shallow water echinoderm diversity in the Project Area.

ECHINODERMS

Echinoderms are predominately marine, occasionally estuarine animals. Modern echinoderms encompass five classes, Asteroidea (sea stars), Echinoidea (urchins, sand dollars), Crinoidea (feather stars), Ophiuroidea (basket and brittle stars), and Holothuroidea (sea cucumbers). The last class includes the commercially important bêche-de-mer or trepang species, of which six species are targeted by fishers in Western Australia (Fletcher and Santoro 2010).

Knowledge of species traits (habitat preference, feeding mode, development, spawning, settlement, and behaviour) and how these interact with biogeochemistry (temperature, salinity and oxygen) and biophysical processes (competition, predation, nutrient availability, coastal complexity, local and regional currents) is important in understanding macroecological processes (Webb et al. 2009) as well as evolution, cryptic speciation and diversity (Byrne 2006). Echinoderms inhabit soft and hard substrates and form associations with a range of sessile marine invertebrates (such as sponges, soft and hard corals and ascidians) and are hosts for an array of motile species (e.g. crustaceans, molluscs, polychaetes and fishes). They have a range of feeding strategies from predatory to scavenging (including carnivorous, herbivorous, omnivorous, microphagous, suspension and deposit feeders) and a variety of reproductive strategies (brooding, broadcast spawning, direct development and asexual reproduction by fissiparity).

Echinoderm species are known to demonstrate substantial differences in population densities, especially over decadal time scales (Uthicke et al. 2009). The crown-of-thorns sea star, *Acanthaster planci* is probably the best studied echinoderm species in this regard largely due to the explosion in numbers and subsequent impact on coral communities on the Great Barrier Reef. Other species are introduced marine pests. For example, the northern Pacific sea star, *Asterias amurensis* has caused habitat alteration and loss of native species in south eastern Australian waters. However, detection of marine pest species requires knowledge of native species (Huisman et al. 2008). Therefore, it is important to document the spatio-temporal occurrence and diversity of echinoderms.

AIMS

This paper aims to:

1. collate records of shallow water (<30 m) echinoderm species in the Project Area, which are verified by specimens lodged in Australian museum collections (1880s–2009) to provide a baseline diversity dataset;
2. identify taxonomic and collection bias and gaps;
3. test whether there are proportionally more wide ranging species (e.g. Indo-West Pacific or Indo-Pacific) occurring offshore than inshore – i.e. species that inhabit clear oligotrophic waters versus endemic or Indo-Australian species, which would have higher tolerances to the silty turbid waters occuring inshore; and
4. explore cross shelf differences in species richness and composition.

HISTORY

The earliest collections of echinoderms in the Kimberley were probably made during a French expedition led by Thomas Nicholas Baudin (1801–1803) on the *Géographe*. This expedition dredged and made a cursory survey of the coast as far north as the Bonaparte Archipelago and anchored near Cassini Island in 1801 (Marchant 1982). Regrettably, the naturalist Péron died before completing his expedition narrative and although Freycinet completed the writing of a volume of expedition notes, these did not detail what happened to all specimens collected from the region. It is likely that the echinoderms collected on this expedition were examined by Lamarck (1816) who described 20 species of echinoderms, 17 of which were Australian, other specimens were from Mauritius and 'la mer des Indies'. Unfortunately, none of these species had a precise locality recorded, as Péron's field notes were not available to Lamarck, so it is unknown if any of the specimens were collected in the Kimberley, although many of these species occur in the area.

Phillip Parker King surveyed northern Australian waters including the Kimberley between 1818 and 1822. Three species of urchins were recorded, although the precise locality of the collections was not (King 1827). Two British navy ships (*H.M.S. Penguin* and *Egeria*) passed through the Kimberley in the 1880s and some collections were made and later documented (Bell 1893, 1894) (Table 1). A new species of sea star collected at Holothuria Bank on the same expedition was later described as *Gomophia sphenisci* (Clark 1967).

The Swedish Mjöberg Expeditions (1910–1913) collected echinoderms off Cape Jaubert (at the northern end of 80 Mile Beach) and at Broome. Thirty nine species of echinoderms were later described from these collections by Mortensen (1918), Ekman (1918), Gislén (1919), and Döderlein (1926) (Table 1). Döderlein (1926) listed three species collected off Cape Jaubert, one of which, *Tamaria pusilla*, appears to have been collected from 110 m depth. Moreover, one of the species figured by Mortensen (1918) was *Goniocidaris tubaria*, a temperate species unlikely to occur in the Kimberley (the locality may have been recorded incorrectly).

The documentation of northern Australian echinoderms owes most to H.L. Clark of the Museum of Comparative Zoology at Harvard who visited Broome in 1929 for two months and again in 1932 for one month (Clark 1938). He collected intertidally, dredged in shallow waters, and obtained specimens from pearl divers between Augustus Island and 80 Mile Beach. From these collections he documented 198 species and described 71 new species (Clark 1938) of which 27 have been synonymised (Rowe and Gates 1995).

TABLE 1 Number of locations, species, families and classes of echinoderms sampled during main survey expeditions in the region and presented as reports. NB. *List provided for north-west Australia includes four locations, two in the Kimberley (Holothuria Bank and Baudin Island) and two in the Pilbara (Magnetic Shoal and Cossack). **Crinoids not surveyed. [D]Collections in deep waters (>100 m). ***WAM surveys.

Survey Year	No. Locations	No. Stations	No. Species	No. Families	No. Classes	Reference
1880s?	1?[D]	-	2	2	1	Bell 1893
1880s?	4*	-	52	20	5	Bell 1894
1911	2	-	7	4	1	Gislen 1919
1911	2	-	13	8	1	Mortensen 1918
1911	2	-	16	5	1	Ekman 1918
1911	1	-	3	3	1	Döderlein, 1926
1929, 1932	c. 15	-	198	47	5	Clark 1938
1982	2	16	90	30	5	Marsh 1986***
1984	2	23	117	35	5	Marsh 1986***
1986	2	24	178	37	5	Marsh et. al. 1993***
1990	7	9	33+	20	5	Marsh 2011
1991	25	34	82	29	5	Marsh 1992***
2006	3	45	52	21	4**	Bryce and Marsh 2009***
2008	5	15	71	25	5	Keesing et. al. 2011

WAM surveyed six offshore atolls in the 1980s: Clerke and Mermaid Reefs, Rowley Shoals in 1982 (Marsh 1986), Scott and Seringapatam Reefs in 1984 (Marsh 1986) and Ashmore Reef and Cartier Island in 1986 (Marsh et al. 1993) (Table 1). Extensive collections were made by one of the authors (L.M. Marsh) who collected all classes of echinoderms from a variety of habitats. Species and family richness were high at all atolls, but highest at Ashmore Reef and Cartier Island (178 species; Table 1). Incidental collections of echinoderms (excluding crinoids and ophiuroids) were made at three offshore atolls (Mermaid, Scott and Seringapatam Reefs) in 2006 with 52 species from 21 families collected (Bryce and Marsh 2009).

Echinoderms were surveyed along the Kimberley coast in 1990 when the Western Australian Naturalists' Club visited Adele Island and sites around Camden Harbour (Marsh 2011). A 1991 WAM survey visited 25 locations between Broome and Wyndham and recorded 82 species from 29 families (Table 1). During both surveys, echinoderm collections were largely incidental. A recent (2008) dredging survey of the epibenthos along the Dampier Peninsula and Gourdon Bay recorded 71 echinoderm species (Keesing et al. 2011).

Based on several of these early collections, some generalisations have been suggested for the echinoderm fauna in the region. Firstly, different species occur inshore compared to offshore (Marsh and Marshall 1983). Secondly, more endemic species occur inshore compared to more widespread (e.g. Indo-West Pacific) species offshore (Marsh and Marshall 1983). Thirdly, species richness is higher offshore than inshore (Marsh 1992), although this conclusion was based on total species richness, and neither the differences between intertidal and subtidal habitats, nor unequal sampling efforts were addressed.

METHODS

The Project Area encompasses an area west and north of the Kimberley coast (south of Broome to the Western Australia-Northern Territory border) extending beyond the 1,000 m bathymetric contour, with the coastline forming a natural inshore boundary (Figure 1, see Sampey et al. 2014 for a full explanation of the study area). We include all five classes of echinoderms.

The methodology followed that explained in detail by Sampey et al. (2014). Briefly, echinoderm species data were sourced from the collection databases of the WAM (data extracted January 2010), the Museums and Art Galleries of the Northern Territory (MAGNT, received August 2009) and the Australian Museum (AM, received August 2009) as well as the species presented in four reports on five survey expeditions in the Kimberley (Table 1; Marsh 1986, 1992; Marsh et al. 1993; Bryce and Marsh 2009). During the review process for this manuscript a small collection of echinoderms at the Museum of Victoria (MV) was drawn to our attention. These were collected on a single expedition to Ashmore Reef and Johnson Bank in 2002 both intertidally and on SCUBA to depths down to 21 m. Where possible we have incorporated these into our tables. We have included the echinoderms recorded by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) survey along the Dampier Peninsula and Gourdon Bay (Keesing et al. 2011) in our species list (Appendix 2), but the numbers of specimen lots, locations, and species richness per location are not included. Many of the specimens collected by this survey, except for the Crinoidea (currently at the MV), have been deposited at WAM and are now incorporated into the collections.

Species names represent hypotheses, which are subject to change as new information (morphological, molecular, behavioural and distributional) is discovered (Gaston and Mound 1993). The species names and taxonomic placement of the records in the dataset were verified to present the currently accepted species name and resolve synonymies and old combinations, but the specimens were not re-examined (Sampey et al. 2014). Species names were checked using online databases (Appeltans et al. 2010; ABRS 2011), the Zoological Catalogue of Australia (Rowe and Gates 1995) and recent taxonomic publications.

SPATIAL INFORMATION, COLLECTION DETAILS AND MAPPING

Data from all sources were collated into a single database (Sampey et al. 2014). Location and collection details were checked and verified. The collection locations of the specimen records were visualised using ARCGIS ArcMap v9.3, outliers were examined and the latitude and longitude corrected, or the record excluded, as appropriate. Maps of species richness and sampling effort were generated for each major location. Since species richness patterns are highly dependent on sampling effort, we calculated the number of collecting events at a location to give an indication of relative sampling effort. A collecting event was defined by the season and year of collecting. The full list of locations, latitude and longitude and other relevant collection information is provided in Table 2 in Sampey et al. (2014).

BIOGEOGRAPHIC AND HABITAT CODING

Species were coded for their known biogeographic range and habitat (Table 2 and 3). Biogeography and habitat coding broadly follows the Australian Faunal Directory (AFD, ABRS 2011) and the Zoological Catalogue of Australia (Rowe and Gates 1995) for each species. Additional information for coding was derived from the distribution ranges listed by Clark and

TABLE 2 Biogeographic Codes assigned to taxa in the Kimberley Project Area.

Code	Definition
WA	Western Australian endemic. Currently known from WA waters, often only from the type locality; may be a northern Australian endemic with more collecting effort.
NA	Northern Australian endemic. Recorded in tropical Australian waters.
SA	Southern Australian endemic. Recorded in temperate Australian waters and presence in the Kimberley region is the northern extent of its range.
A	Australian endemic. Recorded in tropical and temperate Australian waters.
IA	Indo-Australian. Recorded in Australian and Indonesian waters, may extend to the Philippines and Japan.
IO	Indian Ocean. Restricted to the Indian Ocean.
IWP	Indo-West Pacific. Recorded in the Red Sea, Indian and western Pacific Oceans.
IP	Indo-Pacific. Recorded in the Red Sea, Indian and Pacific Oceans.
WP	West Pacific. Recorded in the western Pacific, presence in the Kimberley region indicates occurrence in the south eastern Indian Ocean.
T	Tropicopolitan. Recorded in all tropical oceans.
C	Circumglobal. Recorded in all oceans in both tropical and temperate waters.
RS	Red Sea. Also occurs in the Red Sea, species likely needs revision.

TABLE 3 Habitat Codes assigned to taxa in the Kimberley Project Area.

Code	Description
i	Intertidal zone.
s	Subtidal zone.
H	Associated with hard substrates (e.g. rock, coral, rubble).
S	Associated with soft substrates (e.g. sand, mud).
SG	Seagrass meadows.
EZ	Epizoic. External association with a species of animal.
EP	Epiphytic. External association with a species of marine plant.
U	Habitat of the species is unknown.

Rowe (1971), papers on Australian *Macrophiothrix* species (Hoggett 1990, 1991, 2006), and general habitat information (Coleman 2007). If a species did not conform to a single code then appropriate combinations were used.

DATA ANALYSES

A subset of the data was generated from WAM expeditions (see Table 1 and Sampey et al. 2014 for a summary) where species were recorded per station. These WAM expeditions visited inshore and offshore locations and collected intertidally at low tide by reef walking and subtidally on SCUBA. In this subset, echinoderm data were available from 45 inshore and 8 offshore locations. A 'location' is the nearest named island, reef or coastal feature, which was standardised according to the methods outlined in Sampey et al. (2014). Collection effort was variable amongst stations, expeditions and locations, which affected the calculation of species richness and distance measures, as stations with few species appear as outliers (O'Hara 2007). To address this, we followed the methods employed by O'Hara (2007) and species poor (≤5 species) samples were removed from the dataset. All analyses were undertaken in PRIMER v6.1.11 (Clarke and Warwick 2001; Clarke and Gorley 2006).

To investigate if patterns in species richness were lower inshore than offshore and also intertidally compared to subtidally, species accumulation curves were generated in PRIMER and confidence intervals calculated (Zar, 1999).

To explore compositional differences across the shelf, the presence of species was pooled at location and then visualised using non metric multidimensional scaling (nMDS) with the Bray Curtis distance measure. The species contributing to cross shelf differences were determined using similarity percentages (SIMPER).

RESULTS

NUMBER OF SPECIMENS IN COLLECTIONS

A total of 2,761 registered specimen lots of echinoderm species were included in this dataset (Table 4). A specimen lot is one or more individuals of the same species from a single sample that has been assigned a unique registration number in a museum database. The number of lots included was variable across families, ranging from one for the Spatangidae, Caudinidae and Gorgonocephalidae to 357 for the Ophiotrichidae (Appendix 1). The number of specimen lots housed in the various institutions was also variable (MV: 96, 3% of the total; AM: 374, 14%; MAGNT: 623, 22% and WAM: 1668, 61%; Table 4).

TABLE 4 Number of registered echinoderm specimen lots from the Project Area housed in Australian museum collections. Included are those lots identified to species or Operational Taxonomic Unit and excluded are those lots incompletely identified (out of parentheses) or from deepwater (>30 m) locations (in parentheses).

