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Benthic habitats and biodiversity of the Dampier and Montebello Australian Marine Parks

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Executive summary

Background and study description

The Montebello and Dampier Marine Parks (MPs) off the Pilbara coast of Western Australia were established in 2018 as part of a new network of Commonwealth Australian Marine Parks (AMPs) in north-western Australia. However, little was known of the range or extent of seabed habitat types and of the diversity of marine life they support. These are important information needs for MP management, establishing environmental baselines and monitoring programs and in evaluating MP performance.

The objective of this project was to provide the Director of National Parks (DNP) with baseline data on benthic habitats and marine biodiversity in parts of the Commonwealth Montebello and Dampier Marine Parks (MPs). This information was collected by carrying out a survey in October–November 2017 on the RV *Investigator* and from analysis of data from two historical studies, the Pilbara Marine Conservation Partnership survey of the southern Pilbara in 2013 and the CSIRO North West Shelf surveys conducted between 1982 and 1997. Much of the data from these studies had not been published previously.

Habitat information was collected by mapping depths, sub-bottom profiling to determine seabed structure, multibeam acoustic swathing (bathymetry and backscatter [seabed hardness/softness]) and by interpreting imagery of the seabed. Each of the sites surveyed have about a 7 km length of seabed swathed. Although depths were shallow, multiple passes at most sites mean the swath width was about 500 m. The seabed imagery covers transects of about 3km long at each site. Water column information was collected by conductivity/temperature/depth (CTD) profiling to measure chlorophyll a, salinity, temperature dissolved oxygen and photosynthetically available radiation (PAR). Water sampling was undertaken to measure nutrients.

The biodiversity assessment focused on key sessile, benthic habitat forming filter feeder (sponges, soft corals) and mobile invertebrate species (molluscs, crustaceans, echinoderms) as well as demersal fishes. Both demersal fish trawl and epibenthic sleds were used to sample biodiversity.

In addition to describing the nature of habitats, fish and other biota occurring in the two MPs the report also provides a comparison of areas sampled in the Montebello MP with those in the adjacent Pilbara Fish Trawl Fishery Area 1. These two areas have a different history of fishing effort. Both areas were trawled extensively and intensively in the 1970s and 1980s by a range of foreign vessels, mainly Taiwanese. However, since 1985, there has been little or no trawling in the area that now comprises the Montebello MP. Comparisons of the areas include dominant categories of habitat, bottom topography and benthic biota, biomass, morphology and size composition of habitat forming sponges and soft corals and fish diversity, biomass and assemblage types.

Dampier Marine Park

The physical and biohabitat types present in the Dampier MP were assessed and mapped using data available from 8 sites in the General Use Zone (GUZ) and 2 sites in the Habitat Protection Zone (HPZ). Detailed information based on swath mapping and sub-bottom profiling was limited to the two GUZ sites (29–34 m) and the one deeper HPZ site (35–40 m) surveyed in 2017. The GUZ had predominantly flat or finely rippled, fine sandy substrate, with much of it overlying hard substrate as evidenced by the presence of large numbers of filter feeders. Sponges were especially abundant making up 20–50% of biota present. Only 2 sites had more than 20% of images captured with no biota present over transects of about 3km. The 2017 site W4 had a high density and biomass of sponges, including some very large (ca. 1 m) *Ircinia* barrel sponges, including one that housed 30 individuals of the locally endemic cat shark *Atelomycterus fasciatus*. This revealed an important habitat association not previously documented for this shark. The HPZ was predominantly soft sediment habitat including some sand dunes. It had fewer biota with >30% of images having no biota. Biota that was present was dominated by sponges, soft corals, hydroids and crinoids. The 2017 site W8 had a very high biomass of *Dendronephthy*a soft corals.

Biodiversity assessment was conducted at the three sites surveyed in 2017. Fish diversity was high with 106 species recorded. This represented 31% of the 342 species sampled from just 3% of the 103 sites sampled on the entire voyage across the North West Shelf. Twelve species (11%) recorded from the 2017 survey had not previously been recorded from the Dampier MP bringing the total known fishe species from the Dampier MP to 224 based on Atlas of Living Australia (ALA) records.

There were 46 species of soft coral, covering 12 families and 26 genera, recorded from the Dampier MP, including the species *Nephthyigorgia kükenthali* (Nidaliidae) which was previously thought to be very rare. Other rare species recorded were *Studeriotes crassa* and *Plumarella penna*. The latter is a delicate, feather-like, soft coral that has rarely been recorded from shallow waters (< 60 m). There have been no previous reports of soft corals from the Dampier MP.

There were 110 species of sponge sampled from the Dampier MP, although only 3 species were sampled from the site in the HPZ which had a depauperate filter feeder community. Most species found were singletons suggesting the area has high levels of rare and endemic species. There were 11 species of sponge previously recorded for the Dampier MP in the ALA and WA Museum collections of which six occurred again in our 2017 collections. Thus our 2017 sampling has made a very significant increase in knowledge of sponge diversity in the Dampier MP.

Thirty-one (31) species of crustaceans were collected from the Dampier MP in 2017 with 29 of these recorded at only a single station. Only one species, the Bay lobster (or bug) *Thenus australiensis* was found at all three stations. Two new records for Australia were collected from the Dampier MP, a shrimp (*Metapenaeopsis propinqua*) and a hermit crab (*Pagurus similis*), representing an extension of their previously known ranges from New Caledonia and Taiwan, respectively. *Pagurus similis* also appeared in the Montebello MP samples. This project has contributed significantly to knowledge of crustaceans in the area. Sixteen species (52%) of those collected from the Dampier MP in 2017 had not been reported in previous surveys of the broader Dampier Archipelago region. Records held in the Atlas of Living Australia (ALA) prior to this project listed just 13 crustacean species recorded for the Dampier MP. Most of these were not recorded in our surveys perhaps due to a number of them being small nektonic species probably sampled by plankton nets.

There were 54 mollusc species (24 bivalve, 27 gastropod, 3 cephalopod) collected from the three stations in the Dampier MP and 48 species were recorded at only one station indicating that most species were rare. Indeed many were single specimens. However the number of species at the three stations was quite uniform (17, 20 and 24). Taxa of note in the Dampier MP included *Zoila decipiens*, a rare and endemic cowrie in Western Australia. The 2017 voyage collections have made a significant enhancement to the records of molluscs occurring in the Dampier MP. The ALA had only recorded three species from the Dampier MP prior to this study and the WA Museum collection only had seven species in its collection from the Dampier MP prior to this study.

Among the echinoderms, crinoids and ophiuroids were identified from the three Dampier MP sites. Sixteen crinoid species were collected. Previously only eight species of crinoids had been recorded from the Dampier MP based on ALA records only one of which was not recorded in this study. Nineteen (19) species of ophiuroids (two basket stars, one snake star and 16 brittle stars) were collected from the Dampier MP. Fifteen ophiuroids had previously been recorded for the Montebello MP (ALA) but only seven of these overlapped our study meaning the diversity of ophiuroids at Montebello MP has been increased to 27 (a 59% increase as a result of this study). One undescribed species of *Ophiochasma* was alsorecorded.

Diversity of algae sampled from the Dampier MP was low, with just 15 species from three stations. The seagrass *Halophila spinulosa* was also recorded. Only a few reptiles were recorded in the 2017 survey of the Dampier MP including the Hawksbill turtle, *Eretmochelys imbricate*, and the sea snakes, *Acalyptophis peronii, Aipysurus tenuis* and *Hydrophis ornatus ocellatus*.

Montebello Marine Park

The bathymetry and physical attributes of the seabed in the Montebello MP were assessed and mapped using data from eight sites in the eastern part of the park, which is all General Use Zone (GUZ), and from a single transit across the MP from east to west. The area swathed at each site was approximately 7 – 8 km by 500–1000 m. One site was in 50 m water depth while most sites were 60–70 m deep. In general the seabed was smooth with thick or thin sand covering except in the far western part of the MP where there was rougher and harder rocky substrate.

The substrate and biohabitat types present in the Montebello MP were assessed using a much larger historical data set from a further 27 sites (21 between 1987 and 1997 and six in 2013) covering the full extent of the MP in addition to the eight sites surveyed in 2017. Substrate and topography in the Montebello MP was predominantly fine sand or a mix of fine and coarse sand and occasionally rubbly bottom. Topography was predominantly flat bottom with occasional bioturbated areas. The exception to this was three sites in the far western section of the MP which had large sections of ridges or large sand ripples.

With the exception of the most inshore site, which did have a very high biomass of Nephtheid soft corals, the sites surveyed in 2017 in the eastern section of the Montebello MP had low numbers of sponges, whips and gorgonians and as a result complex benthic filter feeder communities were largely absent. Instead the dominant filter feeders were hydroids, seapens and crinoids. The latter being most commonly *Comatula rotalaria* which is free living on sand rather than associated with other filter feeders like gorgonians. One site was notable for the very large numbers of seapens present. Only one site had more than 50% of images with no biota however most sites had large areas characterised by soft sediment dwelling crinoids or hydroids and seapens rather than the complex sponge and soft coral communities observed in the Dampier MP.

The biota recorded at the historical sites between 1987 and 1997 varied markedly from that during the 2017 surveys. In particular the larger proportion of sponges in the earlier study, which comprised more than 40% of biota at two-thirds of the 21 historical sites. The reason for the differences between the 1980s/90s and 2017 is not apparent, although two of the historical sites located in the eastern part of the MP where the 2017 samples were taken also had a large proportion of images with no biota, indicating there were some areas of low filter feeder abundance in the 1980s/90s.

Biodiversity assessment was conducted at the eight sites surveyed in 2017 and six sites surveyed in 2013. Fish diversity was high with 118 species recorded in 2017. This represented 45% of the 342 species sampled from just 8% of the 103 sites sampled on the entire voyage across the North West Shelf. Twenty-three (23) species (7%) recorded from the 2017 survey had not previously been recorded from the Montebello MP. A further eight previously unrecorded species were sampled from sites in the western and southern parts of the Montebello MP in 2013. Total fish diversity (based on ALA records) is approximately 360. New records for Montebello MP included the smalleye stingray *Megatrygon microps* and pink whipray *Pateobatis fai*, two large, rarely collected stingrays attaining greater than 2 m disc width that were observed both inside and outside the Montebello MP during the 2017 survey.

There were 32 species of soft coral, covering 11 families and 21 genera, recorded from the eight 2017 Montebello MP sites. In 2013, 27 species were collected from six other sites in the park and represented a similar set of suborders and families. The three rare species encountered at Dampier MP (*Nephthyigorgia kükenthali*, *Studeriotes crassa* and *Plumarella penna* were also present in the Dampier MP in some cases from a single specimen. Only four species of soft coral had been recorded in the ALA prior to this study. A new Western Australia record for the seapen *Echinoptilum macintoshi* was made from the Montebello MP on the 2017 voyage.

There were 76 species of sponge collected from the Montebello MP in 2017, 51 of these occurring at the shallowest station and the other seven stations only having between one and 15 sponge species. There was an overlap in the sponges recorded from the 2013 samples and some previous records recorded in the ALA and at the WA Museum, but the state of sponge taxonomy makes it difficult to assemble an accurate and unique list of species. Nevertheless there were 100 ALA or WA Museum sponge records from the Montebello MP prior to our 2017 study (that is including the 2013 sampling) and only 52 of these species were recorded in our 2017 study indicating that this most recent sampling has led to a significant increase in knowledge of sponge diversity in the Montebello MP.

One hundred and fifty-two (152) species of crustaceans were collected from the 14 Montebello MP stations in 2013 (36 species) and 2017 (128 species) with just 12 species common between the two years and 93 of these 152 species recorded at only a single station. This indicates that rare species were predominant among the crustacean fauna. There were four new records for Australia among the 2017 samples, a hairy crab (*Achaeus* cf. *villosus*), two hermit crabs (*Pagurus similis* and *Spiropagurus profundorum*) and the polimnid crab (*Xlumnus* cf. *nhatrangensis*), representing an extension of their known ranges from the Indo-Malay Archipelago, Taiwan, Thailand and Vietnam, respectively. This project has yielded a significant increase in knowledge of crustaceans in the area. Records held in the Atlas of Living Australia (ALA) prior to this project listed just 26 species for the Montebello MP. More than half of these were not recorded in our surveys perhaps due to a number of them being small nektonic species, probably sampled by plankton nets.

There were 75 mollusc species (21 bivalve, 47 gastropod, 7 cephalopod) collected in the Montebello MP from 14 sites in 2013 and 2017. Fifty-five (55) species were collected from only one station indicating that most species were rare. Indeed many were single specimens. The number of species per station varied from one to 20. Three likely new species were collected from Montebello MP, *Margovula* cf. *marginata*, possibly new ovulid, *Dolomena* cf. *dilatatus*, a likely new species of strombid with this collection providing the best example of the difference in morphology from the form found in Queensland and *Duplicaria* n. sp., a likely a new auger species in the family Terebridae. Other taxa of note included *Globovula cavanaghi*, a rare ovulid species and the cephalopod *Sepiadarium auritum* which is listed as data deficient with the International Union for the Conservation of Nature (IUCN). The 2017 voyage collections have made a significant enhancement to the records of molluscs occurring in the Montebello MP. The ALA had only recorded 14 species from the Montebello MP prior to this study and the WA Museum collection only had 24 species in its collection from the Montebello MP prior to this study.

Among the echinoderms, crinoids and ophiuroids were identified from the eight 2017 and six 2013 sites in the Montebello MP. Thirty (30) crinoid species were recorded including the discovery of a new species of *Capillaster*. Previously only 10 species of crinoid had been recorded from the Montebello MP based on ALA records only one of which was not recorded in this study. Thirty-two (32) species of ophiuroids (six basket stars, one snake star and 25 brittle stars) were recorded from the Montebello MP. Prior to this study only 12 species had been recorded (ALA) of which 7 overlapped our study bringing the total known diversity of ophiuroids in the Montebello MP to 37 species (a 167% increase as a result of this study). One undescribed species of *Ophiochasma* was recorded and the collection established the new southern limit of the distribution of two species (*Astroboa granulatus* and *Ophiarachnella similis*).

Diversity of algae and seagrass was low in the Montebello MP as a result of the depth (shallowest station was 50 m). Thirty-seven (37) species of algae along with the seagrass *Halophila ovalis* were collected. A new record for Western Australia was made, *Aneurianna lorentzii*, which has a widespread Indo-Pacific distribution but not previously recorded in Western Australia. Several newly described species (*Halymenia lunata*, *Gracilaria webervanbosseae* and *Erythroclonium elongatum*) were also recorded.

Two sea snakes, *Acalyptophis peronii* and *Aipysurus laevis* we also recorded in the 2017 surveys of the Montebello MP.

Comparison of Montebello MP and the adjacent Trawl Fishery Area

Both the Pilbara Fish Trawl Fishery (PFTF) Area 1 and the Montebello MP had a similar history of fishing effort up until about 1985, however there has been little or no trawling in the area that is now the Montebello MP since that time.

Substrate type and topography of the seabed were similar between the two areas with predominantly flat bottom with fine sand substrate. Similar biota types (sponges, gorgonians, whips and other soft corals, hydroids, crinoids and sea pens) were present in the two areas. The exception to this was that sponge and whips were more abundant in the PFTF Area 1, making up more than 50% of biota scored in images from 6 sites, while only one site in the Montebello MP had more than 10% of biota scored as sponges or whips. The biomass of habitat forming filter feeder communities was also much greater (5.5 times higher) at sites in the PFTF Area 1 than in the Montebello MP.

Fish species diversity also differed between PFTF Area 1 sites (168 total taxa, range 17–66 species per site, mean 48 species per site) and Montebello MP sites (124 total taxa, 14–50 species per site, mean 31 species per site) and is probably attributable to the lesser availability of complex benthic filter feeder habitat in the MP. We found a strong association between habitat forming benthic filter feeder biomass and fish biomass for most families of fish. In general fish biomass was much greater at stations within the Pilbara Fish Trawl Fishery Area 1 than in the Montebello MP. The commercially important emperor (Lethrinidae) and snapper (Lutjanidae) families had an average biomass more than ten-times greater in the PFTF Area 1 than in the Montebello MP. The other families that had more than ten-times the average biomass in the PFTF Area 1 were groupers (Serranidae), goatfishes (Mullidae), sweetlips (Haemulidae), squirrelfishes (Holocentridae) and parrotfishes (Scaridae). The families that were more abundant in the Montebello MP were those generally associated with poor fishing grounds or degraded habitats. These include lizardfishes (Synodontidae), threadfin breams (Nemipteridae), trevallies (Carangidae).

Recommendations for further survey work

Recommendations arising from this work either relate to findings which warrant further investigation or reflect that limited sampling was possible during this study, meaning that the spatial coverage was less than optimal in some parts of the two Marine Parks.

1. No sampling, either in the historical or 2017 voyages, was carried out in the area of the Dampier MP which is now zoned as “National Park Zone (IUCN II)” (Figure 4). It is recommended that this area be surveyed to establish the extent of different habitat types and to determine whether the other areas surveyed in this study are representative of that area.