Collection	No. of Specimen Lots Included	Excluded	Total
AM	374	137 (18)	529
MAGNT	623	28 (112)	763
WAM	1,668	466 (1,381)	3,515
MV	96	4	100
Total	2,761	2,146	4,907

Many specimen lots were excluded from the present dataset (2146 lots, 45% of the total; Table 4). The majority (1511 lots) were excluded as they were collected from waters deeper than 30 m and so outside the scope of our study. Some of the excluded records would add extra families (and species) to our dataset, but these are known deepwater fauna that never inhabit shallow waters, e.g. Benthopectinidae (Appendix 1). The remaining lots were excluded due to incomplete or incorrect identifications where the specimens require re-identification (631 lots, 30% of the total excluded lots).

The oldest Kimberley specimens were a heart urchin, *Breynia desorii* (originally identified as *B. australiae*) collected from Broome in 1913 in WAM, an urchin (*Proraster jukesii*) collected by H.L. Clark from Roebuck Bay in 1929 in AM and a sea cucumber (*Cercodemas anceps*) and a basket star (*Euryale asperum*) collected in 1975 from York Sound and housed in MAGNT.

In addition to collections of Kimberley specimens housed in Australian museums, the next most important collection is based on the extensive collections made by H.L. Clark in 1929 and 1932. Most of these are housed in the Museum of Comparative Zoology, Harvard (MCZH) with only a few specimens in AM and WAM.

Thirty eight of the echinoderm species collected from the Kimberley have formed the basis of new species descriptions (i.e. holotypes, paratypes and syntypes), although three of these have been synonymised (Appendix 2). For example, *Archaster angulatus* includes specimens originally identified and described as *Archaster laevis* by Clark (1938), and subsequently synonymised. Two species of crinoids,

TABLE 5 Number of species with each biogeographic code.

Biogeographic Code	Inshore	Offshore
no code	6	3
WA	18	2
NA	31	8
A	5	3
IA	45	26
IA/IO	18	7
IA/RS	1	0
IA/WP	0	3
IO	5	5
IP	7	12
IWP	71	132
T	4	4
WP	15	17
C	1	1
Total	227	223

TABLE 6 Number of species with each habitat code.

Habitat Code	Inshore	Offshore
H^{i}	2	7
H/S^{i}	0	4
H/S^{is}	6	3
H/S^{is}	2	4
$H/S^{is}/SG$	0	3
H/S^{s}	16	16
$H/S^{s}/SG$	2	1
H^{i}/S^{is}	7	5
H^{i}/S^{is}	8	8
H^{is}	22	44
H^{is}/EZ	1	2
H^{s}	60	56
H^{s}/EP	0	1
H^{s}/EZ	13	14
H^{s}/S^{i}	0	2
$H^{s}/S^{i}/SG$	0	1
H^{s}/S^{is}	1	4
S^{i}	2	2
S^{i}/SG	1	1
S^{is}	15	9
S^{is}/SG	1	0
S^{s}	61	33
U	7	3
Total	227	223

Toxometra lepta and *T. poecila* collected by H.L. Clarke near Broome are not included in our species list as the types are housed in MCZH collections, which were not searched for this study as only data obtained from Australian museum collections were included (see Methods above and Sampey et al. 2014 for full justification). Our list includes species remaining to be described e.g. *Protankyra* sp. nov. 1 (Appendix 2).

SPECIES RICHNESS AND COLLECTING EFFORT

We recorded a total of 382 echinoderm species from 54 families (Appendix 2). This included 71 species of Asteroidea, 51 species of Crinoidea, 58 species of Echinoidea, 91 species of Holothuroidea, and 111 species of Ophiuroidea. In addition, are three crinoid species recorded previously from the area and not included in our dataset; *T. lepta* and *T. poecila* recorded by Clark (1938), and *Phanogenia typica* recorded by Gislén (1919) from Cape Jaubert (as *Comaster typica*) taking the total number to 385 species.

A number of species are known only from the type material, for example, *Anthenoides dubius* H.L. Clark, 1938, was collected between Lagrange Bay and Broome in 10–37 m of water. The types are lodged in MCZH and AM and the species has not been collected since.

Echinoderm data are available for 93 locations in the Kimberley (Appendix 3, Figures 1–3), and Johnson Bank (12.37367°S 123.26833°E); MV collections are not incorporated into the figures). Species richness ranged from 173 at Ashmore Reef to one at 15 inshore locations. Collecting effort was also variable, ranging from 41 collecting events at Broome to one at 48 locations. The number of families collected at any one location was also variable with 41 families collected at Broome compared to only one family at 17 locations. Cumulatively, more species have now been recorded inshore than offshore (227 versus 223 species; Tables 5, 6, Appendix 2), but collecting effort is also higher inshore than offshore (90 versus 15 collecting events). No collecting has occurred at Browse Island (midshelf), Hibernia or Imperieuse Reefs. Only three locations in the eastern Kimberley have been sampled for echinoderms.

Although the total cumulative number of species is higher inshore than offshore this is not the case for individual locations. Generally, species richness recorded from any inshore location (except for Broome) is lower than that recorded offshore. For example, Ashmore Reef had the highest species richness of the offshore locations (173 species), which was similar in species richness to Broome (167 species). However, the collecting effort at Broome was much higher (41 collecting events) than at Ashmore Reef (8 collecting events).

With similar sampling effort, species richness was substantially higher offshore than inshore for the intertidal stations and the combined dataset (Figure 4). For subtidal stations, this pattern was much less clear. To date, only 20 subtidal stations have been sampled inshore, providing a total species richness of 60. The total species richness for the subtidal stations offshore was substantially higher (144 species from 70 stations). The species accumulation curves for subtidal habitats inshore and offshore are closer than for either intertidal or the combined stations. Species richness values were only slightly higher offshore than inshore for comparable sampling effort (20 stations offshore had 76 species versus 60 species inshore), and the confidence intervals of the data overlap. There has been more sampling effort in the intertidal inshore compared to offshore (42 versus 31 collecting events respectively). In the subtidal there has been little collecting effort inshore compared to offshore (20 versus 70 collecting events, respectively; Table 5).

Multivariate species composition patterns show a clear division offshore compared to inshore, both intertidally and subtidally (only the combined assemblages shown; Figure 4), with an average dissimilarity of 94%. The offshore locations are more tightly clustered indicating a higher degree of similarity (average similarity 52%) in assemblage composition offshore compared to the inshore locations (average similarity 14%). This is in part a function of the lower numbers of echinoderm species inshore compared to offshore, but also due to the variety of habitats sampled inshore compared to offshore. Moreover, some species have been found only inshore while others occurred only offshore, e.g. *Phyllacanthus longispinus* inshore and the common coral reef sea star, *Linckia laevigata* offshore (Appendix 2). Some of these differences may be due to a sampling artefact, but they agree with the currently known Australian distributions of the species.

Several species pairs of the same genus exemplify the inshore versus offshore division in species composition. *Protoreaster nodulosus* (Perrier, 1875) is an inshore endemic species found only from the Houtman Abrolhos to Admiralty Gulf, while *P. nodosus* (Linnaeus, 1758) is widespread from Queensland throughout the Indo-West-Central Pacific, and in Western Australia has been recorded only from Ashmore Reef (Appendix 2).

BIOGEOGRAPHY AND HABITATS

The majority of species at both inshore and offshore locations were widespread species (all categories C, IO, IP, IP/AT, IWP, T, WP; see Table 2 for definitions), with 102 species inshore compared to 167 offshore (Table 5). However, the proportion of widespread species was higher offshore than inshore (77% of the total versus 45%, respectively; Table 5). By comparison, the proportion of endemics (categories WA, NA, and A) inshore was almost five times the proportion of endemics offshore (54 species, 24% of total versus 12 species, 5%, respectively; Table 5). The proportion of Indo-Australian species was also higher inshore than offshore (45 species, 19% versus 24 species, 11%, respectively; Table 5).

A high proportion of the species were associated with hard substrates, 140 species (62%) inshore, compared to 169 species (78%) offshore for all combinations. Some of the species associated with hard substrates were also associated with soft substrates; these were generally reef associated species occurring in sand pockets either on or close to the reef or under rocks. However, some species were associated only with soft substrates (80 species, 35% inshore versus 44 species, 20% offshore; Table 6). Twenty four species were epizoic (EZ), but these were in similar numbers and proportions inshore and offshore (14 species, 6%, versus 16 species, 7%, respectively; Table 6, Appendix 2). Only a single species, *Ophiocomella sexradia*, was associated with marine plants, but this species is also found under rock slabs (Appendix 2).

DISCUSSION

We have provided a broad summary of the cumulative knowledge of echinoderm diversity from the Kimberley Project Area based primarily on museum collection and survey data. These qualitative datasets are irreplaceable for providing species inventories of an area (Mikkelsen and Cracraft 2001). Many species of echinoderms cannot be identified in the field as they require microscopic examination. This needs taxonomic expertise, access to specialised literature, and previously (and accurately) identified specimens, which are all available at natural science museums. Hence, the diversity of echinoderms known from many regions under the jurisdiction of museums will be well represented in these collections. All the recent collections from the Project Area have resulted in new species and range extensions (Marsh 1986, 1992; Marsh et al. 1993; Bryce 2009; Keesing et al. 2011; Marsh 2011). This is expected to continue as the region has a high diversity of habitats and remains remote and under sampled.

To date, collecting focus in the Kimberley Project Area has been the generation of species inventories for the locations sampled. Although data from some expeditions were presented in reports with species listed per station, which facilitated statistical analysis, some caveats must be made. Firstly, these data can be considered to be presence only, with absences implied. This limits the analyses able to be undertaken using software such as PRIMER, where comparable sampling effort is an implicit assumption. Secondly, collecting effort (spatial, temporal and taxonomic) across locations is highly variable and this has potentially influenced the observed patterns. We attempted to reduce this variability in our analyses by removing species poor samples and by using species accumulation curves to explore species richness patterns.

SPECIES RICHNESS PATTERNS

Our combined dataset provides records of 382 shallow water echinoderm species for the Project Area. This is higher than the 286 species recorded for the Dampier region (Marsh and Morrison 2004), which was derived from a comprehensive assessment of the habitats in the Dampier Archipelago utilising intertidal, diving and dredging surveys over two years, and supplemented with database records of historical collections. Endean (1957) reported 267 species of shallow water echinoderms (excluding crinoids) from Queensland. Although this estimate is lower than our Kimberley estimate, it is fifty years old. There have been more recent publications describing new species from the Great Barrier Reef (e.g. O'Loughlin and Rowe 2006), but none provided a summary of the echinoderm biodiversity in the area. We recorded 91 species of holothurians in this dataset, which is higher than the 56 species reported for the Spermonde Archipelago, Indonesia (Massin 1999) at the centre of the 'Coral Triangle', a known centre of maximum marine biodiversity (Hoeksema 2007). Due to the vastly different sampling efforts (spatial and temporal) of each study it would be misleading to claim echinoderm species richness is greater in the Kimberley than in these areas, but it appears to be comparable. This could in part be explained by the proximity of the Kimberley to these other regions and the potential connectivity via regional currents (e.g. Indonesian Throughflow, Marsh 1976; Marsh and Marshall 1983; Marsh et al. 1993) and planktonic larval duration (e.g. hours to months, Yamaguchi and Lucas 1984).

Our cumulative species richness estimates for inshore are slightly higher than for offshore (227 versus 223). However, at any one location species richness was generally lower inshore than offshore. This pattern was obvious in the intertidal locations and may be due to the harsh environment inshore (tidal exposure, siltation and seasonal flood plumes).

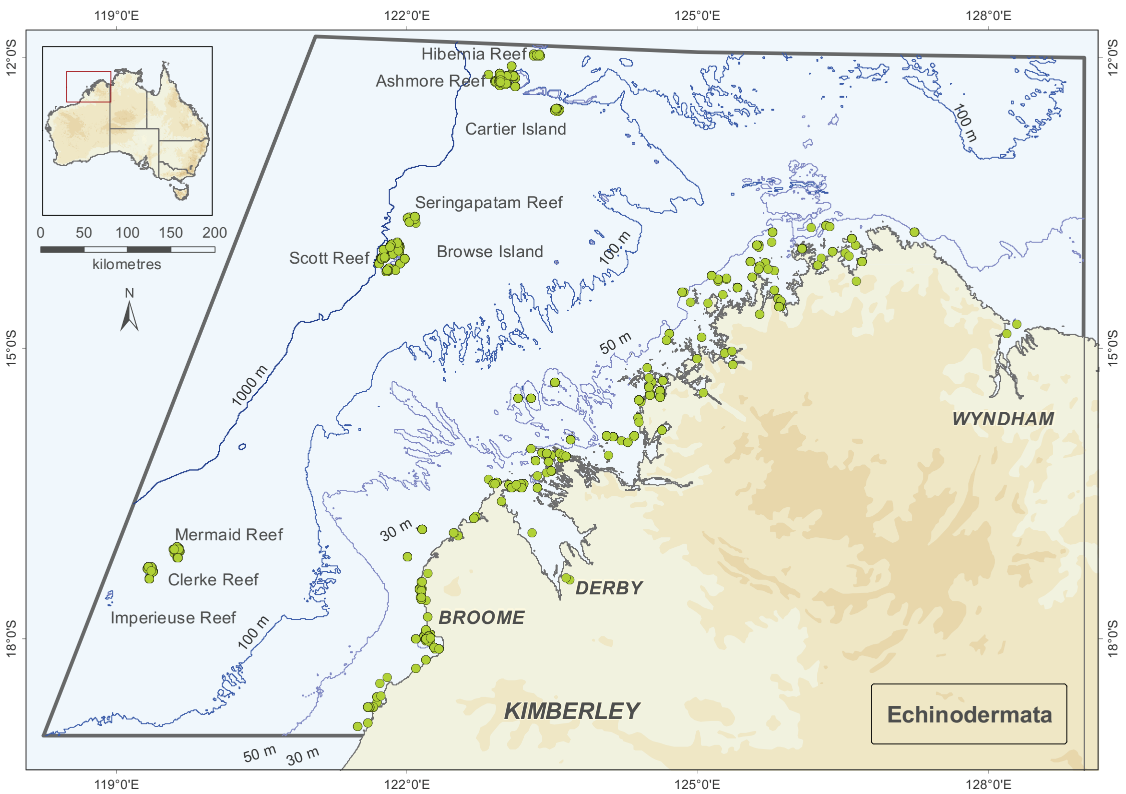

FIGURE 1 Location of historical records of echinoderms in the Kimberley Project Area of Western Australia. The Project Area boundary is marked in grey. Map projection: GDA94, Scale: 1:6, 250,000.

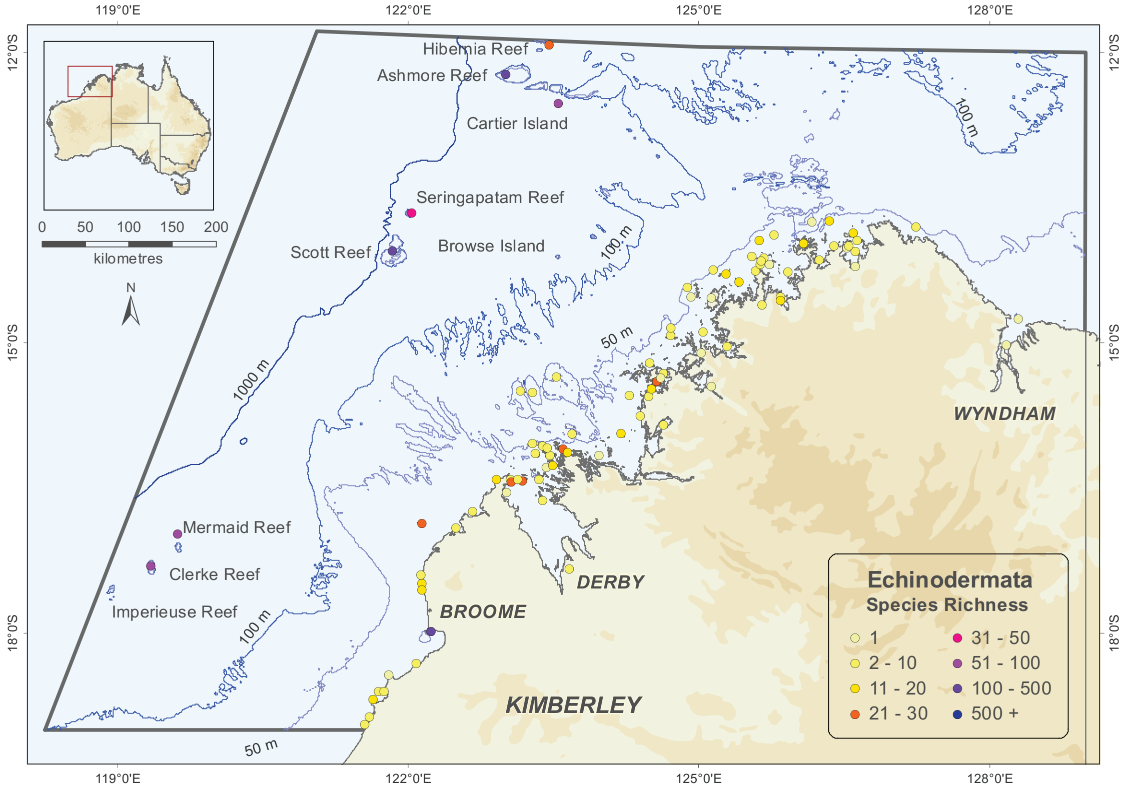

FIGURE 2 Species richness of echinoderms for each location. Map projection: GDA94, Scale: 1:6, 250,000.

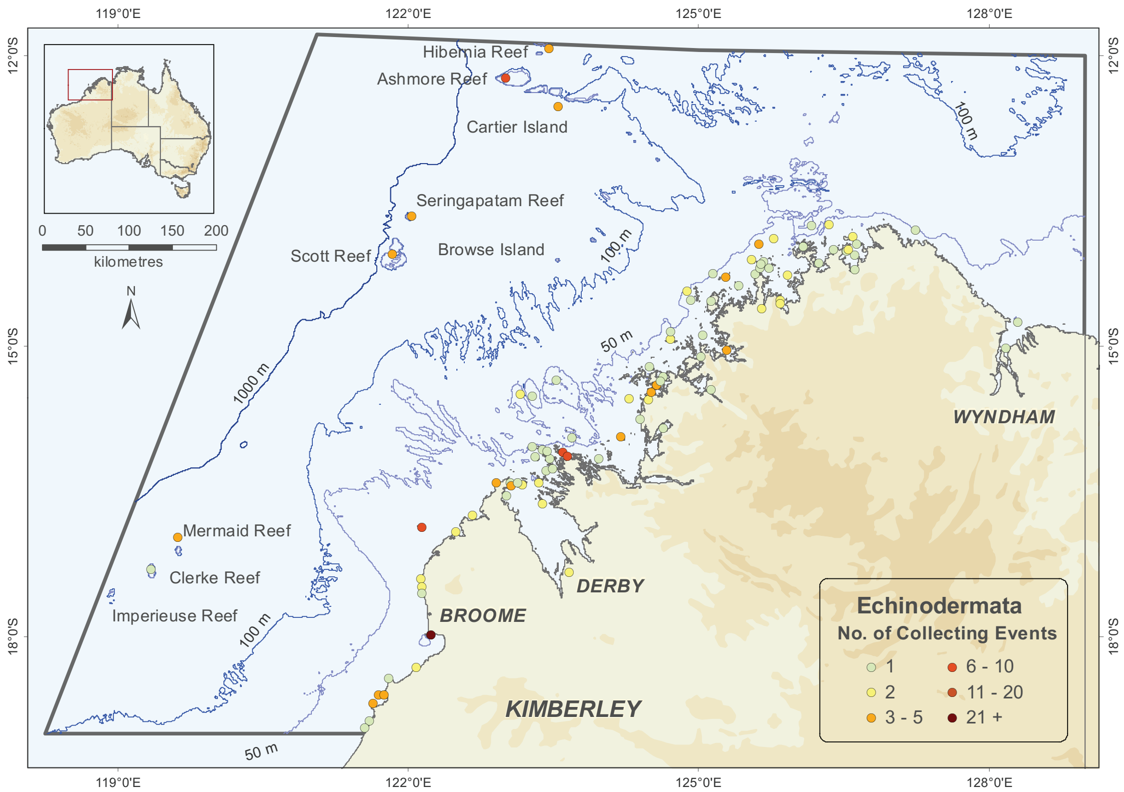

FIGURE 3 Number of collecting events for echinoderms at each main location for which there are collections. This was based on a count of the season code and provides an indication of sampling effort. Map projection: GDA94, Scale: 1:6, 250,000.

Echinoderms are a predominately marine phylum and most species do not tolerate extremes of salinity (Stickle and Diehl 1987) so only a few species are likely to inhabit such intertidal areas. For the subtidal stations inshore and offshore, differences in species richness were smaller. Thus, it appears species richness is not necessarily consistently lower inshore compared to offshore locations, but may have been influenced by the limited sampling from subtidal areas in the inshore Kimberley to date.

Species richness patterns across locations for the most part reflect the variable collection effort and should not be interpreted as an accurate measure of species richness, especially when it is the result of a single collecting event. However, this data presentation has allowed an assessment of surveyed locations and identified gaps in the available data.

COLLECTION GAPS

A number of collecting gaps have been identified in this dataset: location, habitat, which is also linked to the collecting method used and taxonomic. In our dataset there were no echinoderm data available from the midshelf and two of the offshore atoll locations (Hibernia and Imperieuse Reefs). The eastern Kimberley was also poorly surveyed with only a single echinoderm species recorded from three locations along this section of coastline. Contemporary surveys undertaken by WAM as part of the Woodside Collection Project (Kimberley) 2009–2014 have targeted specific locations through the Project Area and these will address some of the location gaps identified, including the lack of data from midshelf locations and some of the offshore atolls e.g. Imperieuse and Hibernia Reefs. However, the eastern Kimberley remains under sampled and this region also contains extensive soft sediment habitat (Wilson 2013).

The majority of the surveys from which this dataset has been derived collected fauna by hand on reef walking and diving surveys, so collecting methodology was limited. The Project Area encompasses a wide range of habitats including mangroves, seagrass beds, coral reefs, intertidal sand and mud flats, filter feeder, and subtidal soft sediment habitats. The habitat coding of the species in our dataset provides some indication of the habitats sampled to date, which are predominantly hard substrates. Yet extensive soft substrate habitats occur in the region and recent sampling using an epibenthic sled indicates that the subtidal echinoderm communities (10–25 m) may be diverse and some species in high abundance (Keesing et al. 2011). One of the authors (L.M. Marsh) has observed this at some locations (e.g. Prince Frederick Harbour) where the subtidal habitats were exposed at an extreme low spring tide revealing a rich filter feeder community with many coral and echinoderm species. The difficulties of sampling these subtidal habitats in the remote Kimberley will require different collecting methods. The macro-tides, turbid waters, crocodiles and sharks will necessitate different collecting methods other than intertidal and diving surveys utilised so far, to adequately sample echinoderm diversity in the region.

On many expeditions to the Project Area, echinoderms were collected only incidentally (1988, 1994, 1995, 1996, 1997), or collected in conjunction with other taxa (1991, 2006). Only on the earlier

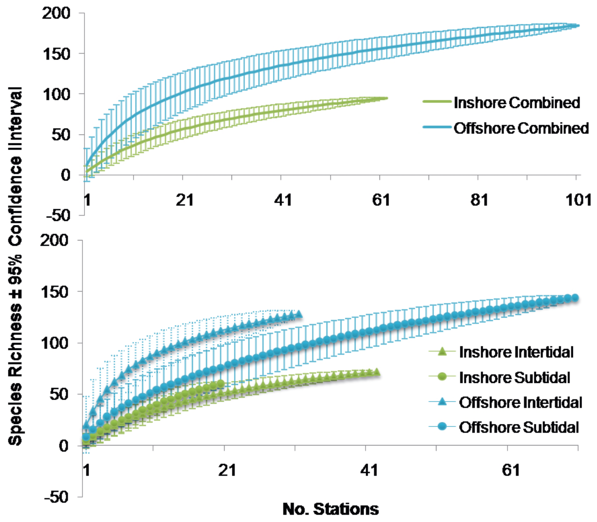

FIGURE 4 Species accumulation curves for the Western Australian Museum surveys.

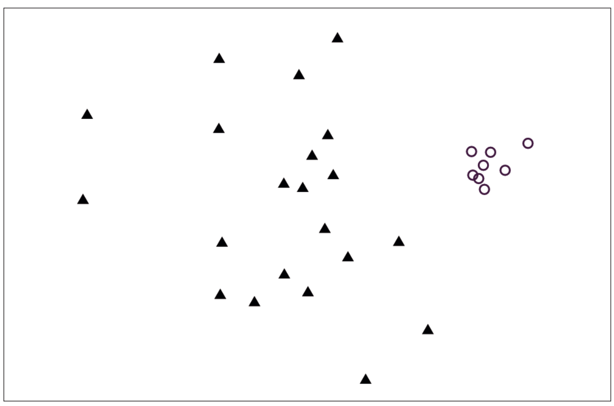

FIGURE 5 Ordination (nMDS) based on Bray-Curtis Similarity of the presence of echinoderm species. Each symbol represents a single location, inshore (▲), offshore (○). Two-dimensional stress 0.18.

offshore atolls surveys (Ashmore 1986, Rowley Shoals 1982 and Scott/Seringapatam 1984) did echinoderms have a specialist allocated for their collection and field preservation. The benefits of this are illustrated by the higher numbers of species recorded. Much of the diversity of echinoderms will be generated from intensive collections of an array of habitats (primarily sessile invertebrates) where small cryptic species reside, and these will be overlooked unless specifically targeted.

TAXONOMIC GAPS

Taxonomic biases in a dataset arise due to collecting partiality (e.g. a collector may target only certain groups and hard-to-collect species will be under represented) and identification partiality (e.g. easily identified and taxonomically resolved species or species of particular interest to a taxonomist will be over represented). To date, Kimberley echinoderm collections have focussed on large, visually apparent species including commercially important sea cucumber species. The most frequently collected family in our dataset was Holothuriidae, collected from 39 of the 91 locations surveyed. These are easy to collect, but require microscopic examination of spicules to obtain accurate identification. By comparison, species of sea urchin in the Diadematidae can readily be identified in the field, but are difficult to collect as they live in crevices and have toxic spines (Marsh and Slack-Smith 2010). These urchins were collected from 19 of the 91 locations in our dataset. When utilising museum data to inform conservation decisions, consideration needs to be given to taxonomic biases in the collecting of the data as this can impinge on interpretations of the biodiversity of an area and any comparisons to other areas.

Some families were inconsistently present across locations, for example, many species of Amphiuridae have been collected at inshore than offshore locations. Many amphiurids are associated with macroalgae, rubble or soft sediment (i.e. infauna) (Marsh and O'Hara, personal observation) so the apparent paucity offshore will be due partly to limited sampling of suitable habitat. However, macroalgal diversity offshore is lower than inshore (Huisman et al. 2009) so lack of suitable habitat may also have contributed to this pattern.

CROSS SHELF AND ALONG SHELF PATTERNS IN SPECIES COMPOSITION

In general, the inshore is a turbid silty environment, with freshwater runoff and input of nutrients particularly during the summer wet season (Brocx and Semeniuk 2011) compared to the clear oligotrophic waters offshore (Collins 2011). These differences are likely to have contributed to cross shelf differences in echinoderm species assemblages. Our data clearly show that species richness and composition differ inshore compared to offshore. Many echinoderms cannot live in low salinity or very turbid and silty environments which could affect larval settlement and recruitment as well as adult feeding and reproduction. However, some species can tolerate such environments: e.g. *Amphipholis squamata* has been reported to tolerate salinity as low as 5‰ (Stickle and Diehl 1987). This species has been found at both inshore and offshore locations in the Project Area, but shown to contain divergent lineages that may represent a suite of cryptic species (O'Hara, personal communication).

The degree of silt and turbidity also varies within the inshore Kimberley. For example, Hutchins (1999) reported three assemblages of fishes along the coast and suggested that these compositional differences may be related to different degrees of turbidity. Two major coastal morphological and botanical boundaries have been suggested for the Kimberley coastline, one at Cape Leveque (SW of King Sound) and one at Cape Rulhiers (NE tip of the Kimberley Coast), both of which are associated with major river outflows (Semeniuk 1993; Brooke 1996; Hutchins 1999). Currently, we do not have enough echinoderm data for all sections of the coastline to make such a comparison. However, the sand dollar *Arachnoides tenuis*, a Western Australian endemic species occurs south from Cape Leveque to Shark Bay. It is replaced north of King Sound by *A. placenta*, a widespread east Indo-West Pacific species (ABRS 2011), suggesting a transition from one faunal zone to another. This warrants further investigation with targeted surveys in the region.

REGIONAL BIOGEOGRAPHY AND ENDEMISM

Regionally, the Project Area represents an overlap zone of fauna and our synthesis shows species with different biogeographic ranges (NA, IA, IO, WP, IWP, C; Table 2) co-occurring in the region. North-west Australia represents the western range limit of Western Pacific species, the eastern limit of a few primarily Indian Ocean species and the southern limit of Indo-Malayan species. An analysis of the zoogeography of north-west Australian echinoderms (other than holothurians) by Marsh and Marshall (1983) included data from the Rowley Shoals and Seringapatam Reef and concluded that the fauna of the offshore shelf edge atolls consisted of widespread Indo-West Pacific species while the coastal and shelf echinoderm fauna had a greater proportion of endemics and species with Indo-Malayan affinities. Our synthesis confirms and reinforces these conclusions.