2. There has been very limited surveying of the north-western part of the Montebello MP. This study found this area to be the most rugged, rocky bottom area of the parts of the park that were mapped acoustically in 2017 (Figure 23). However, there was no seabed imagery collected and no biological samples collected in this area in 2013 or 2017. Imagery collected at two sites in this area in 1989 and 1997 indicates the highest proportion of sponges amongst 21 sites surveyed in the Montebello MP in that era (Figure 60). It is recommended that this area be surveyed to establish the extent of deep-water hard-bottom habitat in the MP and to determine the richness of the benthic filter feeder communities and fish assemblages in this part of the MP. It is possible they compensate for the paucity of such habitats in the area we surveyed in the eastern part of the MP.

3. The Montebello MP has had little or no trawling since 1985. However, this study found a surprising contrast between the eastern area of the Montebello MP and the western part of the PFTF, the latter having greater biomass and diversity of fishes and a much higher biomass of benthic filter feeders. This study confirmed findings of earlier work (e.g. Sainsbury 1991) that these two facets are closely related. That is, demersal fish assemblages are closely associated with habitat forming filter-feeder assemblages. This study also concluded that this eastern part of the Montebello MP exhibited higher biomass of sponges and demersal fishes in surveys made between 1987 and 1997, than we found in 2017. The reasons for this are unclear, given we might have expected more rapid recovery of benthic habitats from trawling in the closed area. Either, there has been an event which has caused significant change to the seabed, such as habitat burial by mobile sediment, or, by chance, our sampling in 2017 did not coincide with the same types of habitats surveyed between 1987 and 1997. It is recommended that there be a resurvey in the exact location of the 10 sites surveyed between 1987 and 1997 (Figure 31) in the eastern part of the MP to establish whether the change we infer in this study can be confirmed.

1 Introduction

In 2018, Australia implemented Management Plans for a new network of Commonwealth Australian Marine Parks, in north-western Australia (Director of Marine Parks, 2018) including the Montebello and Dampier Marine Parks (MPs) off the Pilbara coast of Western Australia. For many of these parks, little is known of the range or extent of seabed habitat types and of the diversity of marine life they support. Such information is needed in order to establish environmental baselines within the new parks which can be used to guide future monitoring programs and to evaluate MPA performance.

The objective of this project was to provide the Director of National Parks with baseline data on benthic habitats and marine biodiversity in parts of the Commonwealth Montebello and Dampier MPs. The biodiversity assessment focused on key sessile, benthic habitat forming filter feeder (sponges, soft corals) and mobile invertebrate species (molluscs, crustaceans, echinoderms) as well as demersal fishes.

The swath mapping and sub-bottom profiling undertaken along with the seabed imagery data collected will provide habitat maps and provide a further basis for understanding what types of species assemblages occur in the parks, enable future monitoring to be planned and priorities to be established for areas of both MPs which were not surveyed during this project.

The project was undertaken as an extension to a concurrent investigation of rates of seabed recovery from foreign trawl fishing undertaken on the North West Shelf during the 1970s and 1980s. The research surveys and sampling was undertaken in October and November 2017 aboard the RV *Investigator*. Given the limited number of sites which could be surveyed during the voyage, other datasets were also used to characterise habitats and biodiversity within the parks. Principally these were tow video, sled and beam trawl sampling undertaken as part of the Pilbara Marine Conservation Partnership (PMCP, Pitcher et al. 2016) and trawl survey data, most of it previously unpublished, collected on the North West Shelf between 1982 and 1997 by CSIRO.

1.1 Voyage summary, survey design and research methods

The voyage took place between 11 October 2017, when the RV *Investigator* left Broome, and 10 November when the ship berthed in Henderson, near Fremantle. Days of active sampling were between 12 October and 6 November in water depths of 25 to 100 m on the Pilbara section of the North West Shelf, off the WA coast, approximately between Port Hedland and the Montebello Islands and between 30 and 125 km offshore (Figure 1). Sampling within the Dampier MP took place between 19 and 23 October and sampling within the Montebello MP took place between 1 and 6 November.

The survey area was stratified spatially into 100 sampling strata, using the available data on historical (1979–1987) and recent (2005–2016) fishing effort, environmental and biological data such that the range of biological and environmental gradients could be represented in the sampling with replication achieved across combinations of low (or zero), medium, high and very high historical (1979–1987) and recent (2005-2016) fishing effort (16 possible combinations). A full description of the design methodology is provided in Appendix A. Where a sufficiently representative (large) section of a sampling strata fell within either the Dampier MP or the Montebello MP, the sampling location (site) for that strata was located in the MP. Buffer zones around submarine cables, gas pipelines and other oil and gas infrastructure had an impact on where sampleing could be undertaken, especially in the eastern part of the Montebello MP. In all there were 3 sites in the Dampier MP and 8 sites in the eastern section of the Montebello MP. This report focusses primarily on those 11 sites in the two MPs. The area comprising the Montebello MP has not been fished since 1985 and for comparison we have included in this report an analysis of a further 12 sites in areas adjacent to the Montebello MP that have been continually fished since the 1970s.

Sampling at each station for biodiversity was undertaken using a commercial scale demersal trawl net and an epibenthic sled. The former covered a large area (about 3 km by 20 m width) and effectively sampled demersal fish and obtained a large representative sample of large benthic invertebrates, while the latter covered a smaller area (400 m by 1.5 m width) effectively sampling benthic invertebrates from 50 cm down to about 20 mm. Habitat and environmental data was collected at each site using an acoustic swath mapper, a sub-bottom profiler and a still camera attached to the trawl net headline, which took an image every 3 seconds or about 4 m. CTD profiles and Niskin bottle sampling were undertaken at some sites.

Although not reported on in this study, sediment grab, turbulence probe and plankton net sampling was also undertaken at most sites. Tow video was not part of the original survey plan however in the latter part of the voyage we had time to video five stations as part of efforts to quantify the efficiency of the trawl net sampling. A detailed description of the sampling methods and equipment used is given in Appendix A.

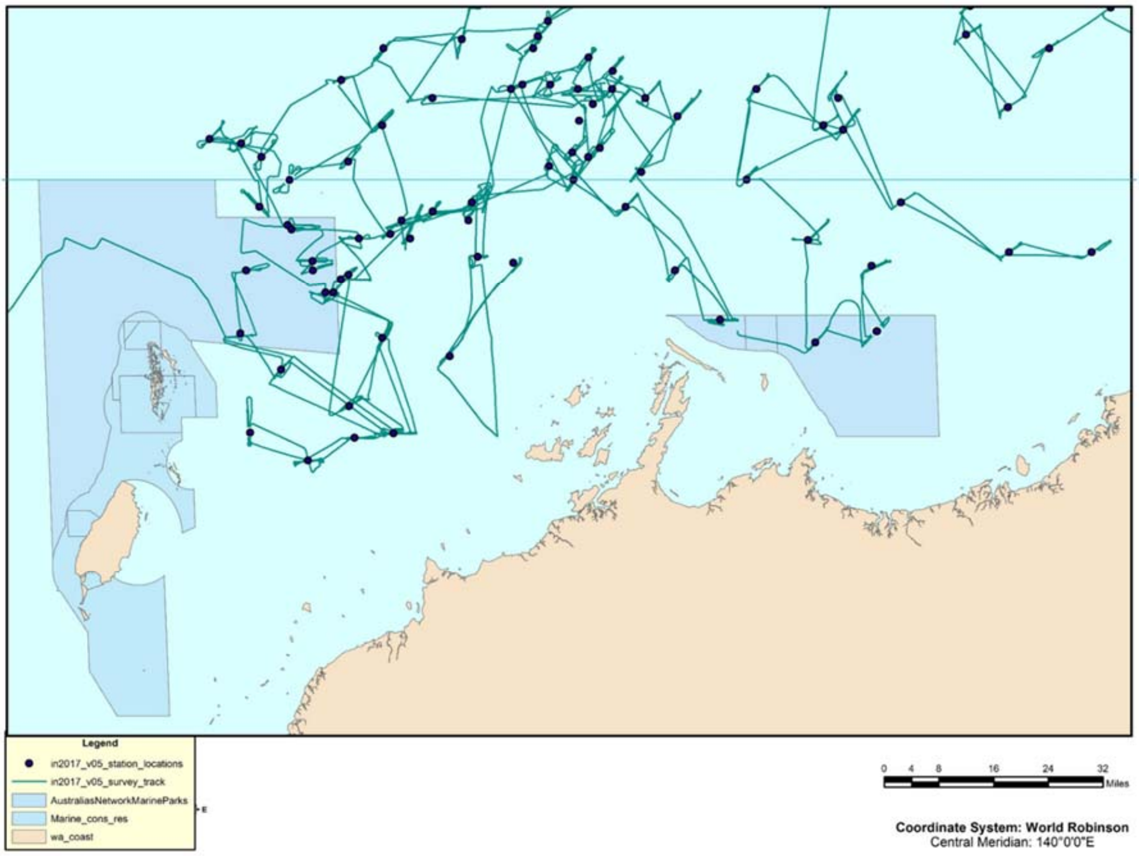


Figure 1. Map of survey area showing survey stations and vessel track (continuous swathing) and location of Commonwealth and State MPAs.

1.2 Operations undertaken

1.2.1 Dampier Marine Park

Three of our 100 sampling strata fell within the Dampier MP (sites 4, 6 and 8) (Figure 2). We surveyed in this area between 19 and 23 October 2017. Table 1 summarises the operations undertaken at these sites and shows that the full set of planned operations were undertaken at all three sites. Appendix B provides a full description of all operations undertaken at each site.

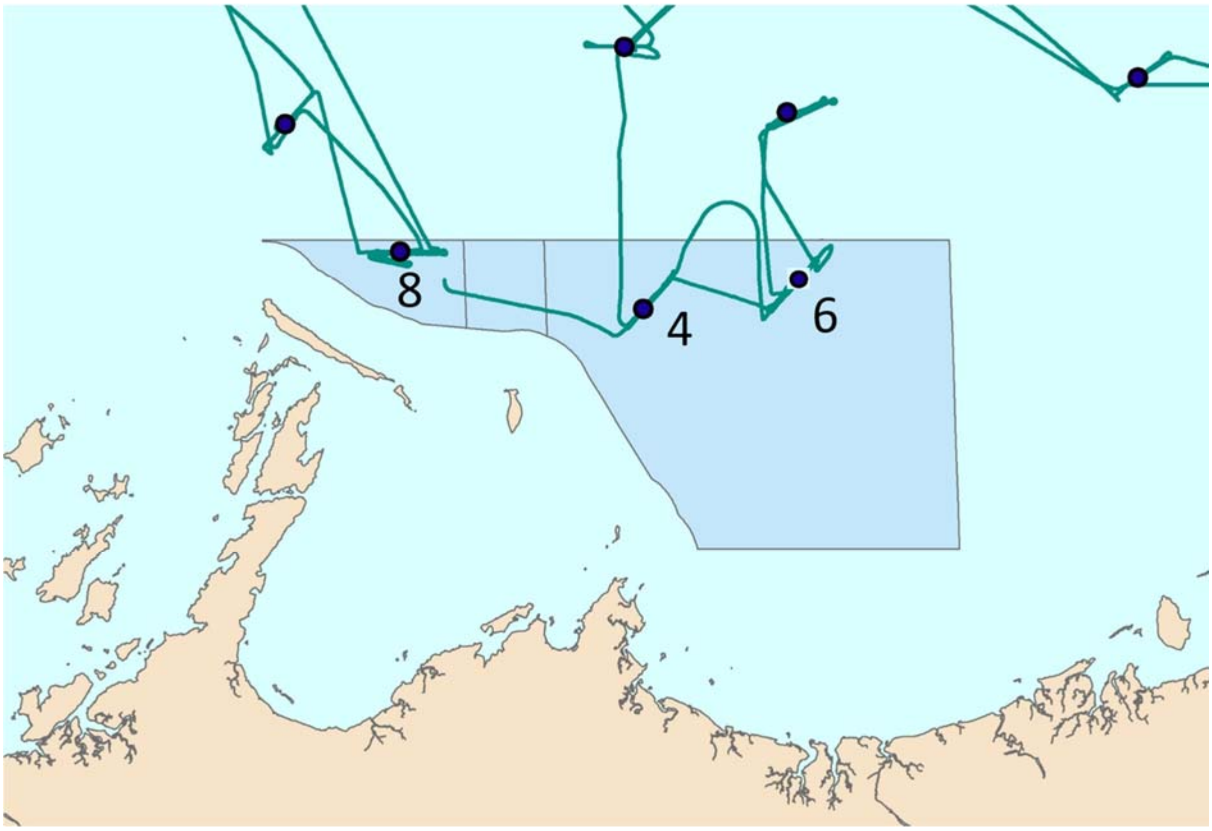


Figure 2. Location of sites surveyed and swath mapping carried out within the Dampier MP.

Table 1. Summary of site locations, depth and sampling undertaken for each site in the Dampier Commonwealth Marine Park. SBP=Sub-Bottom Profiler. *not reported on in this study

Dampier Commonwealth Marine Park												
Site	Depth (m)	Long °E	Lat °S	Swath /SBP	Trawl	Trawl Camera	Tow Video*	Sled	Grab*	CTD	Plankton Tow*	Turb. Probe*
4	34	117.21	20.36	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
6	30	117.39	20.29	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
8	31	116.97	20.31	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

1.2.2 Montebello Marine Park

Eight of our 100 sampling strata fell within the Montebello MP (sites 14, 49, 50, 79, 80, 81, 82, 97) (Figure 3). We surveyed in this area between 1 and 6 November 2017. Table 2 summarises the operations undertaken at these sites and shows that with the exception of CTD casts and turbulence probe measurements at three sites, the full set of planned operations were undertaken at the other five sites and that video tows were also undertaken at two sites. Appendix B provides a full description of all operations undertaken at each site.

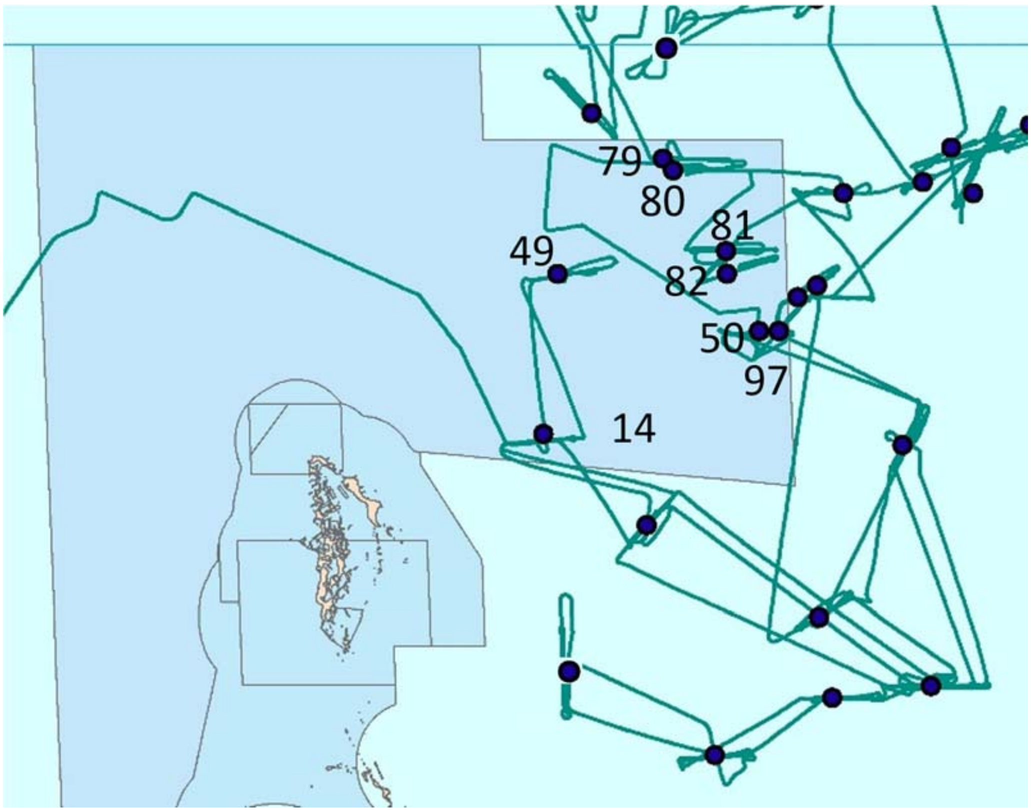


Figure 3. Location of sites surveyed and swath mapping carried out within the Montebello MP.

Table 2. Summary of site locations, depth and sampling undertaken for each site in the Montebello Commonwealth Marine Park. SBP=Sub-Bottom Profiler. *not reported on in this study, ** copies of videos to be provided to DNP

Montebello Commonwealth Marine Park												
Site	Depth (m)	Long °E	Lat °S	Swath/ SBP	Trawl	Trawl Camera	Tow Video*	Sled	Grab*	CTD	Plankton Tow*	Turb. Probe*
14	41	115.75	20.34	Yes	Yes	Yes	Yes**	Yes	Yes	No	Yes	No
49	61	115.77	20.2	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
50	55	115.97	20.25	Yes	Yes	Yes	Yes**	Yes	Yes	No	Yes	No
79	70	115.88	20.1	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
80	68	115.89	20.11	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
81	66	115.94	20.18	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
82	60	115.94	20.2	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
97	56	115.99	20.25	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No

2 Habitat assessment: bathymetry, sub-bottom profiling and acoustic backscatter

Habitat information was collected by mapping depths, sub-bottom profiling to determine seabed structure, multibeam acoustic swathing (bathymetry and backscatter [seabed hardness/softness]). Water column information was collected by CTD profiling to measure chlorophyll a, salinity, temperature dissolved oxygen and photosynthetically available radiation (PAR). Water sampling was undertaken to measure nutrients.