We determined that rates of regional endemism for the echinoderms inshore are more than five times those offshore (25% versus 5%, respectively) and greater than the level reported for the South China Sea (12%, Lane et al. 2001). The Kimberley coast encompasses a range of geological features (sandstones, basalts, sedimentary and metamorphic rocks), coastline morphology (cliffs, bays, mesas, rias, mudflats and beaches), rainfall (humid, subhumid and semi-arid), and is influenced by local and regional water movement (tides, currents, river outflows) (Brocx and Semeniuk 2011). These all influence the diversity of habitats and their proximity to each other, regional connectivity through currents, larval life history and speciation processes. In summary, the high levels of endemism inshore reported here were expected.

Accurate assessments of endemism require that all specimens collected from a region are fully identified and extensive sampling of suitable habitats in adjacent regions is undertaken to determine distributions. This is not yet the case for the Kimberley or adjacent regions. For example, *Echinaster superbus* was collected and described by Clark (1938) and until relatively recently was known only from the type locality of Broome. Recent collecting has recorded this species as far south as Dampier (Marsh and Morrison 2004). Furthermore, many of the endemic species on our list have a wide range (NA) and collections are needed that cover locations across northern Australia to clarify species ranges, although the eastern and western limits of many NA endemic species are known (Rowe and Gates 1995). For some species there is relatively little character variation throughout their range (e.g. *Stellaster princeps*), while for others (e.g. *Anthenea conjungens* and *Goniodiscaster acanthodes*) there is clinal variation in characters across their range blurring the distinction between species. This could be elucidated by DNA studies where cryptic species can be identified. For example, *Anthenea* spp. and *Goniodiscaster* spp. are large and conspicuous, and commonly picked up by prawn trawlers so potentially material is readily available to examine these possible species complexes.

High degrees of endemism pose problems for conservation strategies; an understanding of the biology of a species is required to determine which species are important for conservation purposes and whether endemic species play a more important role in the ecosystem than other species (Gray 1997). Endemic species are generally those with particular life history traits (e.g. restricted habitat requirements, a brooding or direct development larval strategy) (Jones and Kaly 1995; O'Hara 2002). For echinoderms these types of larval life strategies are more prevalent in temperate water species (O'Loughlin 1991), but see Byrne (2006) for some tropical examples. Studies on the biology of tropical species are limited and have usually been restricted to widespread, larger bodied, visually apparent species, such as *Acanthaster plancii* or the commercial sea cucumber species. Thus, not only are the species occurring in the region poorly surveyed throughout their range, but their biology is completely unknown. More research is needed on the biology of selected species, encompassing a range of life history strategies, to aid the interpretation of species lists and inform conservation decisions.

CONCLUSIONS AND FUTURE DIRECTIONS

This synthesis has clearly shown that the Kimberley echinoderm fauna is speciose and encompasses species with a range of distributions. So far, collections in the region have focussed on reef associated species and the soft sediment and deepwater fauna remains poorly documented and described. Moreover, we restricted our dataset to shallow water species (<30 m) for reasons outlined in Sampey et al. (2014), but we recognise there is an extensive deeper water fauna. At least two major expeditions have undertaken sampling from the deeper (30–200 m) shelf waters in the region, the Soela (1979–1984) and the Southern Surveyor (2007). The fauna are housed in WAM and MV collections, but remain incompletely identified and contain undescribed species. This synthesis is a first step in utilising museum data and further research should include re-examination of existing specimens, genetic studies, bioregional analyses of selected taxa, and release of these data to online databases to facilitate utilisation by managers and other researchers. We have identified collection and taxonomic gaps in the data to guide further study.

A lack of echinoderm taxonomists in Australia is a major hindrance to the documentation of the fauna. Currently, there is only one full time echinoderm taxonomist in an Australian museum (MV) and much of the research is undertaken by retired taxonomists, students or early career taxonomists funded from external grants. A number of the specimens in our dataset were not incorporated into our species list due to taxonomic uncertainty. This was due to incomplete identification, taxa that are unresolved taxonomically and species that have undergone recent revisions, either purely morphological (e.g. Rankin and Messing 2008) or those utilising molecular and morphological data (e.g. O'Loughlin and Waters 2004; Mah and Foltz, 2011) resulting in revised species concepts. Examination of specimens is required to resolve species level identifications across multiple collecting events.

Classical taxonomy focussed on morphological characters and the advent and rapid advancement of genetic techniques has led to many projects questioning species concepts (e.g. *Acanthaster planci*, Vogler et al. 2008). To date, no genetic material of echinoderms from the Project Area has been analysed. Historically all echinoderms, except holothurians, were preserved in formalin and not suitable for genetic studies. All specimens collected on two contemporary expeditions (2009/2010) were preserved in high grade ethanol to facilitate genetic studies and this will be an ongoing practice. Genetic studies need to be undertaken in conjunction with morphological studies and cannot be used in isolation from classical taxonomic practice (DeSalle et al. 2005). Integrative taxonomic approaches (utilising DNA, morphological, geographical, reproductive, ecological and behavioural data) for a species are needed so taxonomy can move beyond pattern description to consider the processes underpinning speciation (Padial et al. 2010).

A current area of research utilising museum data is to explore large scale bioregional comparisons (e.g. O'Hara and Poore 2000; Graham et al. 2004; Hooper and Ekins 2004; Fox and Beckley 2005; Harnik 2009; Hoeksema et al. 2011; O'Hara et al. 2011). Our compilation of species from the Project Area is based primarily on specimen records (presence data). We have not listed species likely to occur in the region based on known species ranges. These would need to be incorporated to complete the dataset. Additionally, many species are too rare or cryptic to be adequately sampled across the whole region or have not been surveyed due to taxonomic or collection biases. Model taxa suitable for further analyses require identification to investigate connectivity. These need to be taxonomically resolved and well surveyed throughout their habitat and biogeographic range (Hoeksema 2007). In our dataset three families, Holothuriidae, Ophiotrichidae, and Oreasteridae were more consistently collected across locations. These encompass three classes of echinoderms with an array of life history strategies and would be a starting place to find species that have been adequately sampled across the region. It is imperative that museums and taxonomists are consulted and act as collaborators of projects to identify suitable taxa for further study.

Species richness is a useful biodiversity measure, but it is heavily influenced by sampling effort and scale of interpretation. It is important to present species richness summaries at a scale that is biologically meaningful, but also has relevance to managers. This is in part illustrated by our cross shelf comparisons of species richness (total versus intertidal versus subtidal versus location) and when comparing species richness values to other studies. Further work is needed to both consolidate and make accessible data in standardised, centralised databases so that meaningful summaries can be generated in a manner relevant to research or management questions.

In conclusion, priorities for future research in the region are:

- Collate the deepwater species data from the region (requires collaboration between WAM, MV, CSIRO and AIMS who hold relevant datasets)
- Undertake a survey program in the eastern Kimberley. This will address spatial, habitat and bioregional gaps in the data, and inform interpretation of endemic species ranges.
- Utilise additional survey methodologies (e.g. trawls and epibenthic sleds) to more fully describe the diversity of the region.
- Further taxonomic research on material already held in collections including genetic research.
- Analysis of the data using mathematical models (e.g. Elith et al. 2006) and bioregional analyses (e.g. O’Hara et al. 2011) with a focus on the Holothuriidae, Ophiotrichidae and Oreasteridae as these families were more consistently collected across locations and are reasonably well resolved taxonomically.

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APPENDIX 1 Number of registered specimen lots of echinoderm families from the Project Area housed in Australian museum collections. Included are those lots identified to species or able to be distinguished as a species entity, and excluded are those lots incompletely identified (out of parentheses) or from deepwater (>30 m) locations (in parentheses).

Included Specimens	AM	MAGNT	WAM	MV	Total
Class: Asteroidea					
Acanthasteridae		1	2		**3**
Archasteridae	2	1	2		**5**
Asterinidae	13	5	38		**56**
Asteropseidae			9		**9**
Astropectinidae	13	3	26		**42**
Echinasteridae	4	7	17	4	**32**
Goniasteridae	12		10		**22**
Luidiidae	2	1			**3**
Mithrodiidae			2		**2**
Ophidiasteridae	4	46	128	8	**186**
Oreasteridae	30	6	84	1	**121**
Pterasteridae	1		2		**3**
Class: Crinoidea					**0**
Antedonidae	1	6	9		**16**
Colobometridae	2	9	16		**27**
Comasteridae	36	64	120		**220**
Himerometridae	3		4		**7**
Mariametridae	3	17	33		**53**
Zygometridae	10	1	8		**19**
Class: Echinoidea					**0**
Arachnoididae	7		21		**28**
Astriclypeidae	2		1		**3**
Brissidae	1	3	24	2	**30**
Cidaridae	6	3	33	3	**45**
Clypeasteridae	1	1	6		**8**
Diadematidae		13	22	2	**37**
Echinolampadidae	1	6	15	3	**25**
Echinometridae		1	13	2	**16**
Echinoneidae		1	8		**9**
Fibulariidae	2		5		**7**
Laganidae	15	2	33		**50**
Loveniidae	6	5	22	2	**35**
Parasaleniidae	1	1	20		**22**
Schizasteridae	2		1		**3**
Spatangidae			1		**1**
Temnopleuridae	8	3	36	1	**48**
Toxopneustidae	3	5	11		**19**
Class: Holothuroidea					**0**
Caudinidae	1				**1**
Chiridotidae		3	2		**5**
Cucumariidae	25	10	17		**52**
Holothuriidae	12	120	185	6	**323**
Phyllophoridae	20	7	18		**45**
Sclerodactylidae	5	7	8	1	**21**
Stichopodidae	4	28	26	1	**59**
Synaptidae	11	10	21	2	**44**
Class: Ophiuroidea					**0**
Amphiuridae	19	4	34	5	**62**
Euryalidae	2	1	1	1	**5**
Gorgonocephalidae			1		**1**
Ophiactidae	8	8	51	2	**69**
Ophiocomidae	2	49	169	20	**240**
Ophiodermatidae	16	16	92	11	**135**
Ophiolepididae	10	15	28	3	**56**
Ophiomyxidae			6		**6**
Ophionereididae	7	4	27	4	**42**
Ophiotrichidae	33	129	195	12	**369**
Ophiuridae	8	1	5		**14**
Total	**374**	**623**	**1,668**	**96**	**2,761**

Excluded Specimens	AM	MAGNT	WAM	MV	Total
Class: Asteroidea			1 (139)		**140**
Acanthasteridae			1		**1**
Asteriidae	(2)		(2)		**4**
Asterinidae	2	2 (1)	10 (5)		**20**
Asterodiscididae			1 (1)		**2**
Asteropseidae			2		**2**
Astropectinidae		(3)	3 (46)		**52**
Benthopectinidae	(1)		(22)		**23**
Brisingasteridae			(1)		**1**
Brisingidae			(5)		**5**
Echinasteridae	1	1 (1)	13 (7)		**23**
Goniasteridae	7	(15)	1 (259)		**282**
Goniopectinidae		(1)	(46)		**47**
Luidiidae	2	1	2 (3)		**8**
Mithrodiidae	1		1		**2**
Ophidiasteridae	9	1 (1)	39 (15)		**65**
Oreasteridae	8	2 (6)	9 (15)		**40**
Pterasteridae			(4)		**4**
Solasteridae			(1)		**1**
Zoroasteridae		(5)	(7)		**12**
Class: Crinoidea			(50)		**50**
Antedonidae			1 (1)		**2**
Asterometridae			(1)		**1**
Calometridae	3		(1)		**4**
Colobometridae	1	4	3 (1)		**9**
Comasteridae	12	32 (3)	13 (12)		**72**
Himerometridae	6	1	(2)		**9**
Isocrinidae	(1)	(3)	(15)		**19**
Mariametridae			9		**9**
Thalassometridae		(3)	(3)		**6**
Zygometridae	7	(1)	(1)		**9**
Class: Echinoidea	3		9 (126)		**138**
Apatopygidae	1				**1**
Arachnoididae			1		**1**
Arbaciidae	(2)		(4)		**6**
Asterostomatidae			(1)		**1**
Brissidae	1	1	19 (5)		**26**
Cassidulidae	(1)				**1**
Cidaridae	17	(4)	3 (29)		**53**
Clypeasteridae	1	(1)	2 (3)		**7**
Diadematidae	3	(2)	9		**14**
Echinolampadidae			2 (1)		**3**
Echinometridae			11 (10)	3	**24**
Echinoneidae			8		**8**
Echinothuriidae	8				**8**
Fibulariidae	7		2 (14)		**23**
Holasteridae	(1)		(1)		**2**
Laganidae	2		8 (7)		**17**

Excluded Specimens	AM	MAGNT	WAM	MV	Total
Loveniidae	1		9 (11)		**21**
Micropygidae	4				**4**
Neolampidae	(2)				**2**
Pedinidae		(1)	(1)		**2**
Pericosmidae	(1)	(3)	(8)	1	**13**
Phormosomatidae	(3)				**3**
Psychocidaridae	(1)				**1**
Saleniidae			(1)		**1**
Temnopleuridae	9	(1)	3 (3)		**16**
Toxopneustidae	1		3		**4**
Class: Holothuroidea			45 (49)		**94**
Caudinidae	1				**1**
Cucumariidae	1	(11)	2 (9)		**23**
Holothuriidae	3	7	40 (32)		**82**
Phyllophoridae		(3)	5 (1)		**9**
Sclerodactylidae			(1)		**1**
Stichopodidae		1	8		**9**
Synallactidae		(2)			**2**
Synaptidae	1		5		**6**
Ypsilothuriidae			(9)		**9**
Class: Ophiuroidea		2	2 (93)		**97**
Amphiuridae		1	8 (12)		**21**
Asteroschematidae	3		(5)		**8**
Euryalidae	1	(2)	(16)		**19**
Gorgonocephalidae	(3)	(2)	(26)		**31**
Hemieuryalidae			(2)		**2**
Ophiacanthidae	1		1 (130)		**132**
Ophiactidae		(1)	6 (8)		**15**
Ophiocomidae		(1)	47		**48**
Ophiodermatidae	4	(2)	14 (12)		**32**
Ophioleucidae			(1)		**1**
Ophiomyxidae	1		2		**3**
Ophionereididae			3 (2)		**5**
Ophiotrichidae	5	1 (4)	77 (42)		**129**
Ophiuridae			2 (38)		**40**
Unidentified echinoderms			1 (3)		**4**
Total	**155**	**140**	**1847**	**4**	**2146**

APPENDIX 2 Species of echinoderms recorded from the Project Area. Codes are defined in the methods. Superscripts associated with the species name indicate type material, Holotype[H], Paratype[P]; NB. The following paratypes, *Actinocucumis longipedes**, *Amphiura phrixa***, *Archaster laevis*** were synonymised with the listed species. Species listed in Keesing et al. (2011), but not in our Kimberley Project Area database[K]. Superscripts associated with the EZ habitat code indicates the animal associated with echinoderm species (sponges[1], corals[2], gorgonians[3], soft corals[4], sessile invertebrates[5] and crinoids[6]).

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Class: Asteroidea				
Family: Acanthasteridae				
Acanthaster planci (Linnaeus, 1758)	H^{s}	IP	●	●
Family: Archasteridae				
Archaster angulatus Muller & Troschel, 1842[P***]	S^{s}	IA/IO	●	
Archaster typicus Müller & Troschel, 1840	H^{s}	WP		●
Family: Asterinidae				
Anseropoda rosacea (Lamarck, 1816)	S^{s}	IA	●	
Aquilonastra anomala (H.L. Clark, 1921)	H/S^{is}	IWP	●	●
Aquilonastra cepheus (Müller & Troschel, 1842)	H/S^{is}	IA		●
Aquilonastra coronata (von Martens, 1866)	H/S^{is}	IA	●	
Disasterina abnormalis Perrier, 1875	H^{i}	IWP		●
Indianastra sarasini (de Loriol, 1897)	H^{is}	IA	●	●
Nepanthia belcheri (Perrier, 1875)	H/S^{is}	IA	●	
Nepanthia maculata Gray, 1840	S^{is}	IA	●	
Family: Asteropseidae				
Asteropsis carinifera (Lamarck, 1816)	H^{is}	IWP		●
Valvaster striatus (Lamarck, 1816)	H^{is}/S^{s}	IWP		●
Family: Astropectinidae				
Astropecten granulatus Müller & Troschel, 1842	S^{s}	IA/IO	●	
Astropecten monacanthus Sladen, 1883	S^{s}	IWP	●	
Astropecten vappa Müller & Troschel, 1843	S^{s}	IA/IO	●	
Astropecten velitaris von Martens, 1865	S^{s}	IA/IO	●	
Astropecten zebra Sladen, 1883	S^{s}	IA/IO	●	
Family: Echinasteridae				
Echinaster callosus Marenzeller, 1895	H^{s}	IWP		●
Echinaster luzonicus (Gray, 1840)	H^{is}	IWP		●
Echinaster superbus H.L. Clark, 1916	S^{is}	WA	●	●
Echinaster varicolor H.L. Clark, 1938[P]	H/S^{s}/SG	IA	●	
Metrodira subulata Gray, 1840	S^{s}	IA/IO	●	
Family: Goniasteridae				
Anthenoides dubius H.L. Clark, 1938[P]	S^{s}	WA	●	
Celerina heffernani (Livingstone, 1931)	H^{s}	IWP		●
Fromia eusticha Fisher, 1913	H^{s}	IA		●
Fromia indica (Perrier, 1869)	H^{is}	IWP		●
Fromia milleporella (Lamarck, 1816)	H^{is}	IWP		●
Fromia monilis Perrier, 1869	H^{is}	IWP		●
Iconaster longimanus (Möbius, 1859)	H/S^{s}	IWP	●	

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Neoferdina cumingi (Gray, 1840)	H^{s}	IWP		•
Stellaster childreni Gray, 1840	S^{s}	IA/IO	•	
Stellaster princeps Sladen, 1889	S^{s}	NA	•	
Family: Luidiidae				
Luidia hardwicki (Gray, 1840)	S^{s}	IA/IO	•	
Luidia maculata Muller & Troschel, 1842	S^{s}	IWP	•	
Family: Mithrodiidae				
Mithrodia clavigera (Lamarck, 1816)	H^{is}	IWP		•
Family: Ophidiasteridae				
Bunaster ritteri Döderlein, 1896	H^{is}	IA		•
Cistina columbiae Gray, 1840	H^{s}	IWP		•
Dactylosaster cylindricus (Lamarck, 1816)	H^{i}	IP		•
Gomophia gomophia (Perrier, 1875)	H^{s}	IWP		•
Gomophia sphenisci (A.M. Clark, 1967)	S^{s}	NA	•	
Hacelia helicosticha (Sladen, 1889)	H/S^{s}	WP	•	
Leiaster speciosus von Martens, 1866	H^{s}	IWP		•
Linckia guildingi Gray, 1840	H^{is}	T	•	•
Linckia laevigata (Linnaeus, 1758)	H^{is}	IWP		•
Linckia multifora (Lamarck, 1816)	H^{is}	IWP		•
Nardoa tuberculata Gray, 1840	H^{is}	IWP	•	•
Ophidiaster cribrarius Lütken, 1871	H^{is}	IWP		•
Ophidiaster granifer Lütken, 1871	H^{is}	IWP		•
Ophidiaster hemprichi Müller & Troschel, 1842	H^{is}	IWP		•
Tamaria megaloplax (Bell, 1884)	H^{is}	IA		•
Tamaria tumescens (Koehler, 1910)	S^{s}	IA	•	
Family: Oreasteridae				
Anthenea australiae Doderlein, 1915	H/S^{s}	WA	•	
Anthenea conjungens Döderlein, 1935	H/S^{s}	NA	•	
Anthenea elegans H.L. Clark, 1938[P]	H/S^{s}	NA	•	
Anthenea godeffroyi Döderlein, 1915	S^{s}	NA	•	
Anthenea polygnatha H.L. Clark, 1938[P]	S^{s}	WA	•	
Choriaster granulatus Lütken, 1869	H^{is}	IWP		•
Culcita novaeguineae Müller & Troschel, 1842	H^{is}	IWP	•	•
Culcita schmideliana (Retzius, 1805)	H^{is}/S^{s}	IO	•	
Goniodiscaster acanthodes H.L. Clark, 1938[P]	H/S^{s}	NA	•	
Goniodiscaster australiae Tortonese, 1937	S^{s}	NA	•	
Goniodiscaster rugosus (Perrier, 1875)	S^{s}	NA	•	
Gymnanthenea globigera (Döderlein, 1915)	H^{is}/S^{s}	NA	•	
Pentaceraster multispinus (von Martens, 1866)	S^{i}	IO		•
Pentaceraster regulus (Müller & Troschel, 1842)	$H/S^{is}/SG$	IWP		•
Protoreaster lincki (Blainville, 1830)	$H/S^{is}/SG$	IO		•
Protoreaster nodosus (Linnaeus, 1758)	$H/S^{is}/SG$	IWP		•
Protoreaster nodulosus (Perrier, 1875)	H/S^{is}	WA	•	
Pseudoreaster obtusangulus (Lamarck, 1816)	S^{s}	WA	•	
Family: Pterasteridae				
Euretaster insignis (Sladen, 1882)	S^{s}	IWP	•	•

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Class: Crinoidea				
Family: Antedonidae				
Dorometra nana (Hartlaub, 1890)	H^s	IA	●	●
Dorometra parvicirra (Carpenter, 1888)	H^s	IA	●	●
Euantedon cf. *polytes* A.H. Clark, 1936	H^s	WP		●
Toxometra nomina (H.L. Clark, 1938)[P]	H^s	WA	●	
Family: Colobometridae				
Basilometra boschmai A.H. Clark, 1936	H^s	IA		●
Cenometra bella (Hartlaub, 1890)	H^s/EZ^3	IWP		●
Cenometra cf. *emendatrix* (Bell, 1892)	H^s	IO		●
Cenometra cf. *herdmani* A.H. Clark, 1909	H^s	IA		●
Colobometra perspinosa (Carpenter, 1881)	H^s/EZ^3	WP		●
Decametra laevipinna (A.H. Clark, 1912)	H^s/EZ^3	IA		●
Decametra parva (A.H. Clark, 1912)	H^s/EZ^3	IA		●
Iconometra anisa (H.L. Clark, 1915)	H^s	WP		●
Oligometra serripinna (Carpenter, 1881)	H^s/EZ^3	IWP		●
Oligometrides adeonae (Lamarck, 1816)	H^s/EZ^3	IA	●	
Petasometra clarae (Hartlaub, 1890)	H^s	IA	●	●
Petasometra helianthoides A.H. Clark, 1912	H^s	NA		●
Pontiometra andersoni (Carpenter, 1889)	H^s	IA		●
Family: Comasteridae				
Capillaster multiradiata (Linnaeus, 1758)	S^s	IWP	●	●
Capillaster sentosa (Carpenter, 1888)	H/S^s	IWP		●
Clarkcomanthus littoralis (Carpenter, 1888)	H^s	WP	●	●
Clarkcomanthus luteofuscum (H.L. Clark, 1915)	H^{is}	WP	●[K]	●
Comanthina variabilis (Bell, 1882)	H/S^s	NA	●	
Comanthus alternans (Carpenter, 1881)	H/S^s	IWP		●
Comanthus briareus (Bell, 1882)	H/S^s	IA	●	●
Comanthus gisleni Rowe et al., 1986	H^s	WP	●	●
Comanthus mirabilis Rowe, et al., 1986	H^s/EZ^3	WP	●	
Comanthus parvicirrus (Müller, 1841)	H^s	IWP	●	●
Comanthus suavia Rowe, Hoggett, Birtles & Vail, 1986	H^s	IA		●
Comanthus wahlbergii (Müller, 1843)	H^s	IWP	●	●
Comaster audax? (Rowe, Hoggett, Birtles & Vail, 1986)	H^{is}	IA	●	
Comaster multifidus (Müller, 1841)	H^s	WP	●	●
Comaster schlegelii (Carpenter, 1881)	H^s	WP	●[K]	●
Comatella maculata (Carpenter, 1888)	H^s	IWP	●	●
Comatella stelligera (Carpenter, 1888)	H^s	IWP	●	●
Comatula pectinata (Linnaeus, 1758)	H^s	IWP	●	
Comatula purpurea (Müller, 1843)	H^s	IA	●	
Comatula rotalaria Lamarck, 1816	S^s	IA	●	
Comatula solaris Lamarck, 1816	H^s	IA	●	
Oxycomanthus bennetti (Müller, 1841)	H^s	IWP		●
Oxycomanthus comanthipinna (Gislén, 1922)	H/S^s	WP		●
Oxycomanthus exilis Rowe et al., 1986	H^s	WP		●

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Family: Himerometridae				
Amphimetra tessellata (Müller, 1841)	H^{s}/EZ[3]	WP	●	
Heterometra crenulata (Carpenter, 1882)	H^{s}	IA	●	
Heterometra sarae A.H. Clark, 1941[K]	H^{s}	WP	●[K]	
Himerometra robustipinna (Carpenter, 1881)	H^{s}	IWP		●
Family: Mariametridae				
Lamprometra palmata (Müller, 1841)	H^{is}	IWP	●	●
Stephanometra indica (Smith, 1876)	H^{is}	IWP	●	●
Family: Zygometridae				
Zygometra comata A.H. Clark, 1911	H^{s}	IA	●	
Zygometra elegans (Bell, 1882)	H^{s}	IA	●	
Zygometra microdiscus (Bell, 1882)	H^{s}	IA	●	
Zygometra punctata A.H. Clark, 1912	H^{s}	IA	●	
Class: Echinoidea				
Family: Arachnoididae				
Arachnoides placenta (Linnaeus, 1758)	S^{is}	IWP	●	
Arachnoides tenuis H.L. Clark, 1938	S^{is}	WA	●	
Family: Astriclypeidae				
Echinodiscus auritus Leske, 1778	S^{s}	IP	●	
Family: Brissidae				
Brissus latecarinatus (Leske, 1778)	S^{s}	IWP	●	●
Brissopsis sp.[K]			●[K]	
Metalia dicrana H.L. Clark, 1917	S^{is}	IWP		●
Metalia spatagus (Linnaeus, 1758)	S^{s}	IWP	●	●
Metalia sternalis (Lamarck, 1816)	S^{s}	IWP		●
Rhynobrissus hemiasteroides Agassiz, 1879	S^{s}	WP	●	
Rhynobrissus tumulus McNamara, 1982	S^{s}	WA		●
Family: Cidaridae				
Eucidaris metularia (Lamarck, 1816)	H^{is}	IWP		●
Phyllacanthus longispinus Mortensen, 1918	H^{is}	NA	●	
Prionocidaris baculosa (Lamarck, 1816)	H^{is}	IWP		●
Prionocidaris bispinosa (Lamarck, 1816)	H/S^{s}	IA/IO	●	
Prionocidaris verticillata (Lamarck, 1816)	H^{is}	IA/IO		●
Family: Clypeasteridae				
Clypeaster (Coronanthus) latissimus (Lamarck, 1816)[K]	S^{s}	IA	●[K]	
Clypeaster (Coronanthus) telurus H.L. Clark, 1914	S^{s}	A	●	
Clypeaster (Rhaphidoclypus) reticulatus (Linnaeus, 1758)	S^{s}	IP		●
Clypeaster (Stolonoclypus) virescens Döderlein, 1885[K]	S^{s}	WP	●[K]	
Family: Diadematidae				
Diadema savignyi (Michelin, 1845)	H^{is}/S^{s}	IP		●
Diadema setosum (Leske, 1778)	H^{is}/S^{s}	IP	●	●
Echinothrix calamaris (Pallas, 1774)	H^{is}/S^{s}	IWP	●	●
Echinothrix diadema (Linnaeus, 1758)	H^{is}/S^{s}	IWP		●
Family: Echinolampadidae				
Echinolampas ovata (Leske, 1778)	S^{s}	IA/IO	●	●

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Family: Echinometridae				
Echinometra mathaei (Blainville, 1825)	H/S^{i}	IP		•
Echinostrephus molaris (Blainville, 1825)	H^{is}	IWP		•
Heterocentrotus mammillatus (Linnaeus, 1758)	H/S^{i}	IP		•
Family: Echinoneidae				
Echinoneus cyclostomus Leske, 1778	S^{is}	IP		•
Family: Fibulariidae				
Echinocyamus planissimus H.L. Clark, 1938[P]	S^{s}	A	•	
Fibularia oblonga Gray, 1851	S^{s}	IA	•	
Fibularia ovulum Lamarck, 1816	S^{s}	IA		•
Fibularia volva L. Agassiz, 1847	S^{s}	IA		•
Family: Laganidae				
Peronella lesueuri (Valenciennes, 1841)	S^{s}	IA/IO	•	
Peronella orbicularis (Leske, 1778)	S^{is}	IA/IO	•	
Peronella macroproctes Koehler, 1922[K]	S^{s}	IA	•[K]	
Peronella tuberculata Mortensen, 1918	S^{is}	WA	•	
Family: Loveniidae				
Breynia australasiae (Leach, 1815)	S^{s}	NA		•
Breynia desorii Gray, 1851	S^{s}	NA	•	•
Breynia neanika McNamara, 1982	S^{s}	NA	•	•
Lovenia elongata (Gray, 1845)[K]	S^{s}	IWP	•[K]	
Family: Parasaleniidae				
Parasalenia gratiosa A. Agassiz, 1863	H^{is}	IWP	•	•
Parasalenia pohlii Pfeffer, 1887	H^{is}	IWP		•
Family: Schizasteridae				
Proraster jukesii (Gray, 1851)	S^{s}	NA	•	
Schizaster sp.	S^{s}			•
Family: Spatangidae				
Maretia cordata Mortensen, 1948	S^{s}			•
Family: Temnopleuridae				
Mespilia globulus (Linnaeus, 1758)	H^{is}	IWP	•	•
Salmacis sphaeroides (Linnaeus, 1758)	S^{is}	IWP	•	
Temnopleurus alexandri (Bell, 1884)	S^{is}	IA	•	•
Temnopleurus toreumaticus (Leske, 1778)	S^{is}	IWP	•	
Temnotrema bothyroides (L. Agassiz, 1846)	S^{s}	IA	•	
Temnotrema elegans Mortensen, 1918	S^{s}	NA	•	•
Family: Toxopneustidae				
Cyrtechinus cf. sp.	S^{s}			•
cf. *Gymnechinus* sp. nov. ?[K]			•[K]	
Nudechinus darnleyensis (Tenison-Woods, 1878)	H^{i}/S^{is}	NA	•	
Nudechinus scotiopremnus H.L. Clark, 1912	H^{is}/S^{s}	IO	•	
Pseudoboletia maculata Troschel, 1869	H^{s}	IWP		•
Toxopneustes pileolus (Lamarck, 1816)	H^{s}	IWP		•
Tripneustes gratilla (Linnaeus, 1758)	H^{is}	IP		•