2.1 Bathymetry

Depths were recorded continuously during the voyage using the Kongsberg EM710 multibeam echo-sounder used on the RV *Investigator*. For comparison, these swaths of new depth data are shown in this report, overlain on the gridded bathymetry data for the area that was available pre-voyage (Figure 5, Figure 11). We also compare these new depths with that given in the *North-west Marine Parks Network Management Plan 2018* (Director of National Parks, 2018).

2.1.1 Dampier MP

Regional bathymetry

Indicative bathymetry for the Dampier MP is shown in Figure 4 from the *North-west Marine Parks Network Management Plan 2018* and indicates the eastern multiple use section ranges from 10–30 m while the western National Park and Habitat protection zones range from 30–40 m.

The gridded bathymetry available from Geosciences Australia is shown overlain with bathymetry measured by acoustic swath mapping, including that from our 2017 voyage (Figure 5). There are few swathed tracks in the area at all, and the only ones in the MP area are from our 2017 voyage. In general the swathed bathymetry is slightly deeper than the gridded values (Figure 5). Data from 2017 provides the first detailed bathymetric data available for the Dampier MP. All depths were adjusted to Australian Height Datum (AHD) which is roughly equivalent to mean sea level.

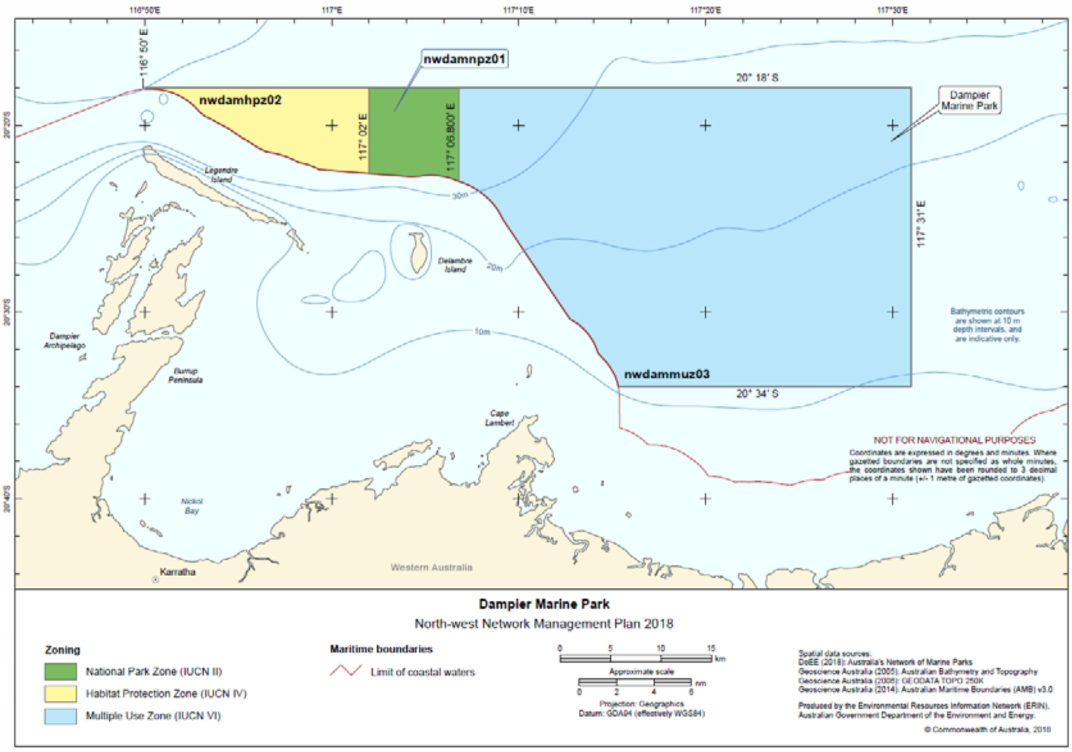


Figure 4. Location, zoning and bathymetry of Dampier MP. From the *North-west Marine Parks Network Management Plan 2018*

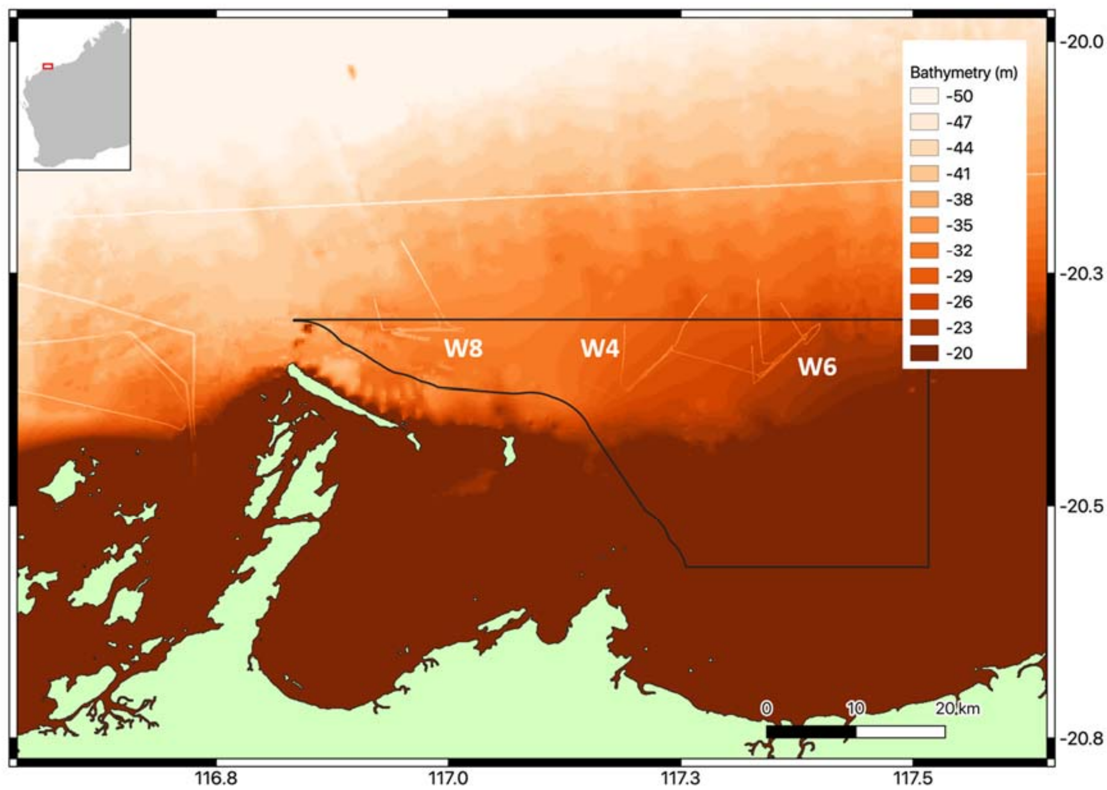


Figure 5. Gridded bathymetry of broader area around Dampier MP (Geosciences Australia 2009 gridded product) overlain with the swath lines from INV2017_05 (sites W4, W6, W8) plus previous voyages in the area which can be seen to the north and west of the MP. Depths in metres

Detailed site bathymetry

Each of the sites surveyed have about 7 km of seabed swathed. In these shallow depths the width of the area swathed is only about 500 m. The site W4 swathed transect ranges from 29 to 33 m with a deeper patch to 34 m towards the northern end (Figure 7). The W6 site is largely flat, from 29–31 m (Figure 8), while the more western W8 site in the Habitat Protection Zone, slopes from 35–40 m going from east to west (Figure 9).

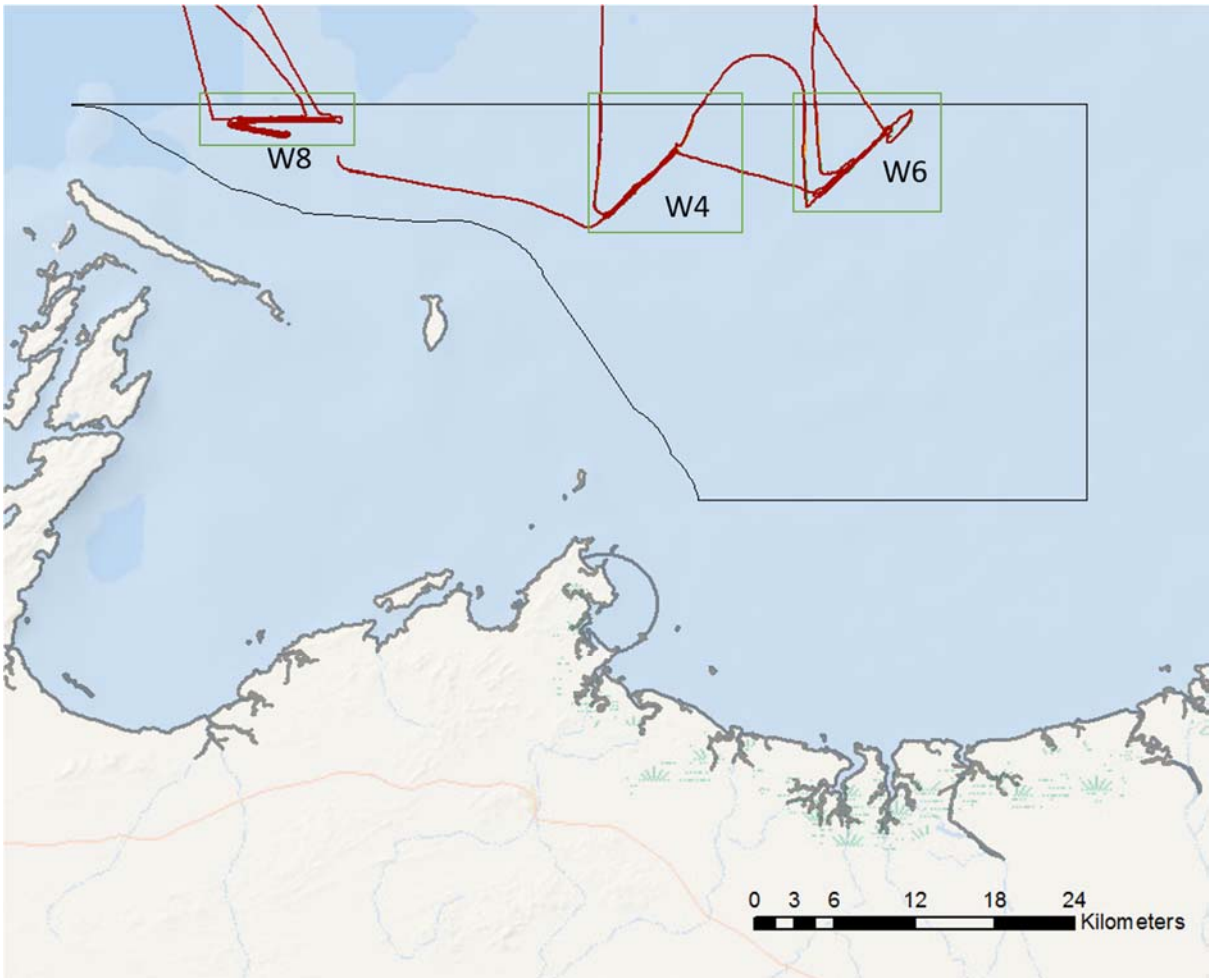


Figure 6. Map of Dampier Marine Park survey area. Green boxes indicate locations of detailed sites (see figures below)

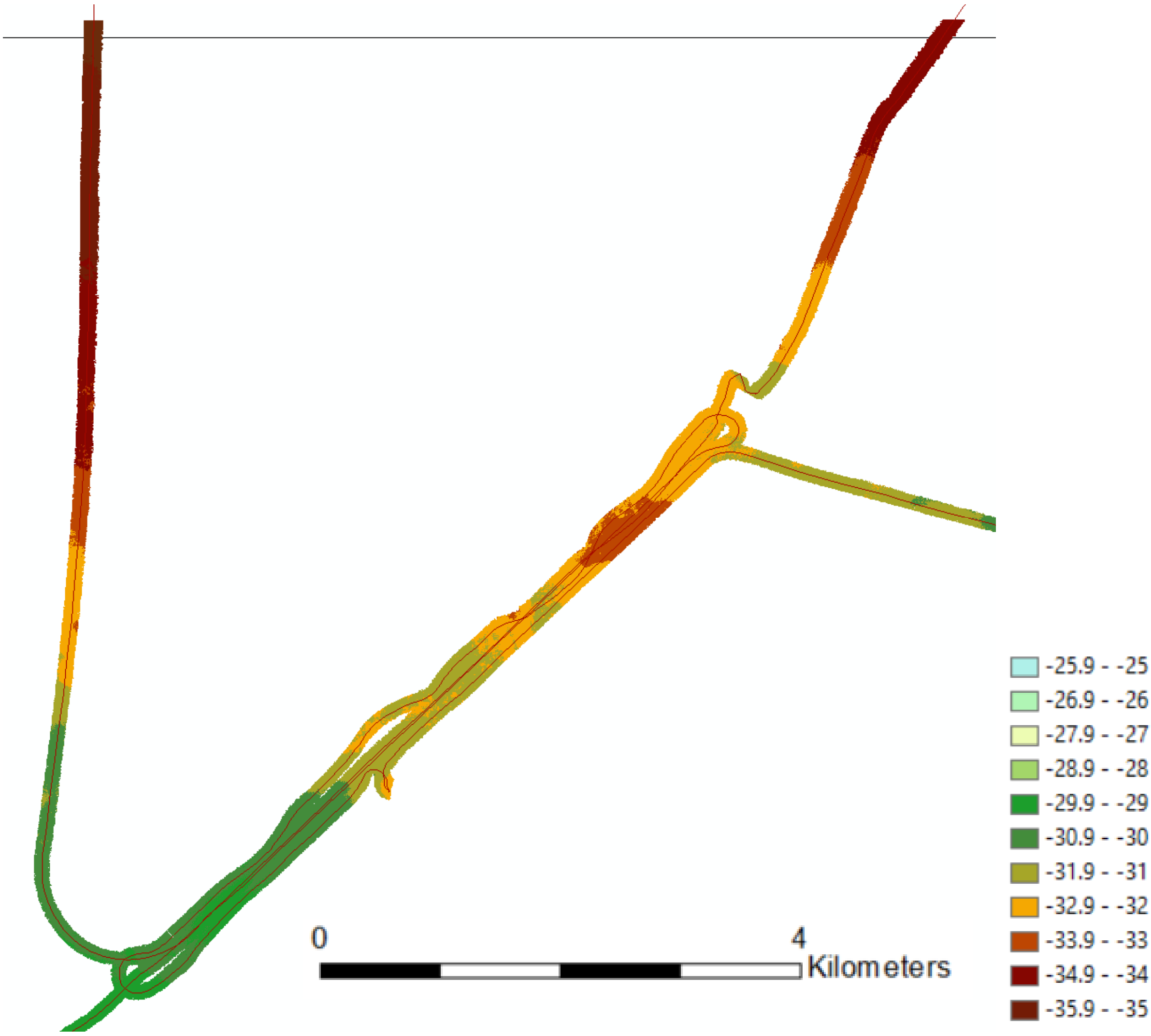


Figure 7. Detailed bathymetry at site W4. See Figure 6 for detailed site locations. Depths in metres

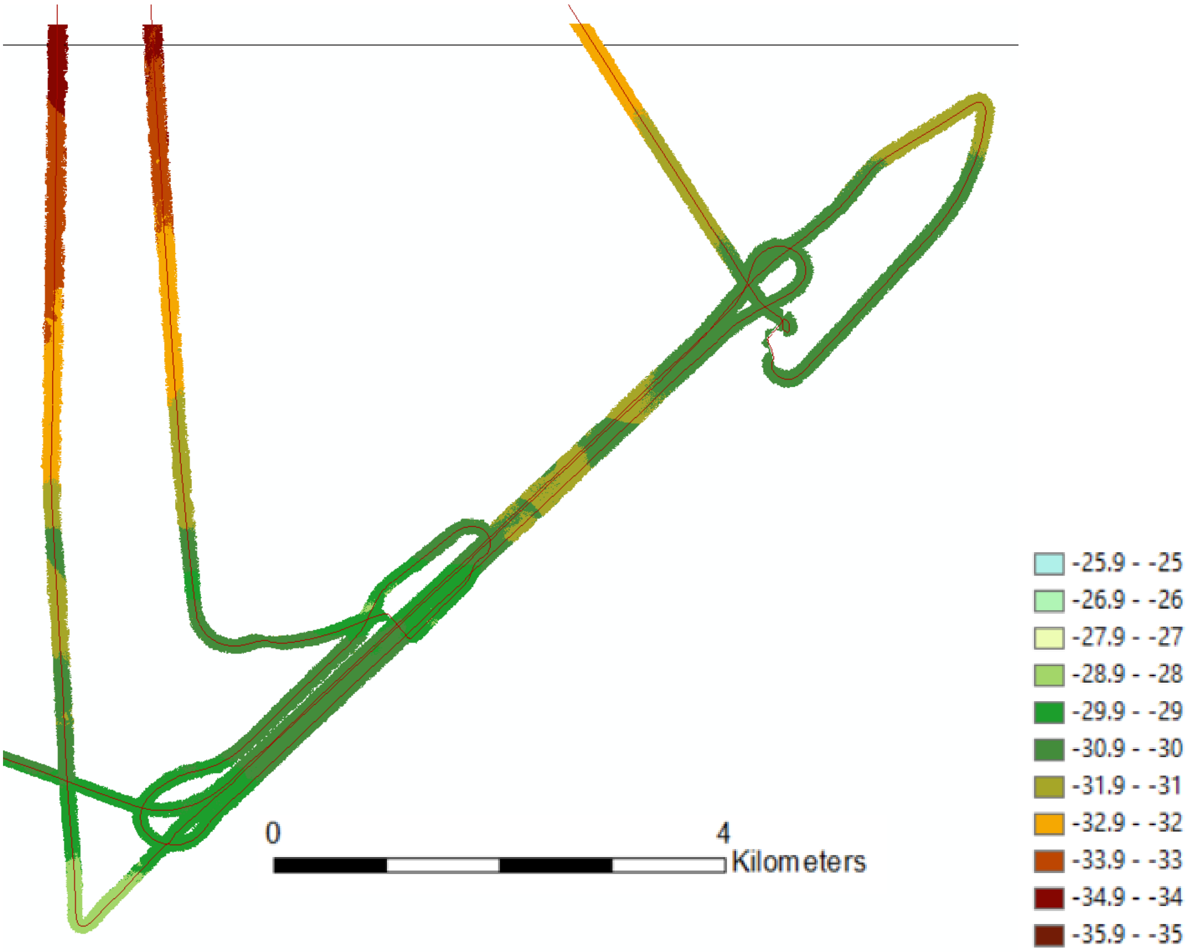


Figure 8. Detailed bathymetry at site W6. See Figure 6 for detailed site locations. Depths in metres

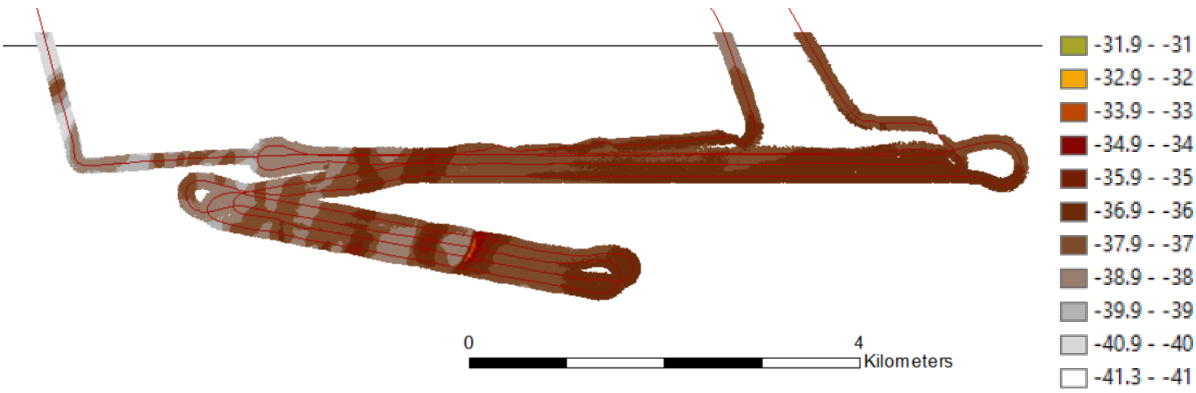


Figure 9. Detailed bathymetry at site W8. See Figure 6 for detailed site locations. Depths in metres

2.1.2 Montebello MP

Regional bathymetry

Indicative bathymetry for the Montebello MP is shown in Figure 10 from the *North-west Marine Parks Network Management Plan 2018* and from the gridded bathymetry available pre-voyage and indicates the eastern multiple use section in the eastern part of the park where we surveyed ranges from 40–70 m. The deepest part of the park was about 150 m in the north-western corner. The gridded depths in the eastern section of the park indicate a depth range of 35–80 m (Figure 11). Detailed bathymetry from the new swath mapping (Figure 14 and Figure 13) indicates that with exception of the absence of the deeper 70–80 m section in the middle, which is found to be only 50–55 m, the gridded bathymetry is reasonably accurate.

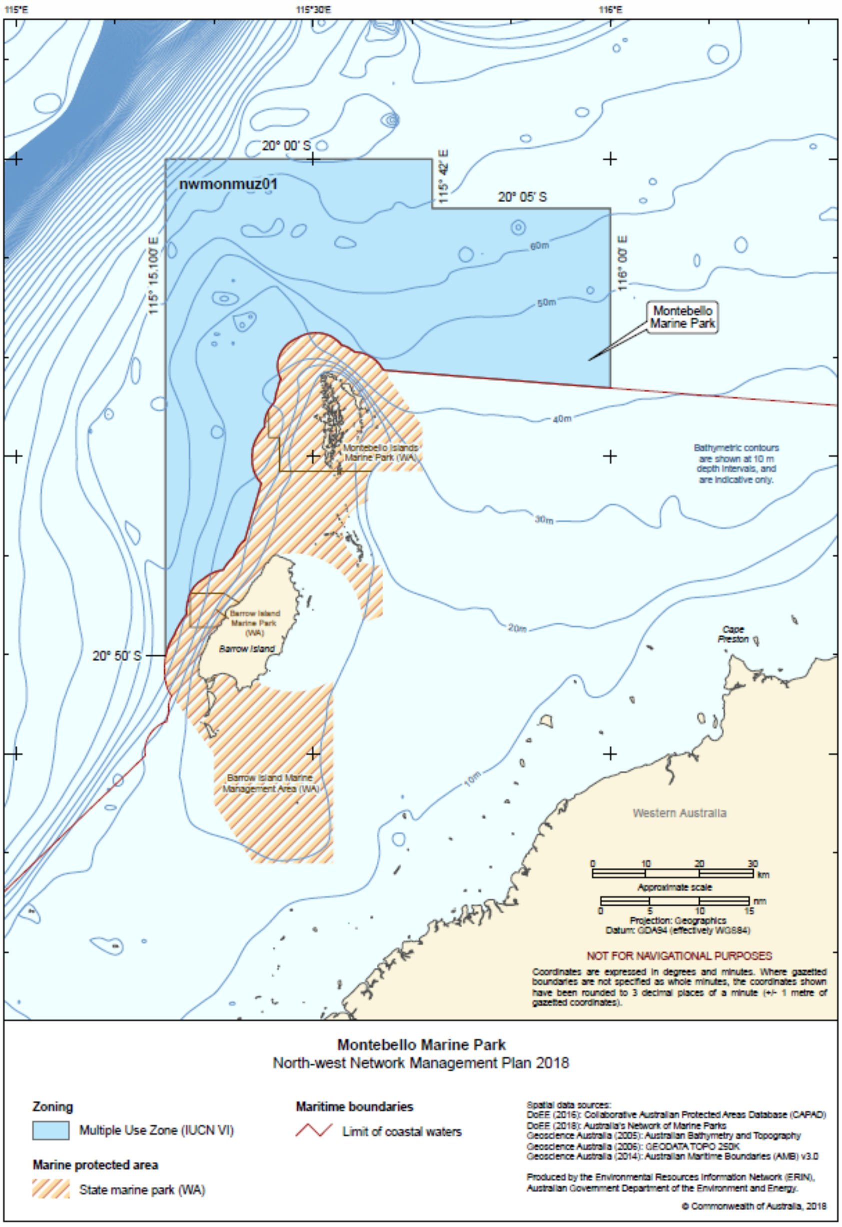
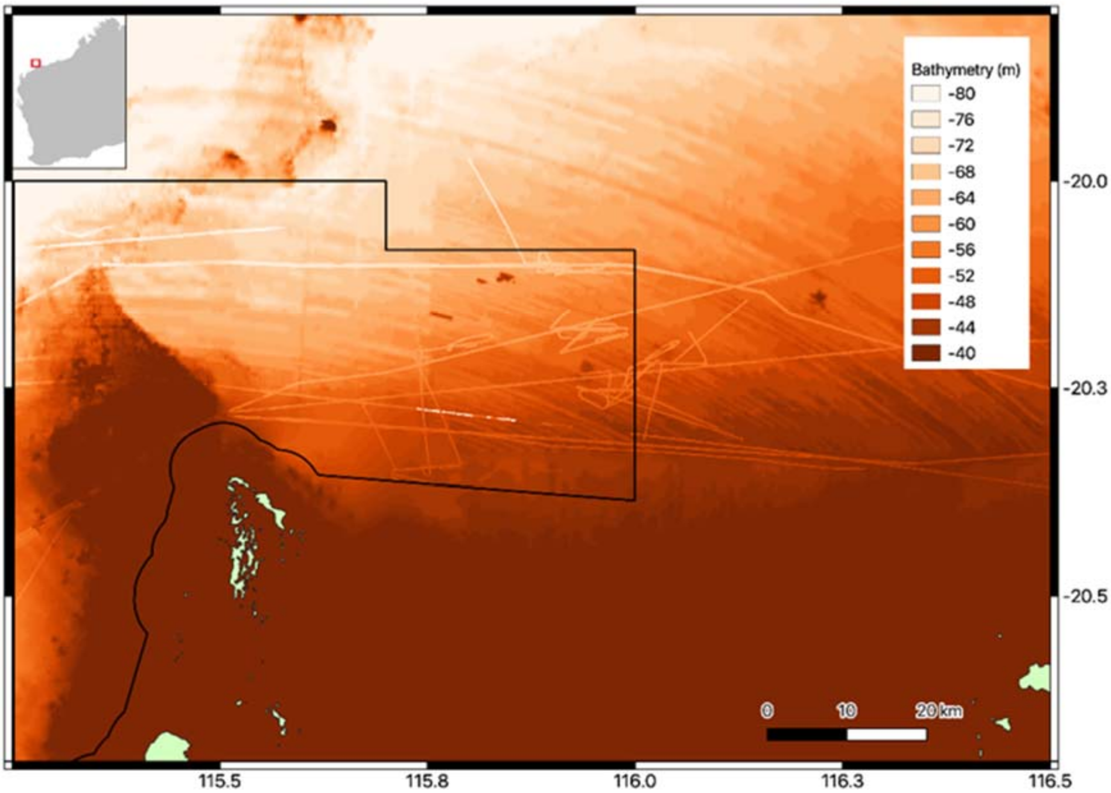


Figure 10. Location, zoning and bathymetry of Montebello MP. From the *North-west Marine Parks Network Management Plan 2018*



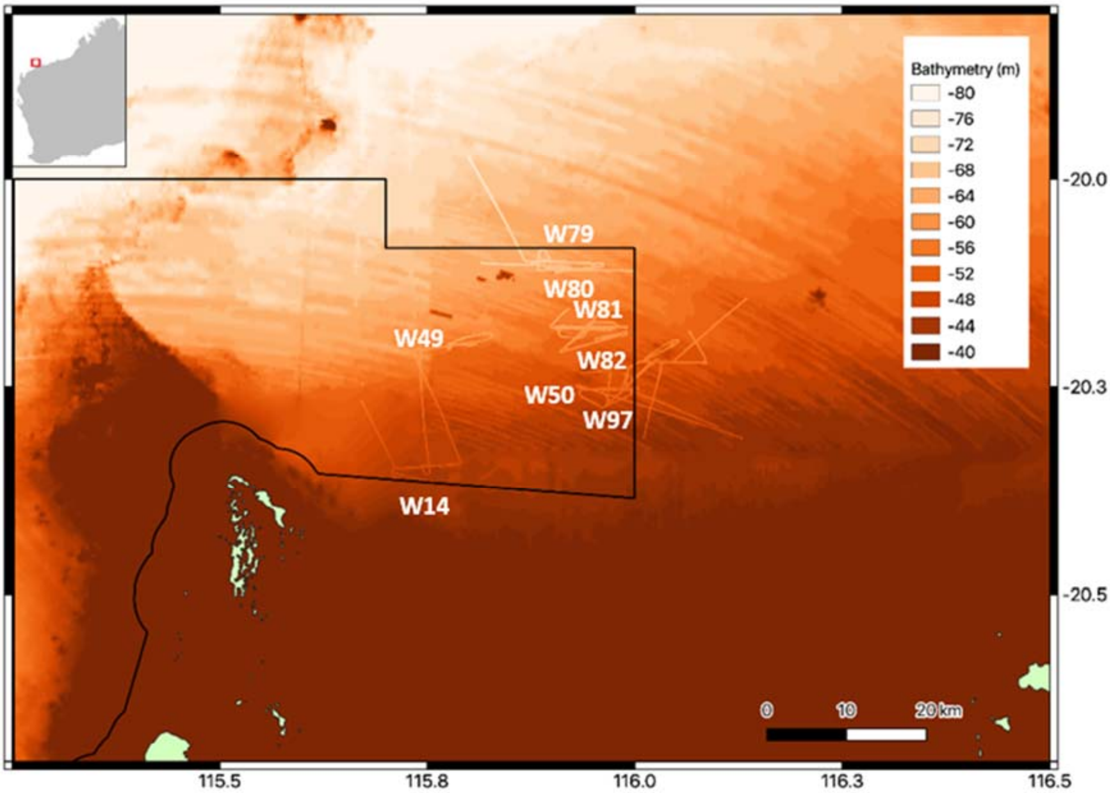


Figure 11. Gridded bathymetry of broader area around the Montebello MP (Geosciences Australia 2009 gridded product). Upper image is overlain with the swath lines from INV2017_05 plus previous voyages in the area. The lower image has just the 8 sites surveyed on INV2017_05. Depths in metres

Detailed site bathymetry

Sites surveyed in the Montebello MP were in the eastern part of the park with most sites running roughly from east to west, except W97 which runs from the north-west to south-east (Figure 12). The area swathed at each site was approximately 7–8 km by 500–1000 m. The most westerly sites swathed were W14 and W49 (Figure 12), with W14 being quite flat (50–48 m, east to west, Figure 13). W49 is deeper but also flat (59–61 m, east to west, Figure 13). Sites W50, W79, W80, W81, W82 and W97 are clustered in the north-western part of the park (Figure 12). The most southerly of these, Site 50 is uniformly flat at 54–55 m while Site W97 slopes slightly from the north-west to south-east 55–51 m (Figure 14). Sites W81 (60–62 m) and W82 (59–61 m) are both uniformly flat (Figure 14). Sites W79 (67–71 m) and W80 (65–69 m) show more structure in the western sections of the transects with W79 holes down to 71 m (Figure 14).