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Class: Holothuroidea				
Family: Caudinidae				
Paracaudina chilensis (Muller, 1850)	S^{s}	IP	●	
Family: Chiridotidae				
Chiridota rigida Semper, 1868	H/S^{s}	IWP		●
Chiridota stuhlmanni Lampert, 1896	S^{is}	IWP		●
Trochodota maculata H.L. Clark, 1921	S^{s}	NA		●
Family: Cucumariidae				
Actinocucumis typica Ludwig, 1875[P*]	U	IWP	●	
Cercodemas anceps (Selenka, 1867)	H^{s}	WP	●	
Colochirus crassus Ekman, 1918	H^{s}	IA	●	
Colochirus quadrangularis Troschel, 1846	H^{s}	WP	●	
Colochirus robustus Östergren, 1898	H^{s}	IA	●	●
Leptopentacta grisea H.L. Clark, 1928	S^{s}	NA	●	
Mensamaria intercedens (Lampert, 1885)	S^{s}	IA	●	
cf. *Neocucumis* sp.	U		●	
Plesiocolochirus australis (Ludwig, 1875)	H^{s}	WP	●	
Plesiocolochirus dispar (Lampert, 1889)	H^{s}	IA/IO	●	●
Pseudocolochirus violaceus (Theel, 1886)	H^{s}	IWP	●	
Staurothyone cf. *rosacea* (Semper, 1869)	H^{s}	IO	●	
Family: Holothuriidae				
Actinopyga echinites (Jaeger, 1833)	H^{i}/S^{is}	IWP		●
Actinopyga lecanora (Jaeger, 1833)	H^{is}	IWP	●	●
Actinopyga mauritiana (Quoy & Gaimard, 1833)	H^{is}	IWP	●	●
Actinopyga miliaris (Quoy and Gaimard, 1833)	H^{s}/S^{is}	IWP		●
Actinopyga obesa (Selenka, 1867)	S^{s}	WP		●
Actinopyga serratidens Pearson, 1903	U	IWP		●
Bohadschia argus (Jaeger, 1833)	H^{i}/S^{is}	IWP		●
Bohadschia marmorata (Jaeger, 1833)	S^{is}	IWP	●	●
Holothuria albiventer Semper, 1868	S^{s}	IWP	●	
Holothuria arenicola Semper, 1868	H/S^{s}	T	●	●
Holothuria atra Jaeger, 1833	H^{is}/S^{s}	IP	●	●
Holothuria coluber Semper, 1868	S^{is}	IA		●
Holothuria conica? H.L. Clark, 1938	S^{is}	NA	●	
Holothuria difficilis Semper, 1868	S^{s}	IP	●	●
Holothuria edulis Lesson, 1830	H^{is}/S^{s}	IWP	●	●
Holothuria fuscocinerea Jaeger, 1833	$H/S^{s}/SG$	IWP	●	●
Holothuria fuscogilva Cherbonnier, 1980	H/S^{s}	IWP		●
Holothuria fuscopunctata Jaeger, 1833	S^{s}	IWP		●
Holothuria fuscorubra Théel, 1886	S^{s}	IWP		●
Holothuria hilla Lesson, 1830	H/S^{is}	IWP	●	●
Holothuria impatiens (Forskål, 1775)	H/S^{is}	T	●	●
Holothuria inhabilis Selenka, 1867	S^{s}	IWP		●
Holothuria lessoni Massin, Uthicke, Purcell, Rowe, Samyn, 2009	S^{s}	IWP		●
Holothuria leucospilota (Brandt, 1835)	H/S^{is}	IWP	●	●
Holothuria lineata Ludwig, 1875	S^{s}	IWP	●	●

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Holothuria michaelseni Erwe, 1913	S^{is}/SG	WA	●	
Holothuria modesta Ludwig, 1875	S^{s}	IA/RS	●	
Holothuria olivacea Ludwig, 1888	S^{s}	IWP		●
Holothuria pardalis Selenka, 1867	S^{s}	IWP	●	●
Holothuria pervicax Selenka, 1867	H^{is}	IWP		●
Holothuria rigida (Selenka, 1867)	H/S^{s}	IWP	●	
Holothuria scabra Jaeger, 1833	S^{is}	IWP	●	●
Holothuria spinifera Théel, 1886	S^{s}	IWP	●	
Holothuria verrucosa Selenka, 1867	S^{s}	IWP	●	
Holothuria whitmaei Bell, 1887	H/S^{s}	IA/WP		●
Labidodemas pertinax Ludwig, 1875	S^{s}	IWP		●
Labidodemas semperianum Selenka, 1867	H^{s}/S^{is}	IWP		●
Pearsonothuria graeffei (Semper, 1868)	H^{is}	IWP		●
Family: Phyllophoridae				
Havelockia versicolor (Semper, 1868)	H/S^{s}	IWP	●	●
Hemithyone semperi (Bell, 1884)	H/S^{s}	IWP	●	
cf. *Phyllophorus* sp.nov. ?[K]			●[K]	
Phyllophorus brocki Ludwig, 1888	H^{s}	IA	●	
Phyllophorus proteus Bell, 1884	H^{s}	NA	●	
Phyllophorus spiculata Chang, 1935	H/S^{s}	IWP	●	
Phyrella sp.	U		●	
Stolus buccalis (Stimpson, 1855)	S^{is}	IWP	●	
Stolus minutus (H.L. Clark, 1938)[P]	H^{s}	WA	●	
Thyone grisea H.L. Clark, 1938[P]	H^{is}	WA	●	
Thyone micra H.L. Clark, 1938	H^{s}	WA	●	
Thyone papuensis Théel, 1886	H^{s}	IWP	●	
Family: Sclerodactylidae				
Afrocucumis africana (Semper, 1868)	H^{is}	IWP	●	●
Cladolabes aciculus (Semper, 1868)	H^{s}	IWP		●
Cladolabes hamatus (Sluiter, 1914)	H^{s}	IO	●	
Cladolabes schmeltzii (Ludwig, 1875)	H^{s}	IWP	●	
Family: Stichopodidae				
Stichopus chloronotus Brandt, 1835	H^{is}	IWP	●	●
Stichopus ellipes H.L. Clark, 1938[P]	S^{s}	A	●	
Stichopus hermanni Semper, 1868	H^{s}/S^{is}	IWP		●
Stichopus horrens Selenka, 1867	H^{s}/S^{is}	IWP	●	●
Stichopus monotuberculatus (Quoy & Gaimard, 1833)	S^{s}	IWP		●
Stichopus naso Semper, 1868	S^{s}	IWP	●	●
Stichopus sp. nov.	U		●	
Thelenota ananas (Jaeger, 1833)	H/S^{s}	IWP		●
Thelenota anax H.L. Clark, 1921	H/S^{s}	IWP		●
Family: Synaptidae				
Euapta godeffroyi (Semper, 1868)	S^{is}	IP		●
Leptosynapta latipatina H.L. Clark, 1921	S^{is}	NA	●	
Opheodesoma grisea (Semper, 1868)	H^{s}/EZ[1]	WP		●
Polyplectana kefersteinii (Selenka, 1867)	H/S^{s}	IWP		●
Protankyra similis (Semper, 1868)	U	WP	●	

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Protankyra sp. nov.1	U		●	
Protankyra sp. nov.2	U		●	
Protankyra verrilli (Théel, 1886)	S^{s}	NA	●	
Rynkatorpa bisperforata (H.L. Clark, 1938)[P]	S^{i}	WA	●	
Synapta maculata (Chamisso & Eysenhardt, 1821)	H/S^{is}	IWP		●
Synaptula macra (H.L. Clark, 1938)	H^{s}/EZ^{1}	IA	●	
Synaptula recta (Semper, 1868)	H^{is}/EZ^{1}	IWP	●	●
Class: Ophiuroidea				
Family: Amphiuridae				
Amphioplus depressa (Ljungman, 1867)	H^{s}	IWP	●	
Amphioplus hastatus (Ljungman, 1867)	H^{s}	IO	●	
Amphioplus ochroleuca (Brock, 1888)	H^{s}	IA	●	
Amphipholis squamata (Delle-Chiaje, 1828)	H^{s}	C	●	●
Amphiura abbreviata Koehler, 1905	S^{s}	IA	●	
Amphiura cf. *ambigua* Koehler, 1905	H^{s}	IA	●	
Amphiura bidentata H.L. Clark, 1938[P]	H^{s}	NA	●	
Amphiura brachyactis H.L. Clark, 1938	H^{s}	WA	●	
Amphiura catephes H.L. Clark, 1938[P**]	H^{i}	NA	●	
Amphiura constricta Lyman, 1879	H^{s}	A	●	●
Amphiura leucaspis H.L. Clark, 1938[P]	H^{s}	WA	●	
Amphiura microsoma H.L. Clark, 1915	U	A		●
Amphiura octacantha (H.L. Clark, 1915)	S^{s}	IA	●	
Amphiura sp. nov.	S^{s}		●	
Amphiura stictacantha H.L. Clark, 1938[P]	H^{s}	WA	●	
Amphiura tenuis (H.L. Clark, 1938)[P]	S^{i}	IA	●	
Amphiura velox Koehler, 1910	S^{s}	IP	●	
Dougaloplus sp.	S^{s}	IA		●
Ophiocentrus aspera (Koehler, 1905)	S^{s}	IA/IO	●	
Ophiocentrus dilatata (Koehler, 1905)	S^{s}	IA/IO	●	●
Ophiocentrus verticillatus (Döderlein, 1896)	S^{s}	IA	●	
Family: Euryalidae				
Euryale asperum Lamarck, 1816	H^{s}/EZ^{5}	IA/IO	●	●
Family: Gorgonocephalidae				
Astroboa nuda (Lyman, 1874)	H^{s}	IA/IO		●
Family: Ophiactidae				
Ophiactis fuscolineata H.L. Clark, 1938[P]	H^{s}	NA	●	
Ophiactis hemiteles H.L. Clark, 1915	H^{s}	IO/NA		●
Ophiactis luteomaculata H.L. Clark, 1915	H^{s}	A	●	●
Ophiactis macrolepidota Marktanner-Turneretscher, 1887	H^{s}	IWP	●	
Ophiactis modesta Brock, 1888	H^{s}	IWP	●	
Ophiactis picteti (de Loriol, 1893)	U	IA/IO		●
Ophiactis savignyi (Müller & Troschel, 1842)	H^{s}/EZ^{1}	T	●	●
Family: Ophiocomidae				
Ophiarthrum elegans Peters, 1851	H^{is}	IWP	●	●
Ophiarthrum pictum (Müller & Troschel, 1842)	H^{is}	IWP	●	●
Ophiocoma anaglyptica Ely, 1944	H^{i}	WP		●

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Ophiocoma brevipes Peters, 1851	S^{i}	IWP		●
Ophiocoma dentata Müller & Troschel, 1842	H^{s}/S^{i}	IWP		●
Ophiocoma doederleini de Loriol, 1899	H^{s}	IWP		●
Ophiocoma erinaceus Müller & Troschel, 1842	H^{s}/S^{i}	IWP		●
Ophiocoma pica Müller & Troschel, 1842	H^{is}/EZ^{2}	IWP		●
Ophiocoma pusilla (Brock, 1888)	H^{s}	IA/IO		●
Ophiocoma schoenleinii Müller & Troschel, 1842	H^{i}	IWP		●
Ophiocoma scolopendrina (Lamarck, 1816)	H^{i}	IWP	●	●
Ophiocomella sexradia (Duncan, 1887)	H^{s}/EP	IWP		●
Ophiomastix annulosa (Lamarck, 1816)	H^{i}	IWP		●
Ophiomastix caryophyllata Lütken, 1869	H^{is}	IWP	●	
Ophiomastix mixta Lütken, 1869	H^{is}	WP	●	
Ophiomastix palaoensis Murakami, 1943	H^{i}	WP		●
Ophiomastix variabilis Koehler, 1905	H^{is}	IWP	●	●
Family: Ophiodermatidae				
Cryptopelta callista H.L. Clark, 1938^{P}	H^{s}	NA	●	
Cryptopelta granulifera H.L. Clark, 1909	H/S^{s}	IO		●
Ophiarachna affinis Lütken, 1869	H^{s}	IWP		●
Ophiarachna delicata (H.L. Clark, 1932)	H^{s}	IWP		●
Ophiarachna incrassata (Lamarck, 1816)	H/S^{s}	IWP		●
Ophiarachnella gorgonia (Müller & Troschel, 1842)	H^{is}	IWP	●	●
Ophiarachnella infernalis (Müller & Troschel, 1842)	H^{is}	IWP	●	●
Ophiarachnella septemspinosa (Müller & Troschel, 1842)	H^{s}	IWP	●	●
Ophiarachnella snelliusi (A.H. Clark, 1964)	H^{s}	IA		●
Ophiarachnella sphenisci (Bell, 1894)	H^{s}	IA	●	
Ophiochaeta hirsuta Lütken, 1869	H^{s}	IWP		●
Ophiochasma stellata (Ljungman, 1867)	S^{s}	IA	●	
Ophioconis cincta Brock, 1888	H^{s}	IA/IO	●	●
Ophiodyscrita acosmeta H.L. Clark, 1938	H/S^{is}	IA	●	
Ophiopeza spinosa (Ljungman, 1867)	H/S^{s}	IWP		●
Family: Ophiolepididae				
Ophiolepis cincta Müller & Troschel, 1842	H^{s}/S^{i}/SG	IWP		●
Ophiolepis irregularis Brock, 1888	H/S^{s}	IWP		●
Ophiolepis superba H.L. Clark, 1915	S^{s}	IWP		●
Ophiolepis unicolor H.L. Clark, 1938^{P}	H/S^{s}	NA	●	
Ophioplocus giganteus Irimura & Yoshino, 1999	H^{i}/S^{is}	IA		●
Ophioplocus imbricatus (Müller & Troschel, 1842)	S^{i}/SG	IWP	●	●
Family: Ophiomyxidae				
Ophiomyxa australis Lütken, 1869	S^{s}	IWP	●	●
Family: Ophionereididae				
Ophionereis dubia (Müller & Troschel, 1842)	H^{is}/S^{s}	IWP	●	●
Ophionereis fusca Brock, 1888	H^{s}	WP		●
Ophionereis hexactis Clark H L, 1938	H^{s}	IWP		●
Ophionereis porrecta Lyman, 1860	H^{s}	IWP		●
Ophionereis semoni (Döderlein, 1896)	H^{s}	WP	●	