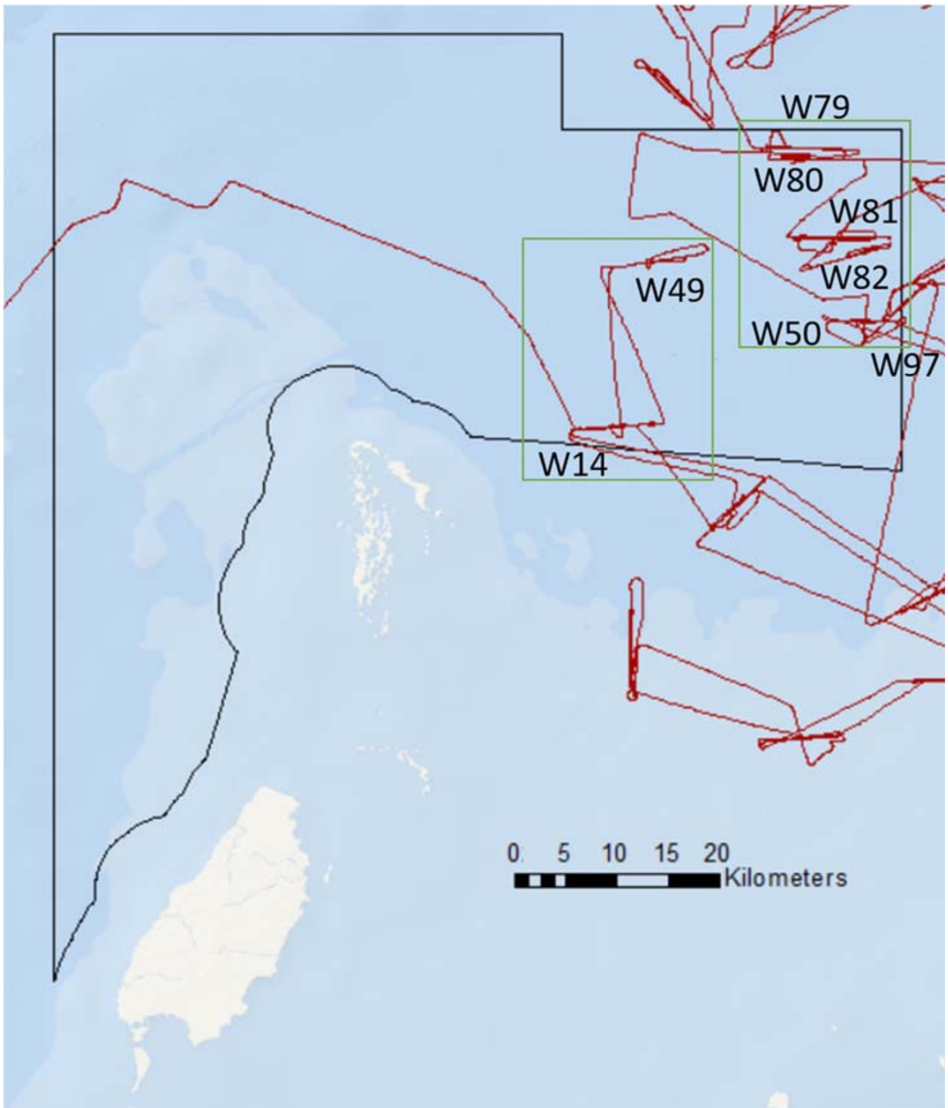


Figure 12. Map of Montebello Marine Park survey area. Green boxes indicate locations of detailed sites (see Figure 13 and Figure 14)

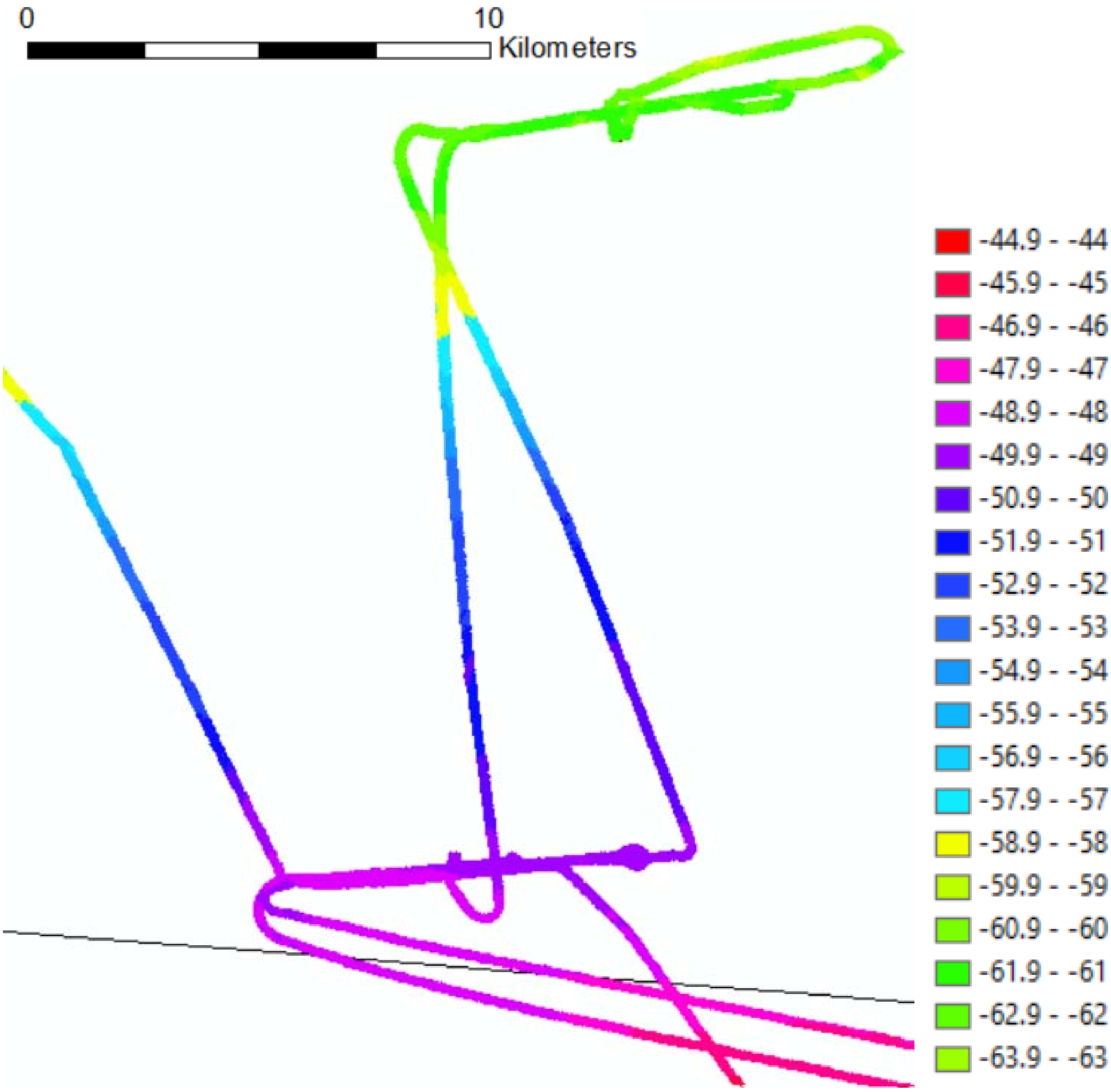


Figure 13. Detailed bathymetry at sites W49 (upper) and W14 (lower). See Figure 12 for detailed site locations. Depths in metres.

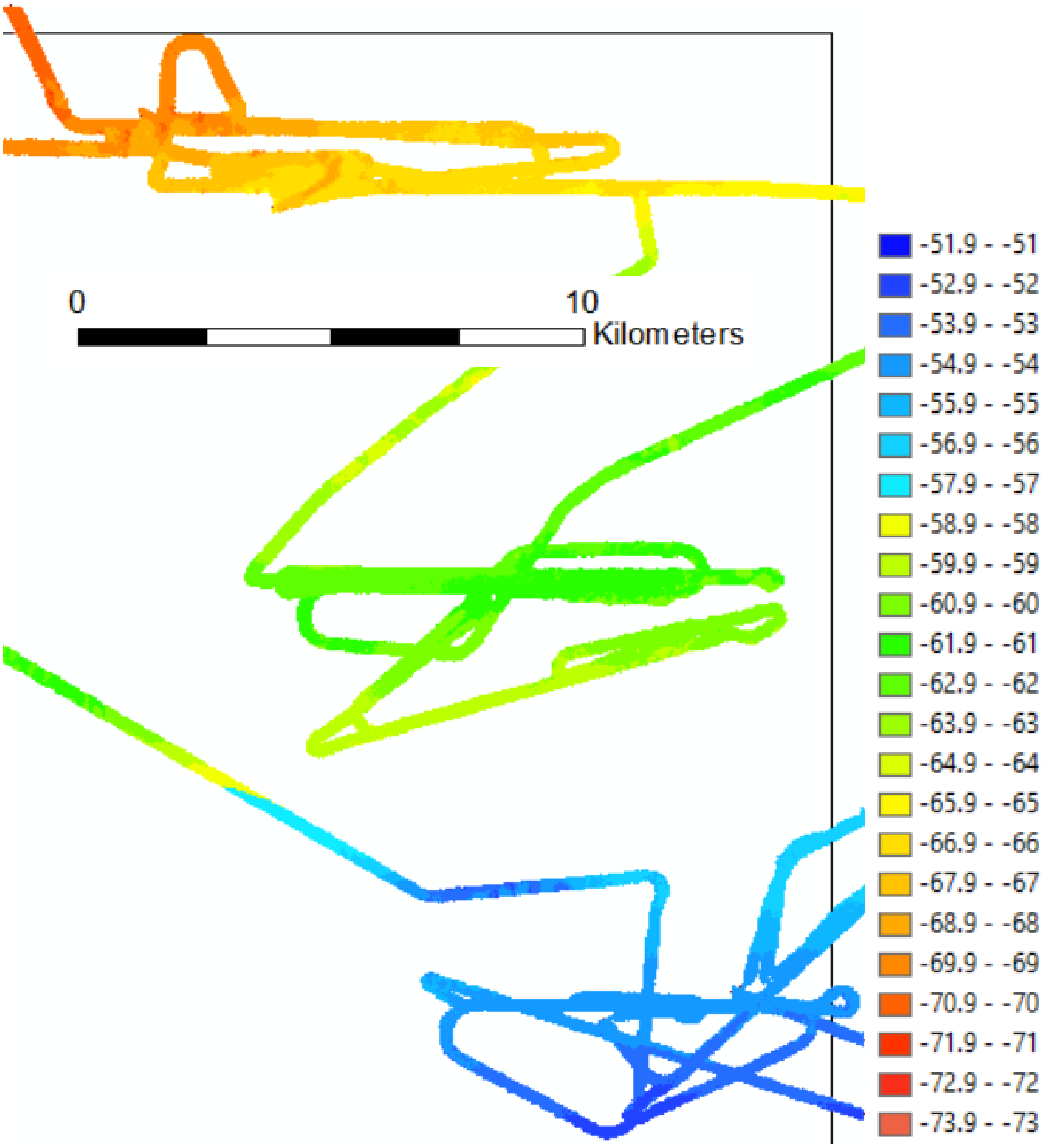


Figure 14. Bathymetry at sites W79, W80, W81, W82, W50 and W97 (from top to bottom). See Figure 12 for detailed site locations. Depths in metres

2.2 Acoustic backscatter and sub-bottom profiling

2.2.1 Acoustic backscatter

The Kongsberg EM710 multibeam echo sounder used on the RV *Investigator* collects acoustic backscatter data as well as bathymetry. This provides a measure of the reflectivity off the seabed which can be interpreted to determine the relative ‘hardness’ and ‘softness’ of the seabed (hard surfaces are more reflective) and ‘roughness’ by using the measured angle of incidence as sound is reflected from the seabed (Angular Range Analysis). We have used both types of analyses in this project to characterise the seabed.

2.2.2 Categorisation of bottom types from the sub-bottom profiler

The Kongsberg SBP120 sub-bottom profiler used on the RV *Investigator* uses acoustic signals to produce a 2-dimensional stratigraphy of the seabed. It is a “chirp” system: a wide-band frequency modulated sub-bottom profiler that produces very high resolution (0.3 milliseconds/~0.25 m) profiles in soft sediments. The thickness of sediment layers cannot be measured accurately but can be approximated from the time it takes the sound signal to return (this is called ‘two way time” TWT).

These high frequency systems give very detailed information for near surface features making them suitable for the interpretation of the recent geomorphology of the seabed (for example rippled surfaces and reefs) and also tracking of thin (decimetre scale) sub-surface layers. The extent of layers of consolidated and unconsolidated material like coarse sediment, compacted sand and rock outcrops were interpreted with the aid of the coincidentally collected backscatter data from the Kongsberg EM710 multibeam echo sounder.

The following bottom type categories were used in this project:

1. Rock outcrop
2. Flat Hard Surface
3. Thin sediment (<3 milliseconds, <~2.5 m over rock)
4. Thick sediment (>3 milliseconds, >~2.5 m over rock)
5. Dunes

Examples of each of these are shown in Figure 15, Figure 16 and Figure 17. These interpretations were then applied to each of the sub-bottom profile lines within the Dampier and Montebello MPs (Figure 18). The distribution of the five bottom type categories along all the voyage track lines in the Dampier and Montebello MPs are shown and described in the following sections of this Chapter.

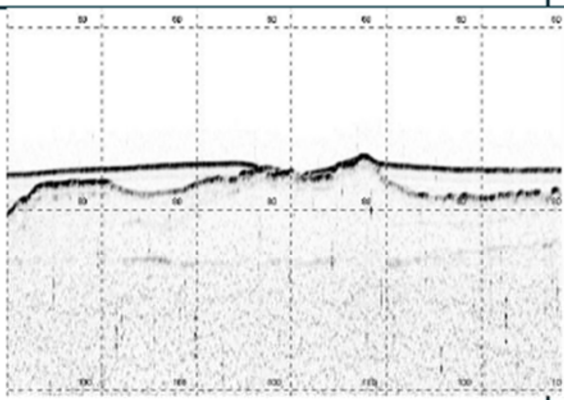
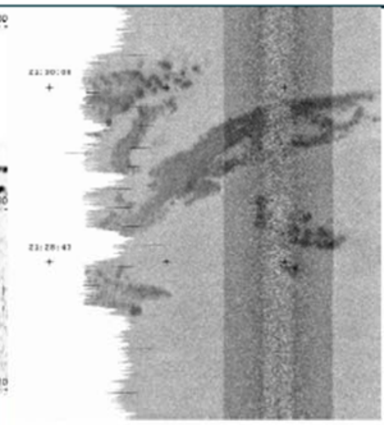
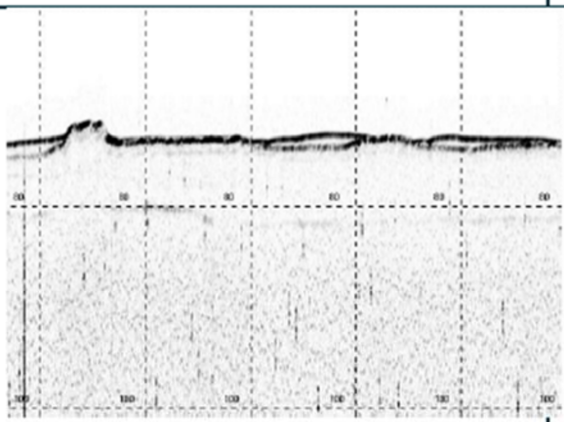
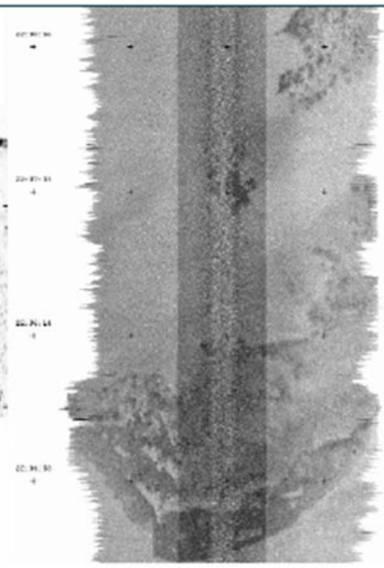
Classification	Sub-bottom Profiler	Seafloor Backscatter
1 – Outcrop **4 - Thick Sediment** UTC 20.10.2017 Time: 21:28 Before Trawl W71 (no photo) SBP Line019_001 MB 0544		
1 – Outcrop **3 - Thin Sediment** UTC 20.10.2017 Time: 22:10 Trawl W71 Op# SBP Line019_001 MB 0544		

Figure 15. Examples of reef outcrop from thick (upper panel) and thin (lower panel) overlying sediment showing interpretation using sub-bottom profile and acoustic backscatter data.

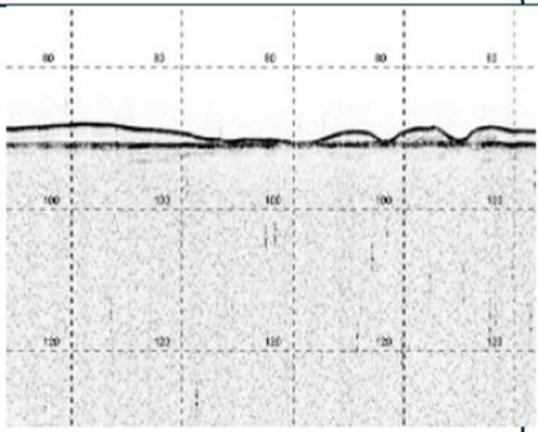
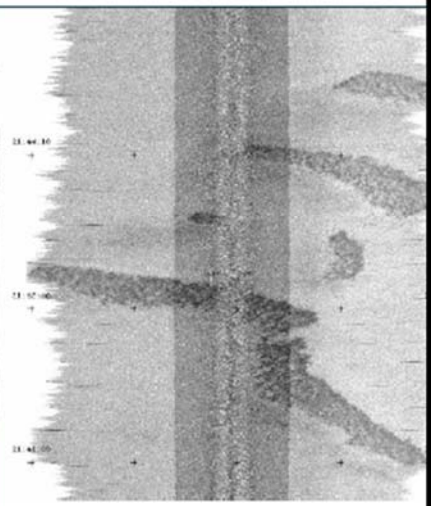
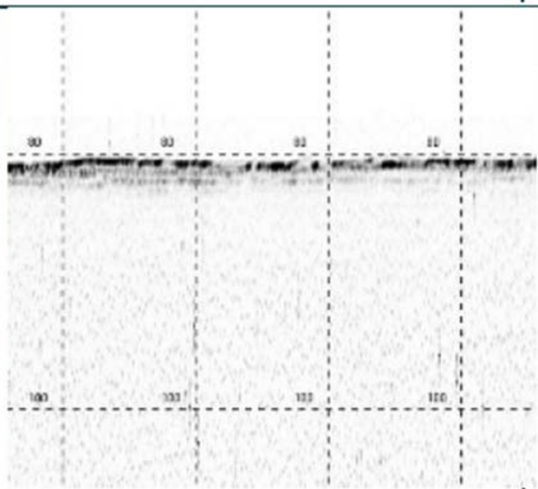
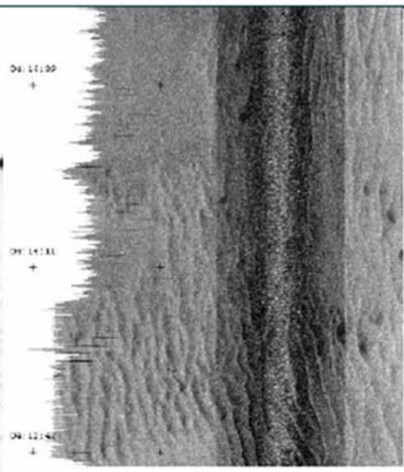
Classification	Sub-bottom Profiler	Seafloor Backscatter
5 - Dunes **Reef/Pockmarks** W30?		
5 – Ripples UTC 15.10.2017 Time 04:15		

Figure 16. Examples of sand dunes overlying reef (upper panel) and sand ripples (lower panel) showing interpretation using sub-bottom profile and acoustic backscatter data

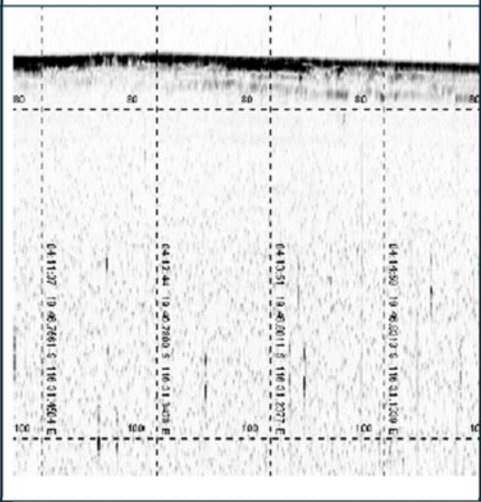
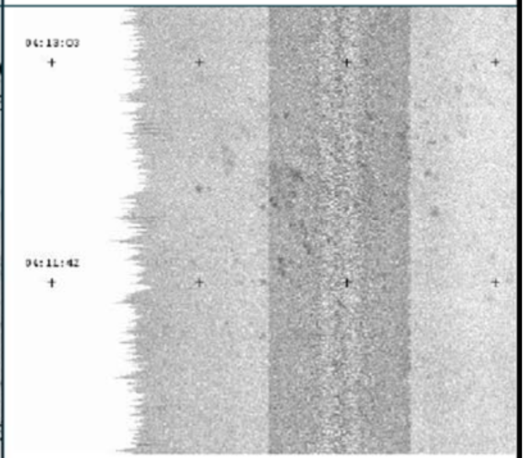
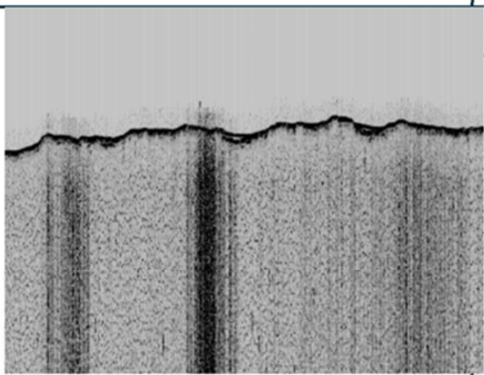
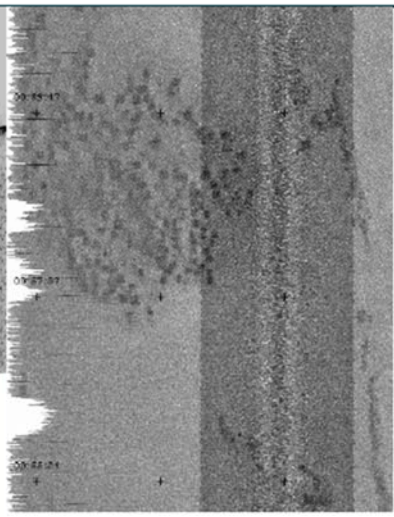
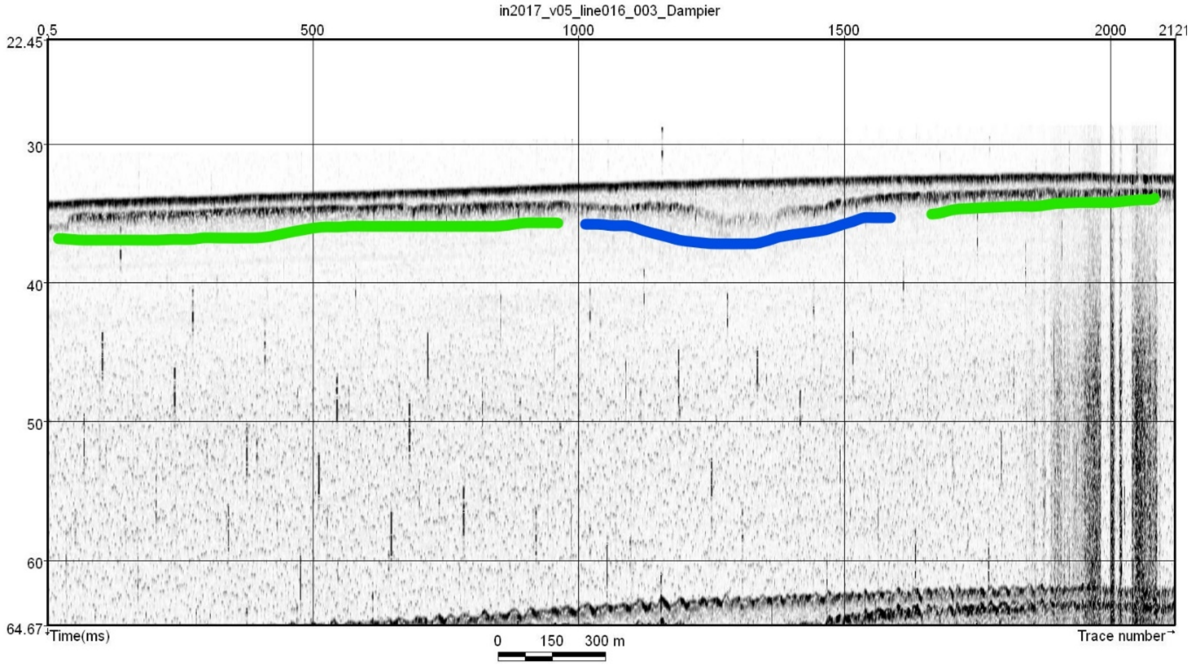
Classification	Sub-bottom Profiler	Seafloor Backscatter
2 – Reef **Flat Hard** W77 Trawl Net not yet down SBP Line050 MB 676		
6 – Reef/pockmark SBP Line008_005		

Figure 17. Examples of flat hard (reef) bottom (upper panel) and pockmarked reef (lower panel) showing interpretation using sub-bottom profile and acoustic backscatter data



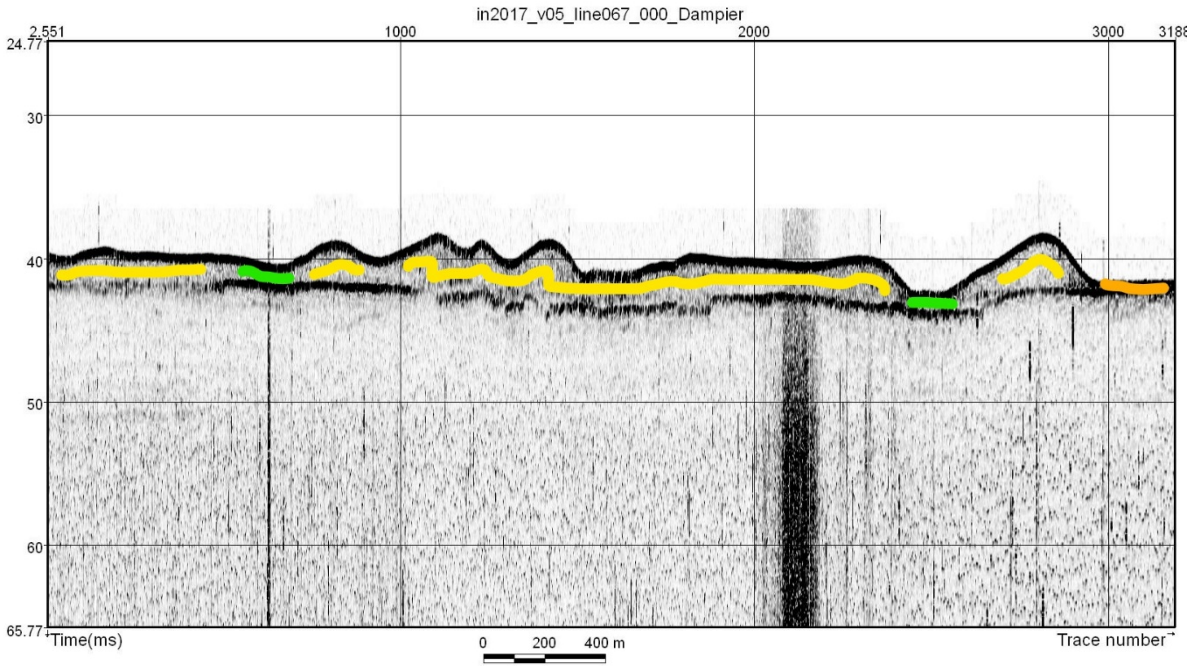


Figure 18. Examples of scoring of categories along sub-bottom profile tracks. Numbers on the right hand vertical axis in milliseconds. Green is thin sediment, blue is thick sediment, yellow is sand dunes and orange is flat hard bottom.

2.2.3 Dampier MP

The figures below provide detailed maps of the substrate at each of the survey sites based on interpretation from the sub-bottom profiler and the acoustic backscatter (roughness and hardness). Figure 19 shows the extent of the Dampier MP mapped using the sub-bottom profiler. At site W4 the bottom is predominantly flat hard substrate or thin sediment, mostly smooth but with some rougher areas towards the south-west extent of the transect (Figure 20). This site carried a very high biomass of sponges (see Chapter 3). Site W6 was similar based on the sub-bottom profile with flat hard substrate and in places with overlying sediment. The substrate became rougher as the transect progressed from north-west to south-west. The hardest sections at the middle and the end of the transect correlate with the rougher sections indicated by the Angular Range Analysis (ARA) (centre panel, Figure 21). The smoothest and softest section at the beginning of the transect correlates with the section of thin sediment (shown in green) detected by the sub-bottom profiler (Figure 21). Site W8 was predominantly thin sediment and dunes. The backscatter map (lower panel, Figure 22) indicates predominantly mid-range reflectivity, i.e., neither very hard nor very soft bottom. There is a section mapped to the south-east of W8 which is flat hard bottom and considerably rougher than the W8 transect (Figure 22).

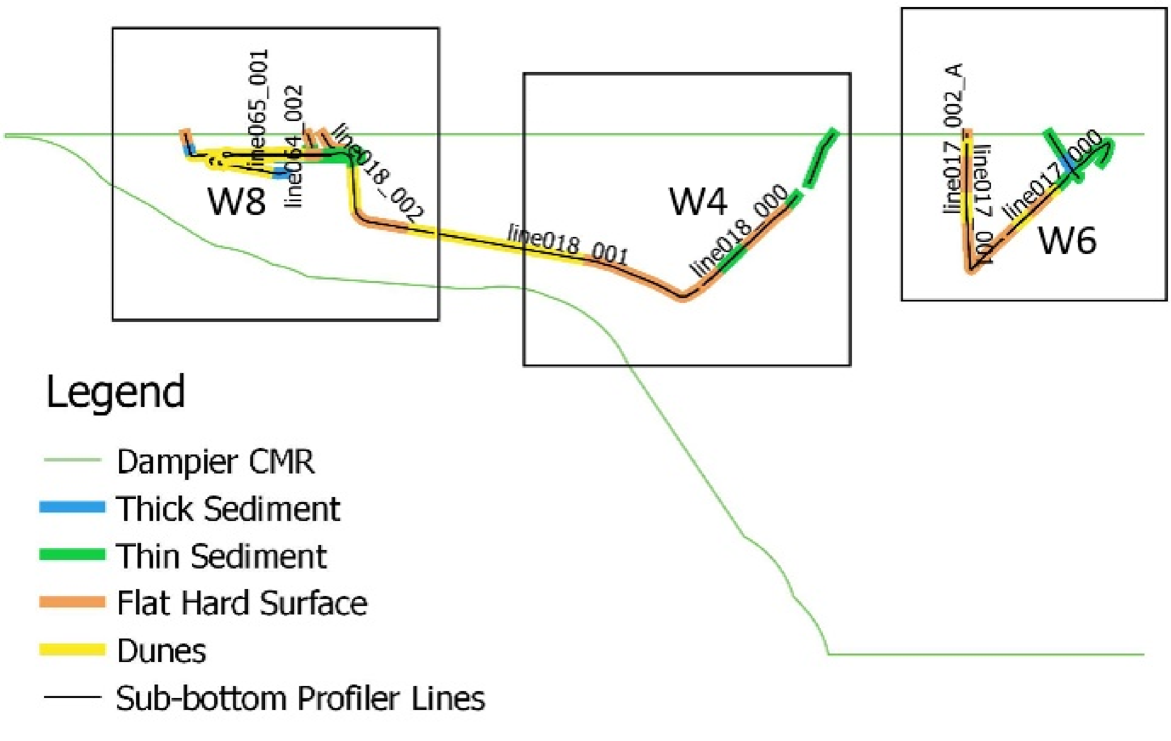


Figure 19. Mapping of sub-bottom profile categories within the Dampier MP. See figures below for more detail at each site

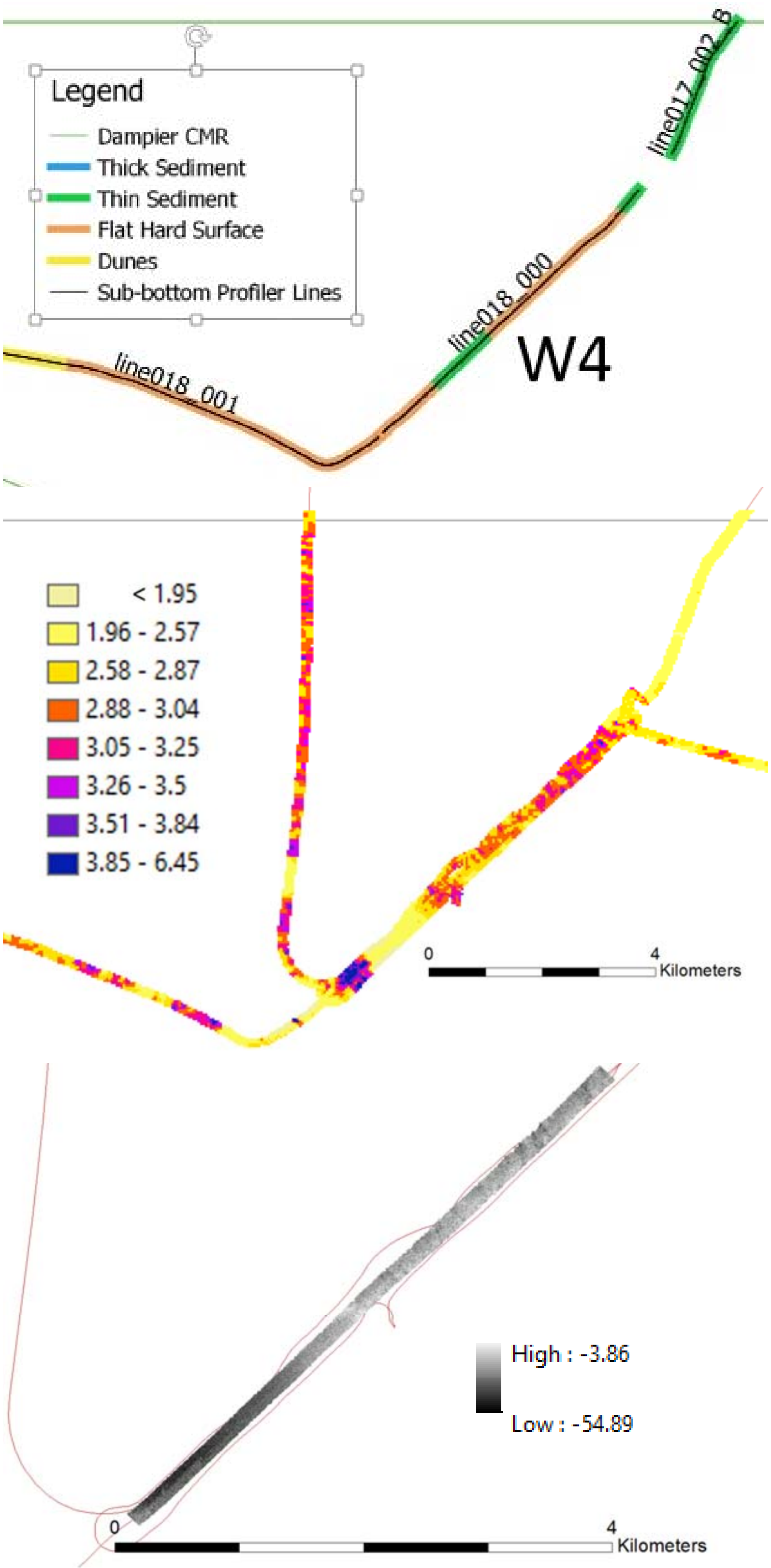


Figure 20. Detail of acoustic seabed mapping of site W4 in the Dampier MP. Top panel: sub-bottom profile categories, middle panel: seabed roughness in relative values (higher values are rougher) and bottom reflectivity (dB) (higher [light] values are more reflective [harder]). See Figure 19 for locality map.