Taxa	Habitat Code	Biogeographic Region	Inshore	Offshore
Family: Ophiotrichidae				
Lissophiothrix delicata H.L. Clark, 1938[P]	H/S^{s}	NA	●	
Macrophiothrix caenosa Hoggett, 2006	H^{i}/S^{is}	IA	●	
Macrophiothrix callizona H.L. Clark, 1938	H^{i}/S^{is}	WA	●	
Macrophiothrix demessa (Lyman, 1861)	H^{is}	IWP		●
Macrophiothrix koehleri A.M. Clark, 1968	H/S^{i}	IA/WP		●
Macrophiothrix leucosticha Hoggett, 1991	H^{is}	IA		●
Macrophiothrix longipeda (Lamarck, 1816)	H^{i}/S^{is}	IWP	●	●
Macrophiothrix lorioli A.M. Clark, 1968	H/S^{is}	IA/WP		●
Macrophiothrix megapoma H.L. Clark, 1938[P]	H^{i}/S^{is}	NA	●	
Macrophiothrix microplax (Bell, 1884)	H^{i}/S^{is}	NA	●	
Macrophiothrix paucispina Hoggett, 1991	H^{i}/S^{is}	NA	●	●
Macrophiothrix propinqua (Lyman, 1861)	H^{is}	IWP		●
Macrophiothrix rhabdota (H.L. Clark, 1915)	H^{is}	NA		●
Macrophiothrix robillardi (de Loriol, 1893)	H/S^{i}	IWP		●
Ophiocnemis marmorata (Lamarck, 1816)	S^{is}	IA/IO	●	
Ophiogymna cf. *pellicula* (Duncan, 1887)	H^{s}/EZ^{4}	IWP		●
Ophiomaza cacaotica Lyman, 1871	H^{s}/EZ^{6}	IWP	●	
Ophiothela danae Verrill, 1869	H^{s}/EZ^{5}	IWP	●	●
Ophiothrix armata Koehler, 1905	H^{s}/EZ^{5}	WP		●
Ophiothrix ciliaris (Lamarck, 1816)	H^{s}/EZ^{1}	IA	●	●
Ophiothrix contenta Koehler, 1930	H^{s}	IA	●	
Ophiothrix deceptor Koehler, 1922	H^{s}	IWP		●
Ophiothrix exigua Lyman, 1874	H^{s}/EZ^{1}	IWP	●	●
Ophiothrix lineocaerulea H.L. Clark, 1928	H^{s}/EZ^{1}	IA	●	
Ophiothrix martensi Lyman, 1874	H^{s}	IA	●	●
Ophiothrix melanosticta Grube, 1868	H^{s}	IA	●	
Ophiothrix miles Koehler, 1905	H^{s}	WP	●	
Ophiothrix nereidina (Lamarck, 1816)	H^{s}/EZ^{5}	IWP	●	●
Ophiothrix plana Lyman, 1874	H^{s}	WP	●	
Ophiothrix picteti de Loriol, 1893	H^{s}	IA		●
Ophiothrix purpurea von Martens, 1867	H^{s}/EZ^{5}	IWP		●
Ophiothrix savignyi (Müller & Troschel, 1842)	H^{s}	IWP		●
Ophiothrix smaragdina Studer, 1882	H^{s}/EZ^{1}	NA	●	
Ophiothrix (Placophiothrix) striolata Grube, 1868	S^{s}	IP	●[K]	
Ophiothrix trilineata Lütken, 1869	H^{s}	IWP	●	●
Family: Ophiuridae				
Dictenophiura stellata (Studer, 1882)	S^{s}	IA	●	
Ophiura kinbergi (Ljungman, 1866)	S^{s}	IWP	●	

APPENDIX 3 Species and family richness, number of collecting events, and family occurrence at each location within the Project Area.

Location	Collecting Year Range	Species Richness	No. Collecting Events	No. Families
Adele Island	1962–1990	4	2	3
Admiral Island	1989	4	1	1
Admiralty Gulf	1978	4	2	4
Albert Islands	1988	1	1	1
Ashmore Reef[OA]	1978–2002	173	8	36
Augustus Island	1933–1990	26	5	17
Beagle Bay	1932–1988	4	2	4
Beagle Reef	1991	8	1	7
Bedford Island	1989	6	1	5
Bigge Island	1987	1	1	1
Broome	1913–2006	167	41	41
Buffon Island	1983–1988	4	2	3
Caffarelli Island	1994	2	1	2
Cambridge Gulf	1995	1	1	1
Camden Sound	1987–1990	10	2	10
Cape Bossut	1929–1985	15	5	12
Cape Frezier	1980	2	1	2
Cape Jaubert	-	2	1	2
Cape Leveque	1972–1988	18	4	9
Cape Villaret	1929	2	2	2
Cape Voltaire	1976	7	1	6
Careening Bay	1987	1	1	1
Cartier Island[OA]	1977–1992	56	3	23
Cassini Island	1991–1998	17	4	12
Churchill Reef	1991	8	1	6
Clerke Reef[OA]	1982	63	1	21
Cockatoo Island	1962–1998	21	7	15
Condillac Island	1976–1991	4	2	3
Corneille Island	1976	1	1	1
Coulomb Point	1975–2009	6	2	6
Cygnet Bay	1975	1	1	1
Derby	1974	2	2	2
Entrance Island	1988	4	1	3
False Cape Bossut	1929–1946	6	3	5
Fenelon Island	1988	2	1	2
Gourdon Bay	1962	1	1	1
Hale Island	1991	14	1	8
Hibernia Reef[OA]	1991–1998	24	3	10
Heritage Reef	1991	5	1	5
James Price Point	1988–2009	17	2	10
Jar Island	1995	2	1	2
Johnson Bank[OA]	2002	4	1	2
Jones Island	1991–1995	11	2	8
Kalumburu	1960	1	1	1
King Sound	1929	2	2	2

Location	Collecting Year Range	Species Richness	No. Collecting Events	No. Families
Kingfisher Island	1990	1	1	1
Kuri Bay	1964–1991	11	4	7
Lacepede Islands	1962–1991	22	6	16
Lacrosse Island	1995	1	1	1
Lagrange Bay	1929–1985	7	4	7
Langgi	1988	3	1	3
Leonie Island	1994	3	1	2
Lesueur Island	1991	9	1	5
Long Reef	1988–1991	9	2	8
Lord Island	1991	5	1	4
Louis Islands	1995	1	1	1
Lucas Island	1988	2	1	2
Macleay Island	1989	6	1	5
Mary Island	1989	3	1	1
Mermaid Island	1991–1994	5	2	3
Mermaid Reef[OA]	1978–2006	71	3	22
Mitchell River	1968–1977	2	2	2
Montalivet Islands	1963–1991	11	5	8
Montgomery Reef	1987–1994	19	4	14
Napier Broome Bay	1991	9	1	8
One Arm Point	1975–1988	26	4	13
Parry Harbour	1991	11	1	9
Pender Bay	1974	6	2	3
Port Warrender	1976	3	2	3
Powerful Island	1991	6	1	5
Prince Frederick Harbour	1987–1997	4	3	3
Prince Regent River	1978	1	1	1
Quondong Point	1975	12	1	7
Robroy Reefs	1988–1991	5	2	4
Scorpion Island	1991	14	2	9
Scott Reef[OA]	1984–2006	125	3	36
Seringapatam Reef[OA]	1978–2006	41	4	18
Sheep Island	1987	1	1	1
Shirley Island	1988	1	1	1
Solem Islands	1991	8	1	5
Storr Island	1990	4	1	4
Sunday Island	1991–1994	21	2	11
Tallon Island	1994	7	1	4
Troughton Island	1971	1	1	1
Vansittart Bay	1971–1991	2	2	2
Wailgwin Island	1988–1990	9	2	5
Walsh Point	1976	12	2	6
West Governor Island	1995	2	1	2
Whirlpool Pass	1994	11	1	8
Woodward Island	1991	2	1	2
Yampi Sound	1958–1959	11	6	9
Yankawingarri Island	1991	9	1	6
York Sound	1975	2	1	2

CLASS: ASTEROIDEA

Location	Collecting Year Range	Acanthasteridae	Archasteridae	Asterinidae	Asteropseidae	Astropectinidae	Echinasteridae	Goniasteridae	Luidiidae	Mithrodiidae	Ophidiasteridae	Oreasteridae	Pterasteridae
Adele Island	1962–1990										•		
Admiral Island	1989												
Admiralty Gulf	1978								•				
Albert Islands	1988												
Ashmore Reef[OA]	1978–2002	•	•	•	•		•			•	•	•	
Augustus Island	1933–1990											•	
Beagle Bay	1932–1988								•				
Beagle Reef	1991												
Bedford Island	1989			•									
Bigge Island	1987												
Broome	1913–2006		•	•		•	•	•	•		•	•	•
Buffon Island	1983–1988							•			•		
Caffarelli Island	1994												
Cambridge Gulf	1995												
Camden Sound	1987–1990												
Cape Bossut	1929–1985							•				•	
Cape Frezier	1980												
Cape Jaubert	-												
Cape Leveque	1972–1988			•									
Cape Villaret	1929												
Cape Voltaire	1976											•	
Careening Bay	1987												
Cartier Island[OA]	1977–1992			•	•						•		
Cassini Island	1991–1998	•						•			•	•	
Churchill Reef	1991										•		
Clerke Reef[OA]	1982				•		•				•	•	
Cockatoo Island	1962–1998			•							•	•	
Condillac Island	1976–1991												
Corneille Island	1976												
Coulomb Point	1975–2009											•	
Cygnet Bay	1975												
Derby	1974												
Entrance Island	1988												
False Cape Bossut	1929–1946											•	
Fenelon Island	1988												
Gourdon Bay	1962												
Hale Island	1991											•	
Hibernia Reef[OA]	1991–1998										•	•	
Heritage Reef	1991												
James Price Point	1988–2009												
Jar Island	1995												
Johnson Bank[OA]	2002						•						
Jones Island	1991–1995												
Kalumburu	1960					•							
King Sound	1929							•					
Kingfisher Island	1990												
Kuri Bay	1964–1991											•	

CLASS: ASTEROIDEA

Location	Collecting Year Range	Acanthasteridae	Archasteridae	Asterinidae	Asteropseidae	Astropectinidae	Echinasteridae	Goniasteridae	Luidiidae	Mithrodiidae	Ophidiasteridae	Oreasteridae	Pterasteridae
Lacepede Islands	1962–1991											•	
Lacrosse Island	1995												
Lagrange Bay	1929–1985		•										
Langgi	1988			•									
Leonie Island	1994												
Lesueur Island	1991											•	
Long Reef	1988–1991			•								•	
Lord Island	1991											•	
Louis Islands	1995												
Lucas Island	1988							•					
Macleay Island	1989											•	
Mary Island	1989												
Mermaid Island	1991–1994												
Mermaid Reef[OA]	1978–2006			•			•				•	•	
Mitchell River	1968–1977												
Montalivet Islands	1963–1991	•										•	
Montgomery Reef	1987–1994					•						•	
Napier Broome Bay	1991			•									
One Arm Point	1975–1988			•								•	
Parry Harbour	1991			•		•							
Pender Bay	1974						•				•	•	
Port Warrender	1976											•	
Powerful Island	1991												
Prince Frederick Harbour	1987–1997												
Prince Regent River	1978											•	
Quondong Point	1975												
Robroy Reefs	1988–1991												
Scorpion Island	1991												
Scott Reef[OA]	1984–2006	•		•	•		•			•	•	•	•
Seringapatam Reef[OA]	1978–2006			•	•		•				•	•	
Sheep Island	1987												
Shirley Island	1988												
Solem Islands	1991											•	
Storr Island	1990			•									
Sunday Island	1991–1994											•	
Tallon Island	1994												
Troughton Island	1971											•	
Vansittart Bay	1971–1991					•							
Wailgwin Island	1988–1990			•									
Walsh Point	1976			•								•	
West Governor Island	1995												
Whirlpool Pass	1994											•	
Woodward Island	1991												
Yampi Sound	1958–1959			•								•	
Yankawingarri Island	1991	•											
York Sound	1975												
Total			3	18	5	5	7	6	3	2	14	33	2

CLASS: CRINOIDEA

Location	Collecting Year Range	Antedonidae	Colobometridae	Comasteridae	Himerometridae	Mariametridae	Zygometridae
Adele Island	1962–1990						
Admiral Island	1989						
Admiralty Gulf	1978						•
Albert Islands	1988						
Ashmore Reef[OA]	1978–2002	•	•	•	•	•	
Augustus Island	1933–1990	•		•			
Beagle Bay	1932–1988						
Beagle Reef	1991					•	
Bedford Island	1989			•			
Bigge Island	1987						
Broome	1913–2006		•	•	•	•	•
Buffon Island	1983–1988						
Caffarelli Island	1994						
Cambridge Gulf	1995						
Camden Sound	1987–1990						•
Cape Bossut	1929–1985	•		•			•
Cape Frezier	1980						
Cape Jaubert	-						
Cape Leveque	1972–1988			•			
Cape Villaret	1929			•			
Cape Voltaire	1976						
Careening Bay	1987						
Cartier Island[OA]	1977–1992		•	•			
Cassini Island	1991–1998			•			
Churchill Reef	1991					•	
Clerke Reef[OA]	1982	•	•	•		•	
Cockatoo Island	1962–1998			•			
Condillac Island	1976–1991						
Corneille Island	1976						
Coulomb Point	1975–2009						
Cygnet Bay	1975						
Derby	1974						
Entrance Island	1988						
False Cape Bossut	1929–1946			•			
Fenelon Island	1988						
Gourdon Bay	1962						
Hale Island	1991		•	•			
Hibernia Reef[OA]	1991–1998						
Heritage Reef	1991			•		•	
James Price Point	1988–2009			•		•	
Jar Island	1995						
Johnson Bank[OA]	2002						
Jones Island	1991–1995			•		•	
Kalumburu	1960						
King Sound	1929						
Kingfisher Island	1990						
Kuri Bay	1964–1991						