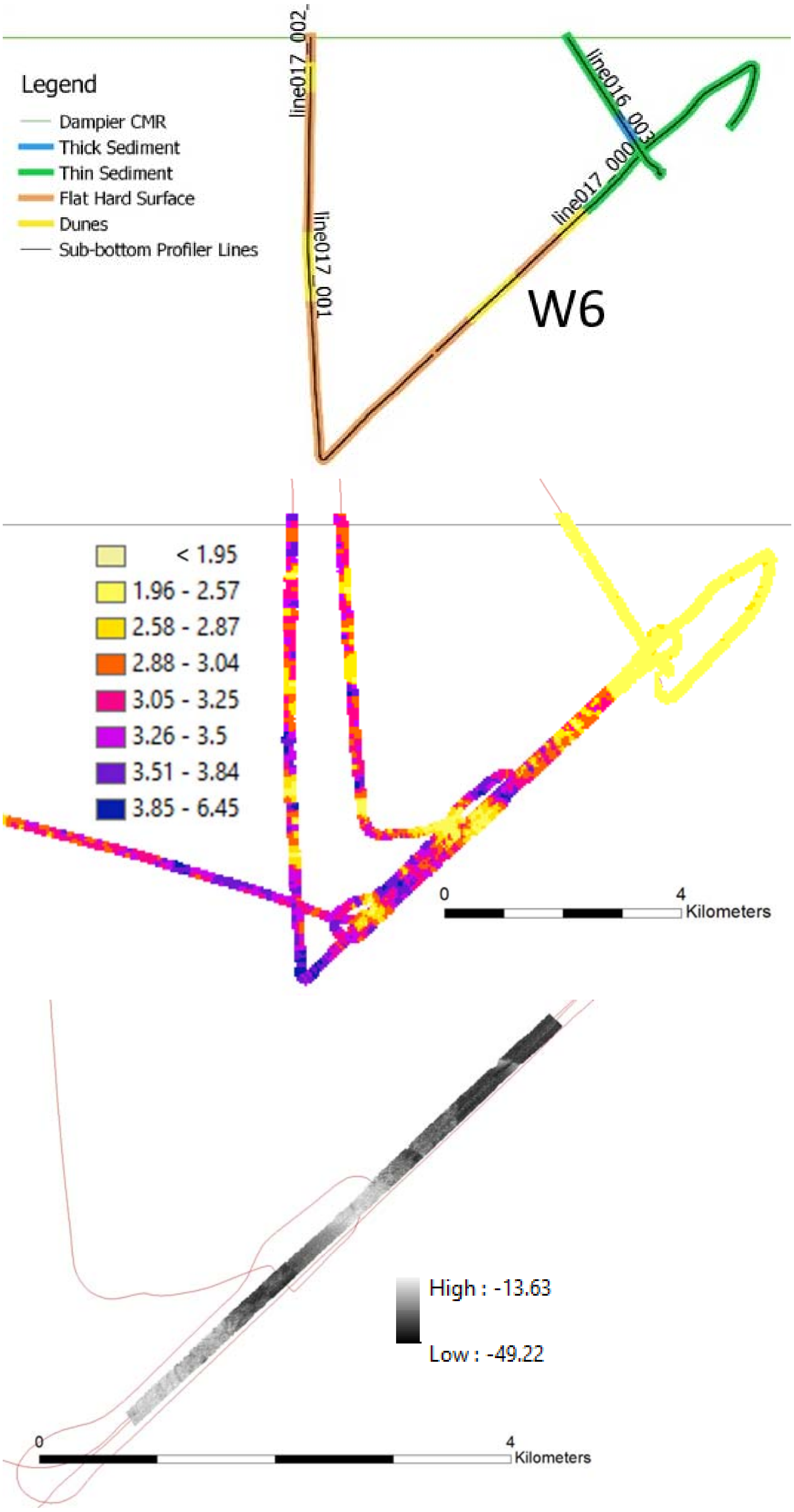


Figure 21. Detail of acoustic seabed mapping of site W6 in the Dampier MP. Top panel: sub-bottom profile categories, middle panel: seabed roughness in relative values (higher values are rougher) and bottom reflectivity (dB) (higher [light] values are more reflective [harder]). See Figure 19 for locality map

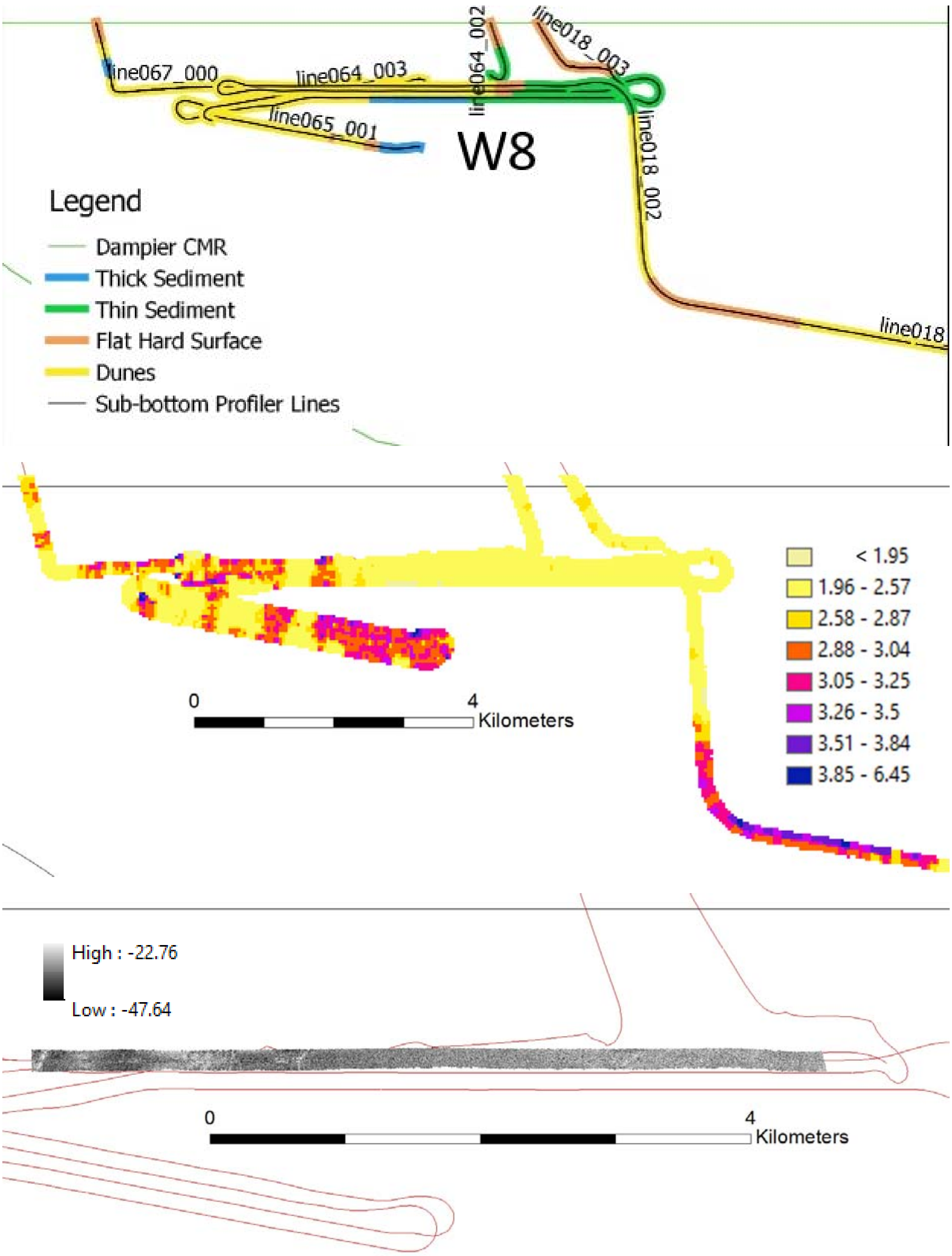


Figure 22. Detail of acoustic seabed mapping of site W8 in the Dampier MP. Top panel: sub-bottom profile categories, middle panel: seabed roughness in relative values (higher values are rougher) and bottom reflectivity (dB) (higher [light] values are more reflective [harder]). See Figure 19 for locality map.

2.2.4 Montebello MP

The north-eastern section of the Montebello MP (our sites W50, W79, W80, W81, W82, W97) is predominantly thick or thin sediment and relatively smooth based on the sub-bottom profiling and Angular Range Analysis (ARA) of the area (Figure 23, Figure 25). Backscatter analysis of the sites surveyed in this area (W50, W79, W80, W81, W82, W97) (Figure 26, Figure 27) indicates mainly intermediate reflectance values without any noticeable gradient in hardness/softness. There are however two clear areas of rocky outcrop bottom to the west of the stations. These are noted as “line 273” and “line 274” on Figure 23 and the ARA shows these as being notably more rough (Figure 23) which is in clear contrast to the majority of the rest of the area surveyed. Our site W49 is to the west of this area and comprises hard surface for the western half of the transect and thick sediment for the eastern half (Figure 24, upper panel) and the ARA indicates the western part of the transect is considerable rougher (Figure 24, lower panel). However, the backscatter analysis of site W49 (Figure 26) does not show much of a gradient in reflectivity between these two sections. Site W14 was the shallowest site we surveyed in the Montebello MP (48–50 m) and is situated to the south of the other 7 stations (Figure 23, Figure 24). It is indicated to have a hard bottom based on the sub-bottom profiling and is rougher at eastern and western ends than in the middle (Figure 24). Again the backscatter analysis for W14 (Figure 26) reveals little gradient in reflectivity. The most obviously contrasting feature from our survey is the hard, very rough, rocky outcrop section swathed in the far western part of the MP (Figure 23). Unfortunately we lack any detailed surveys in this area.

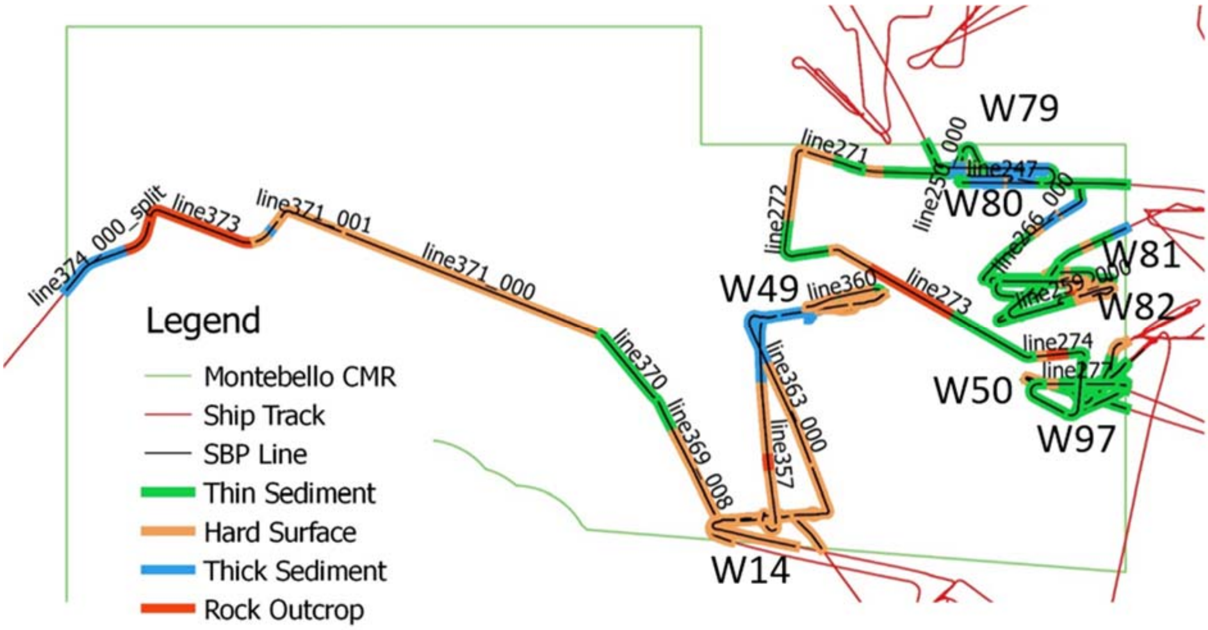


Figure 23. Mapping of seabed acoustic properties within the Montebello MP. Top panel: sub-bottom profile categories, lower panel: seabed roughness in relative values (higher values are rougher). See figures below for detail.

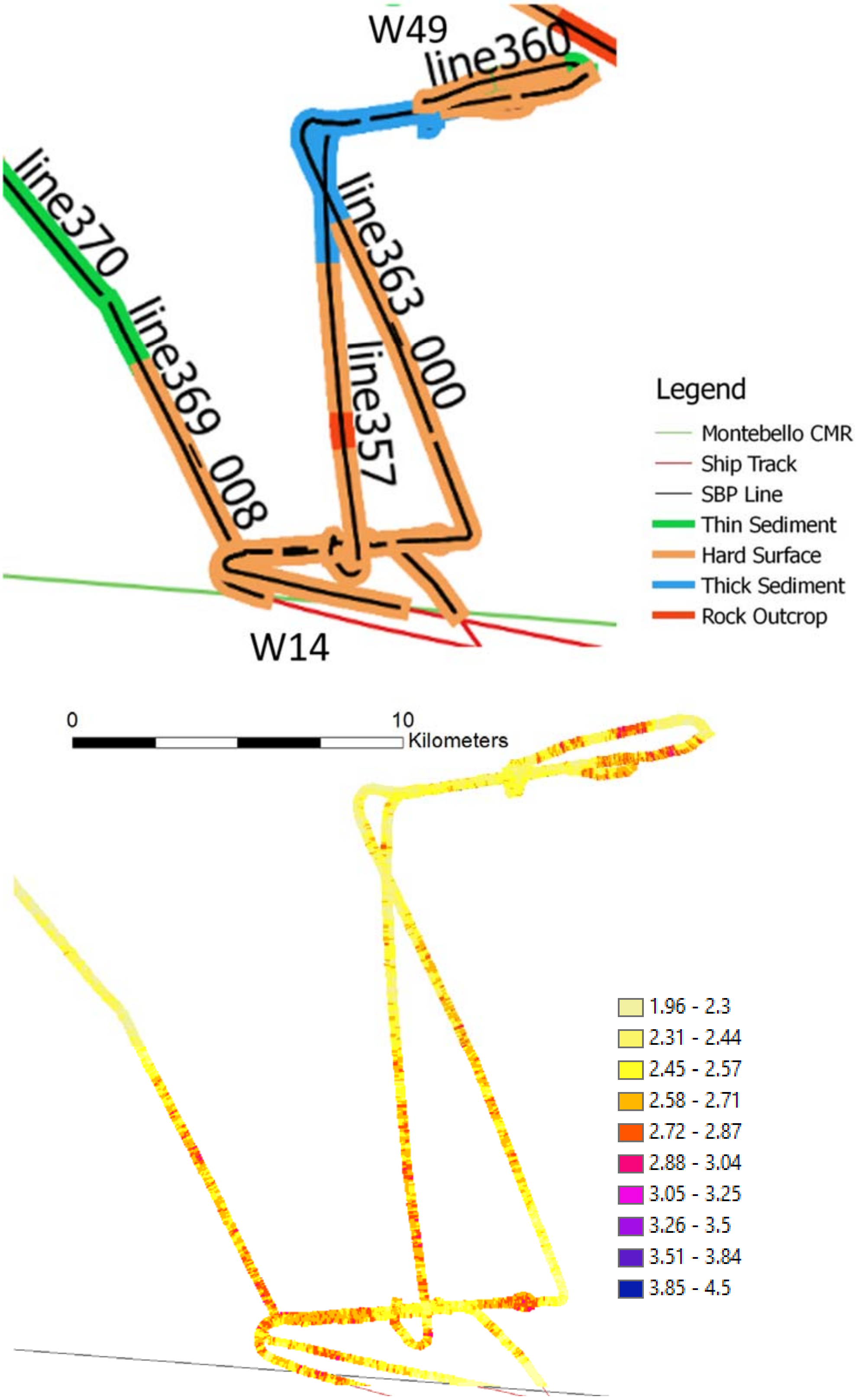


Figure 24. Detail of mapping of seabed acoustic properties at sites W14 and W49 within the Montebello MP. Top panel: sub-bottom profile seabed categories, lower panel: seabed roughness in relative values (higher values are rougher).