CLASS: CRINOIDEA

Location	Collecting Year Range	Antedonidae	Colobometridae	Comasteridae	Himerometridae	Mariametridae	Zygometridae
Lacepede Islands	1962–1991			●		●	●
Lacrosse Island	1995						
Lagrange Bay	1929–1985						
Langgi	1988						
Leonie Island	1994						
Lesueur Island	1991						
Long Reef	1988–1991			●		●	
Lord Island	1991						
Louis Islands	1995						
Lucas Island	1988						
Macleay Island	1989			●			
Mary Island	1989						
Mermaid Island	1991–1994						
Mermaid Reef[OA]	1978–2006			●		●	
Mitchell River	1968–1977						
Montalivet Islands	1963–1991						
Montgomery Reef	1987–1994			●		●	
Napier Broome Bay	1991						
One Arm Point	1975–1988			●			
Parry Harbour	1991						
Pender Bay	1974						
Port Warrender	1976	●					
Powerful Island	1991			●		●	
Prince Frederick Harbour	1987–1997						
Prince Regent River	1978						
Quondong Point	1975			●			
Robroy Reefs	1988–1991						
Scorpion Island	1991			●		●	
Scott Reef[OA]	1984–2006	●	●	●		●	
Seringapatam Reef[OA]	1978–2006						
Sheep Island	1987						
Shirley Island	1988						
Solem Islands	1991			●		●	
Storr Island	1990						
Sunday Island	1991–1994			●		●	
Tallon Island	1994						
Troughton Island	1971						
Vansittart Bay	1971–1991						
Wailgwin Island	1988–1990						
Walsh Point	1976						
West Governor Island	1995						
Whirlpool Pass	1994			●			
Woodward Island	1991						
Yampi Sound	1958–1959			●			
Yankawingarri Island	1991			●			
York Sound	1975						
Total		6	6	31	2	17	5

CLASS: ECHINOIDEA Location	Collecting Year Range	Arachnoididae	Astriclypeidae	Brissidae	Cidaridae	Clypeasteridae	Diadematidae	Echinolampadidae	Echinometridae	Echinoneidae	Fibulariidae	Laganidae	Loveniidae	Parasaleniidae	Schizasteridae	Spatangidae	Temnopleuridae	Toxopneustidae
Adele Island	1962–1990																	
Admiral Island	1989																	
Admiralty Gulf	1978																	
Albert Islands	1988																	
Ashmore Reef[OA]	1978–2002			●	●	●	●	●	●	●			●	●			●	●
Augustus Island	1933–1990	●			●		●	●				●		●			●	
Beagle Bay	1932–1988	●										●	●					
Beagle Reef	1991				●													
Bedford Island	1989											●						
Bigge Island	1987											●						
Broome	1913–2006	●	●	●	●	●		●			●	●	●		●		●	●
Buffon Island	1983–1988																	
Caffarelli Island	1994																	
Cambridge Gulf	1995	●																
Camden Sound	1987–1990	●										●	●	●			●	
Cape Bossut	1929–1985											●	●					
Cape Frezier	1980							●					●					
Cape Jaubert	-																●	
Cape Leveque	1972–1988											●						
Cape Villaret	1929				●													
Cape Voltaire	1976				●		●							●			●	
Careening Bay	1987	●																
Cartier Island[OA]	1977–1992			●	●	●	●		●	●				●				
Cassini Island	1991–1998						●											
Churchill Reef	1991				●													
Clerke Reef[OA]	1982			●	●		●		●	●								
Cockatoo Island	1962–1998				●			●				●	●		●		●	
Condillac Island	1976–1991						●											
Corneille Island	1976													●				
Coulomb Point	1975–2009											●						
Cygnet Bay	1975											●						
Derby	1974	●									●							
Entrance Island	1988	●										●						
False Cape Bossut	1929–1946																	
Fenelon Island	1988							●					●					
Gourdon Bay	1962																	
Hale Island	1991																	
Hibernia Reef[OA]	1991–1998			●										●				
Heritage Reef	1991																	
James Price Point	1988–2009																	
Jar Island	1995																	
Johnson Bank[OA]	2002																	
Jones Island	1991–1995				●		●											
Kalumburu	1960																	
King Sound	1929				●													
Kingfisher Island	1990											●						
Kuri Bay	1964–1991											●	●	●				

CLASS: ECHINOIDEA

Location	Collecting Year Range	Arachnoididae	Astriclypeidae	Brissidae	Cidaridae	Clypeasteridae	Diadematidae	Echinolampadidae	Echinometridae	Echinoneidae	Fibulariidae	Laganidae	Loveniidae	Parasaleniidae	Schizasteridae	Spatangidae	Temnopleuridae	Toxopneustidae
Lacepede Islands	1962–1991				●			●										●
Lacrosse Island	1995	●																
Lagrange Bay	1929–1985	●						●				●	●					
Langgi	1988													●				
Leonie Island	1994																	
Lesueur Island	1991						●											
Long Reef	1988–1991						●											
Lord Island	1991																	
Louis Islands	1995	●																
Lucas Island	1988																	
Macleay Island	1989				●							●						
Mary Island	1989																	
Mermaid Island	1991–1994											●						
Mermaid Reef[OA]	1978–2006			●		●	●		●	●				●		●		●
Mitchell River	1968–1977	●																
Montalivet Islands	1963–1991						●											
Montgomery Reef	1987–1994				●												●	
Napier Broome Bay	1991	●									●	●						
One Arm Point	1975–1988				●									●			●	●
Parry Harbour	1991	●											●				●	
Pender Bay	1974																	
Port Warrender	1976																●	
Powerful Island	1991											●						
Prince Frederick Harbour	1987–1997	●															●	
Prince Regent River	1978																	
Quondong Point	1975											●					●	
Robroy Reefs	1988–1991						●											
Scorpion Island	1991			●			●											
Scott Reef[OA]	1984–2006			●	●	●	●		●	●	●			●	●		●	●
Seringapatam Reef[OA]	1978–2006			●	●		●		●	●				●				
Sheep Island	1987											●						
Shirley Island	1988				●													
Solem Islands	1991						●											
Storr Island	1990																	
Sunday Island	1991–1994				●													
Tallon Island	1994																	
Troughton Island	1971																	
Vansittart Bay	1971–1991	●																
Wailgwin Island	1988–1990																	
Walsh Point	1976						●										●	
West Governor Island	1995	●															●	
Whirlpool Pass	1994				●									●			●	
Woodward Island	1991																	
Yampi Sound	1958–1959																●	
Yankawingarri Island	1991				●		●											
York Sound	1975																	
Total		17	1	9	22	5	19	8	6	6	4	21	11	14	3	1	18	6

CLASS: HOLOTHUROIDEA

Location	Collecting Year Range	Caudinidae	Chiridotidae	Cucumariidae	Holothuriidae	Phyllophoridae	Sclerodactylidae	Stichopodidae	Synaptidae
Adele Island	1962–1990				•			•	
Admiral Island	1989				•				
Admiralty Gulf	1978			•			•		
Albert Islands	1988								
Ashmore Reef[OA]	1978–2002		•		•	•	•	•	•
Augustus Island	1933–1990			•					
Beagle Bay	1932–1988								
Beagle Reef	1991				•				
Bedford Island	1989								
Bigge Island	1987								
Broome	1913–2006	•		•	•	•	•	•	•
Buffon Island	1983–1988								
Caffarelli Island	1994				•				
Cambridge Gulf	1995								
Camden Sound	1987–1990				•				
Cape Bossut	1929–1985			•		•			
Cape Frezier	1980								
Cape Jaubert	-							•	
Cape Leveque	1972–1988				•				
Cape Villaret	1929								
Cape Voltaire	1976								
Careening Bay	1987								
Cartier Island[OA]	1977–1992				•		•	•	
Cassini Island	1991–1998				•			•	
Churchill Reef	1991				•				•
Clerke Reef[OA]	1982				•				
Cockatoo Island	1962–1998				•				
Condillac Island	1976–1991				•				
Corneille Island	1976								
Coulomb Point	1975–2009				•	•	•		
Cygnet Bay	1975								
Derby	1974								
Entrance Island	1988								
False Cape Bossut	1929–1946			•		•	•		
Fenelon Island	1988								
Gourdon Bay	1962			•					
Hale Island	1991								•
Hibernia Reef[OA]	1991–1998		•		•				
Heritage Reef	1991								
James Price Point	1988–2009			•	•	•	•		
Jar Island	1995								•
Johnson Bank[OA]	2002								
Jones Island	1991–1995				•				•
Kalumburu	1960								
King Sound	1929								
Kingfisher Island	1990								
Kuri Bay	1964–1991				•				

CLASS: HOLOTHUROIDEA

Location	Collecting Year Range	Caudinidae	Chiridotidae	Cucumariidae	Holothuriidae	Phyllophoridae	Sclerodactylidae	Stichopodidae	Synaptidae
Lacepede Islands	1962–1991				●	●			
Lacrosse Island	1995								
Lagrange Bay	1929–1985								
Langgi	1988								
Leonie Island	1994				●				
Lesueur Island	1991				●			●	
Long Reef	1988–1991				●				
Lord Island	1991				●				
Louis Islands	1995								
Lucas Island	1988								
Macleay Island	1989							●	
Mary Island	1989				●				
Mermaid Island	1991–1994				●				
Mermaid Reef[OA]	1978–2006				●			●	
Mitchell River	1968–1977			●					
Montalivet Islands	1963–1991				●				
Montgomery Reef	1987–1994			●	●	●			●
Napier Broome Bay	1991				●	●			
One Arm Point	1975–1988				●				
Parry Harbour	1991					●			●
Pender Bay	1974								
Port Warrender	1976								
Powerful Island	1991			●	●				
Prince Frederick Harbour	1987–1997								
Prince Regent River	1978								
Quondong Point	1975								
Robroy Reefs	1988–1991							●	
Scorpion Island	1991				●				
Scott Reef[OA]	1984–2006			●	●		●	●	●
Seringapatam Reef[OA]	1978–2006				●				
Sheep Island	1987								
Shirley Island	1988								
Solem Islands	1991							●	
Storr Island	1990								
Sunday Island	1991–1994				●		●		
Tallon Island	1994				●	●			
Troughton Island	1971								
Vansittart Bay	1971–1991								
Wailgwin Island	1988–1990				●				
Walsh Point	1976								
West Governor Island	1995								
Whirlpool Pass	1994					●	●		
Woodward Island	1991				●				
Yampi Sound	1958–1959				●				●
Yankawingarri Island	1991								
York Sound	1975			●					
Total		1	2	12	40	12	10	12	10

CLASS: OPHIUROIDEA

Location	Collecting Year Range	Amphiuridae	Euryalidae	Gorgonocephalidae	Ophiactidae	Ophiocomidae	Ophiodermatidae	Ophiolepididae	Ophiomyxidae	Ophionereididae	Ophiotrichidae	Ophiuridae
Adele Island	1962–1990											
Admiral Island	1989											
Admiralty Gulf	1978											
Albert Islands	1988							•				
Ashmore Reef[OA]	1978–2002	•			•	•	•	•			•	
Augustus Island	1933–1990				•	•	•	•			•	•
Beagle Bay	1932–1988											
Beagle Reef	1991				•		•	•			•	
Bedford Island	1989						•				•	
Bigge Island	1987											
Broome	1913–2006	•	•		•		•	•		•	•	•
Buffon Island	1983–1988						•					
Caffarelli Island	1994				•							
Cambridge Gulf	1995											
Camden Sound	1987–1990				•		•				•	
Cape Bossut	1929–1985							•		•		•
Cape Frezier	1980											
Cape Jaubert	-											
Cape Leveque	1972–1988				•		•	•		•	•	
Cape Villaret	1929											
Cape Voltaire	1976						•					
Careening Bay	1987											
Cartier Island[OA]	1977–1992	•			•	•	•	•	•	•	•	
Cassini Island	1991–1998				•	•	•				•	
Churchill Reef	1991										•	
Clerke Reef[OA]	1982	•			•	•	•	•		•	•	
Cockatoo Island	1962–1998					•	•	•			•	
Condillac Island	1976–1991						•					
Corneille Island	1976											
Coulomb Point	1975–2009				•							
Cygnet Bay	1975											
Derby	1974											
Entrance Island	1988	•										
False Cape Bossut	1929–1946											
Fenelon Island	1988											
Gourdon Bay	1962											
Hale Island	1991				•	•	•				•	
Hibernia Reef[OA]	1991–1998				•	•	•				•	
Heritage Reef	1991						•		•		•	
James Price Point	1988–2009						•	•		•	•	
Jar Island	1995										•	
Johnson Bank[OA]	2002					•						
Jones Island	1991–1995					•	•					
Kalumburu	1960											
King Sound	1929											
Kingfisher Island	1990											
Kuri Bay	1964–1991	•									•	

CLASS: OPHIUROIDEA

Location	Collecting Year Range	Amphiuridae	Euryalidae	Gorgonocephalidae	Ophiactidae	Ophiocomidae	Ophiodermatidae	Ophiolepididae	Ophiomyxidae	Ophionereididae	Ophiotrichidae	Ophiuridae
Lacepede Islands	1962–1991	•	•		•	•	•			•	•	
Lacrosse Island	1995											
Lagrange Bay	1929–1985	•									•	
Langgi	1988							•				
Leonie Island	1994						•					
Lesueur Island	1991				•							
Long Reef	1988–1991				•	•						
Lord Island	1991	•									•	
Louis Islands	1995											
Lucas Island	1988										•	
Macleay Island	1989											
Mary Island	1989											
Mermaid Island	1991–1994						•					
Mermaid Reef[OA]	1978–2006				•	•	•		•	•	•	
Mitchell River	1968–1977											
Montalivet Islands	1963–1991				•	•	•				•	
Montgomery Reef	1987–1994					•	•	•			•	
Napier Broome Bay	1991				•						•	
One Arm Point	1975–1988				•	•	•	•			•	
Parry Harbour	1991	•									•	
Pender Bay	1974											
Port Warrender	1976											
Powerful Island	1991											
Prince Frederick Harbour	1987–1997										•	
Prince Regent River	1978											
Quondong Point	1975					•		•		•	•	
Robroy Reefs	1988–1991				•				•			
Scorpion Island	1991				•		•	•			•	
Scott Reef[OA]	1984–2006			•	•	•	•	•	•	•	•	
Seringapatam Reef[OA]	1978–2006	•			•	•	•			•	•	
Sheep Island	1987											
Shirley Island	1988											
Solem Islands	1991											
Storr Island	1990	•					•				•	
Sunday Island	1991–1994				•	•	•	•			•	
Tallon Island	1994						•	•				
Troughton Island	1971											
Vansittart Bay	1971–1991											
Wailgwin Island	1988–1990					•	•				•	
Walsh Point	1976				•						•	
West Governor Island	1995											
Whirlpool Pass	1994										•	
Woodward Island	1991				•							
Yampi Sound	1958–1959					•		•			•	
Yankawingarri Island	1991	•			•							
York Sound	1975		•									
Total		13	3	1	28	21	33	20	5	11	39	3