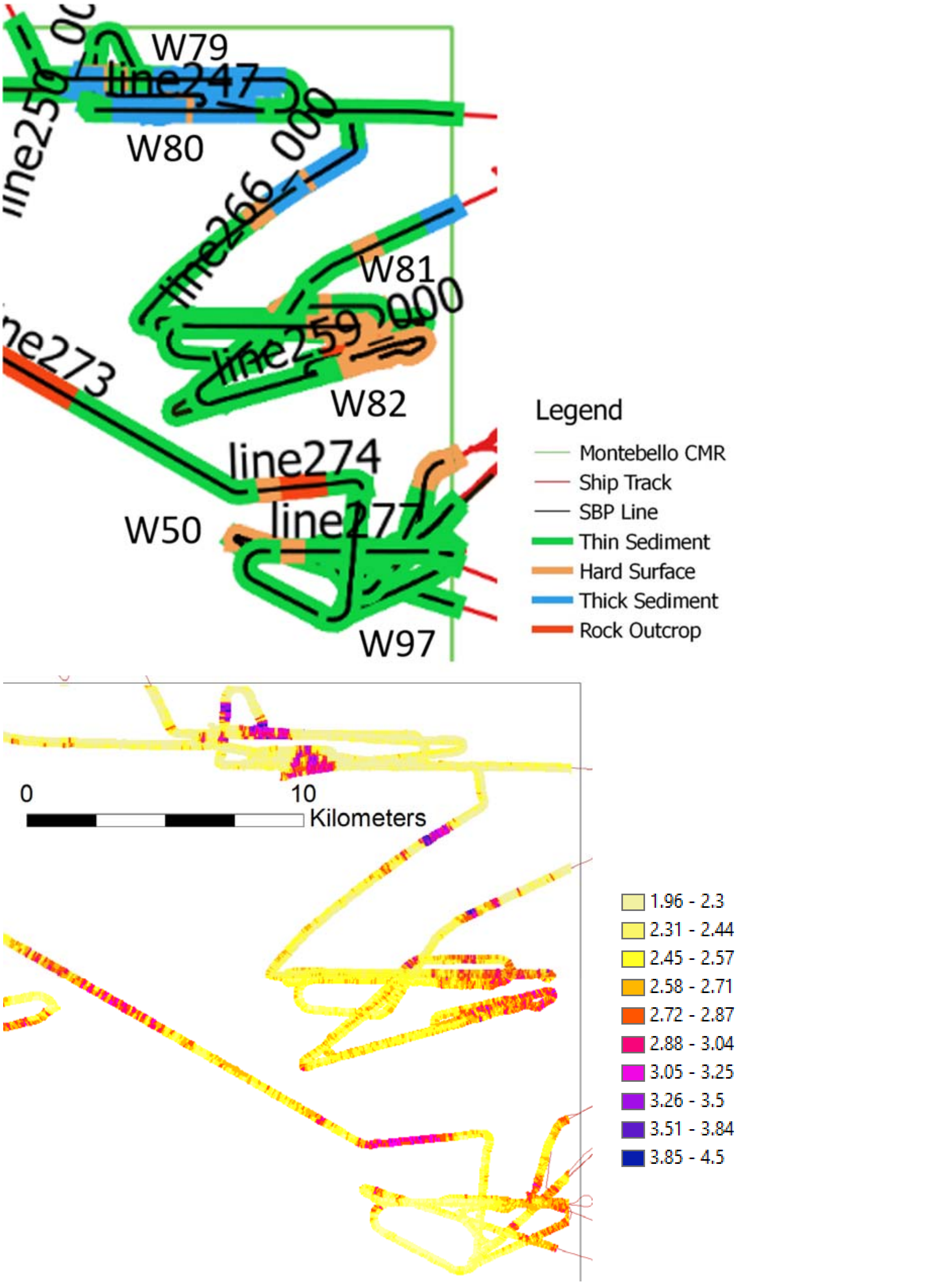


Figure 25. Detail of mapping of seabed acoustic properties at sites W50, W79, W80, W81, W82 and W97 within the Montebello MP. Top panel: sub-bottom profile seabed categories, lower panel: seabed roughness in relative values (higher values are rougher).

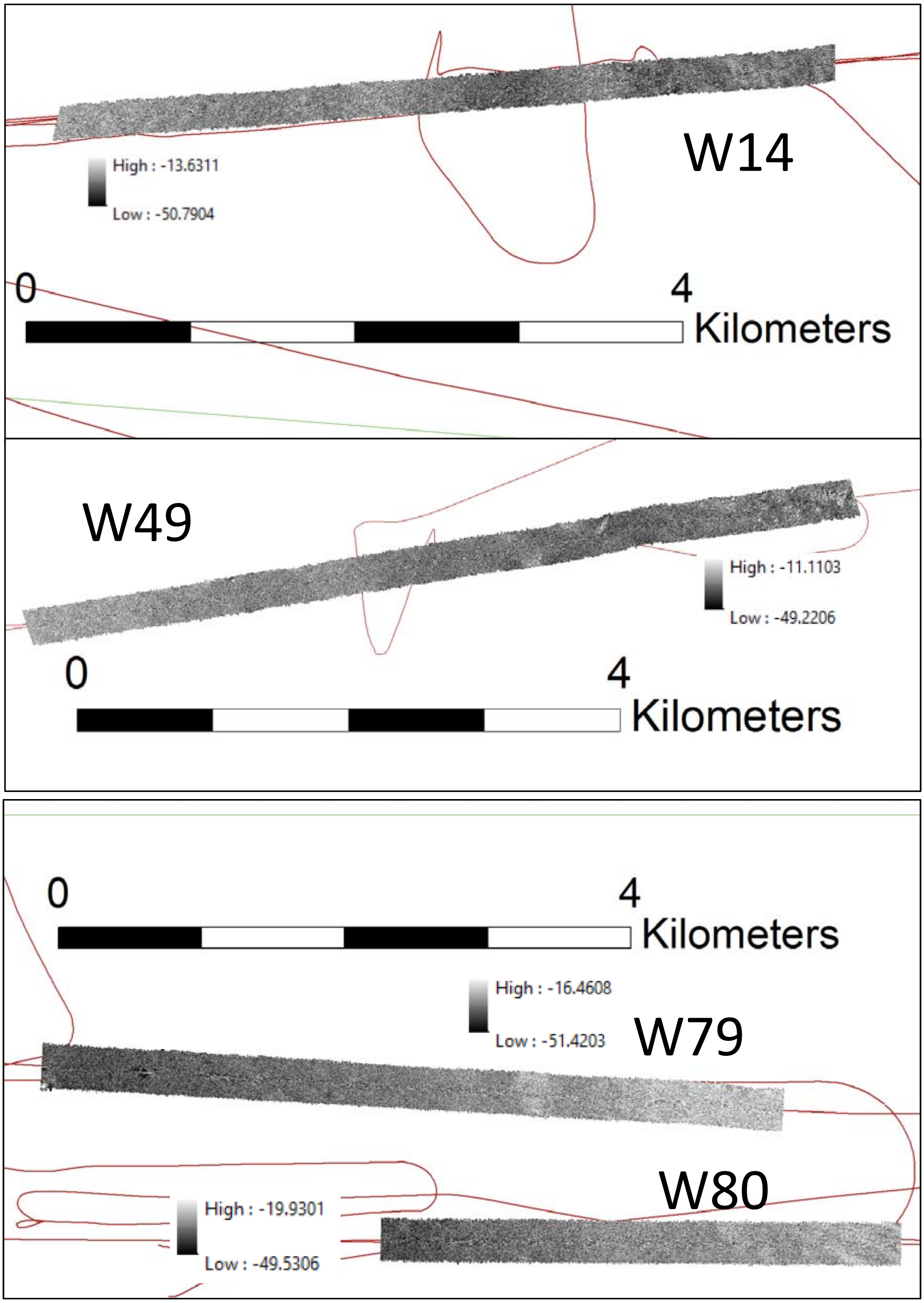
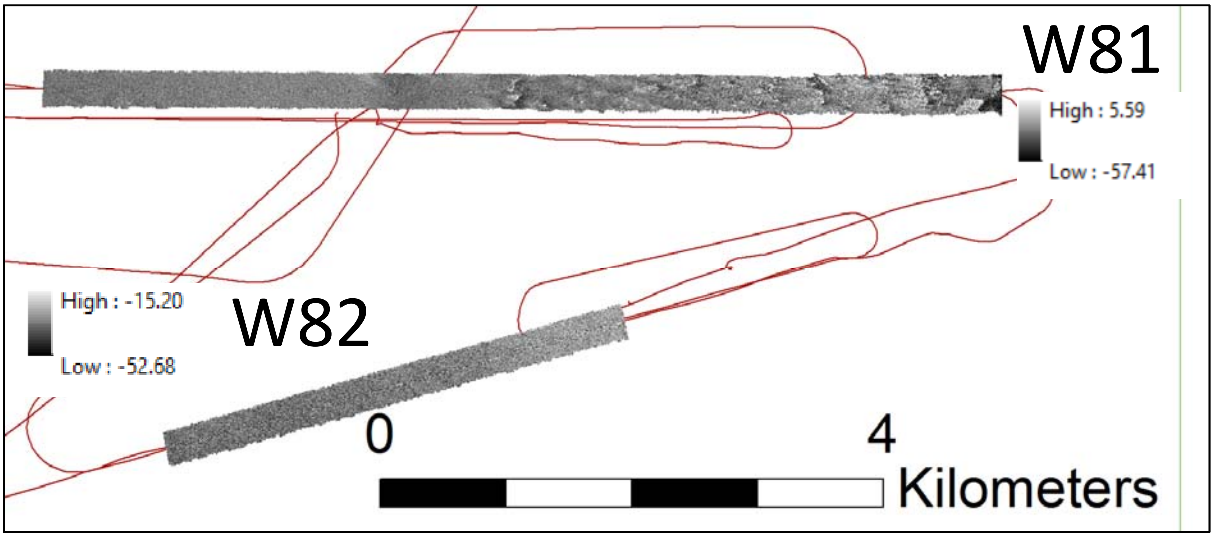


Figure 26. Detail of acoustic seabed mapping of sites W14, W49, W79 and W80 in the Montebello MP. Values range from approximately -11 dB (lighter shade, harder) to -51 dB (darker shade, softer).



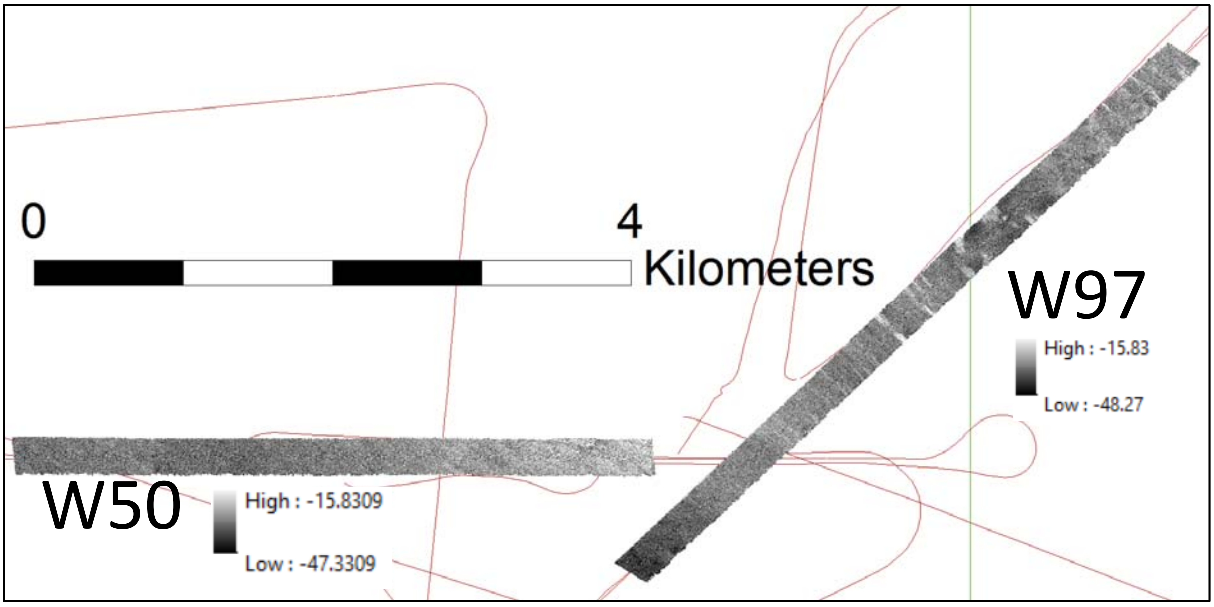


Figure 27. Detail of acoustic seabed mapping of sites W81, W82, W50 and W97 in the Montebello MP. Values range from approximately -15 dB (lighter shade, harder) to -57 dB (darker shade, softer). There are some anomalous high values at W81 but these have little effect on the image shown.

2.3 Water column sampling

2.3.1 Nutrients

Water samples were collected using a 24 x 10 L Niskin bottle rosette. Replicate 10 mL water samples of unfiltered seawater from each depth was analysed for dissolved inorganic nutrients (nitrate + nitrite [hereafter nitrate], ammonia, phosphate and silicate) by flow injection analysis (Lachat QuickChem 8000) with detection by absorbance at specific wavelengths for silicate [QuikChem Method 31-114-27-1-D], nitrate [QuikChem Method 31-107-04-1-A] and phosphate [QuikChem

Method 31-115-01-1-G]), and by fluorescence for ammonia (Watson et al. 2005). Detection limits were 0.02 µM for all inorganic nutrient species, with a standard error of < 0.7%.

In addition to nutrients, samples for chlorophyll- *a* (chl-*a*) were collected with 1 L of seawater from each depth vacuum-filtered onto a Whatman 25 mm diameter glass fibre filter (GF/F) (nominal pore size of 0.7 µm). The filters were stored in at -80°C until analysis (24–48 hours post-collection), when pigments were extracted in 90% acetone overnight and analysed for chl-*a* and phaeopigment (represents the total chl-*a* fraction) using a calibrated Turner Designs model 10AU fluorometer and the acidification technique of Parsons et al. (1989).

Total chl-*a* ranged from 0.27 to 0.48 mg m^{-2} within the Dampier MP with concentrations in the Montebello MP lower (0.16 to 0.28 mg m^{-2}; Table 3). Conversely, nitrate, ammonia and silica were all lower in the Dampier MP (NOx = 0.01–0.017 mmol m^{-2}; NH_4 = 0.009–0.014 mmol m^{-2}; Si = 1.47–3.91 mmol m^{-2}) than nutrient concentrations in the Montebello MP (NO_x = 0.024–0.049 mmol m^{-2}; NH_4 = 0.015–0.057 mmol m^{-2}; Si = 4.24–4.84 mmol m^{-2}; Table 3). There were no real differences in phosphate concentrations between the two MPs.

Using chl-*a* as a proxy for standing stock of phytoplankton, we would suggest that the Dampier MP with a higher concentration of phytoplankton could potentially cause the drawdown of nutrients. In coastal environments, diatoms are generally the dominant phytoplankton taxa and the drawdown of silica is indicative of this, but without specific phytoplankton taxa data we can only speculate based on what has been published.

Table 3. Nutrients (depth averaged values) for Dampier MP and Montebello MP stations. * Station W98 was outside of the Marine Park but close to station W97

Marine Park / Station	Ave total Chl a (mg m^{-2})	Ave NO_x (mmol m^{-2})	Ave NH_4 (mmol m^{-2})	Ave PO_4 (mmol m^{-2})	Ave Si (mmol m^{-2})
Dampier MP					
W4	0.30	0.010	0.011	0.140	3.905
W6	0.27	0.013	0.014	0.132	3.513
W8	0.48	0.017	0.009	0.110	1.471
Montebello MP					
W49	0.27	0.046	0.057	0.137	4.838
W79	0.28	0.049	N/A	0.118	4.236
W81	0.27	0.043	0.015	0.124	4.455
W98*	0.16	0.024	N/A	0.121	4.432

2.3.2 CTD profiles

Water column profiles of conductivity (as a proxy for salinity) and temperature (Seabird SBE 9/11 dual-sensor unit), photosynthetically active radiation (PAR 400–700 nm; Biospherical Instruments QCP-2300), fluorescence (Chelsea Instruments Aquatracka™ fluorometer), and dissolved oxygen

(DO; Anderra 3975 series optode) were determined concurrently via a CTD rosette deployed from the starboard side of the ship.

In the Dampier MP stations water column profiles indicated that there was a drop in temperature of roughly 1°C forming a small thermocline between 8 and 12 m (Figure 28). In the Montebello MP stations the thermocline was deeper with steady decrease between 15 and 35 m with a temperature change between 1 and 2 °C (Figure 29). Salinity increased slightly (~ 0.03 psu) with depth at the three stations in the Dampier MP (Figure 28). A small pycnocline was observed between 20 and 35 m at all four stations in the Montebello MP (Figure 29). W79's salinity profile had an anomalous signal near the surface before the trace changed to a profile similar to the other three stations. Dissolved oxygen (DO) did not show any consistent pattern between the Dampier MP stations (Figure 28), but at three stations in the Montebello MP followed a similar pattern as salinity having a DO minimum associated closely with the pycnocline (Figure 29). Station W49 was different from the rest in the Montebello MP having a DO maximum associated with the pycnocline (Figure 29).

There was a steady decline in PAR across all stations in the Dampier MP with the exception of an anomalous surface signal at station W6 likely caused by ship shadow. Light extinction reached 22% surface irradiance at Station W6 while at the other two stations (W4 and W8) the % surface irradiance decreased to 10% or lower at the bottom (Figure 28). At the Montebello MP stations PAR declined steadily as well, with 1% light level reached at bottom depth at station W79 and W81. At W98 the light reaching the bottom was calculated at 8% surface irradiance. Station W49 was profiled early in the morning and the surface PAR levels are low resulting in inaccurate calculation of the light level at depth.

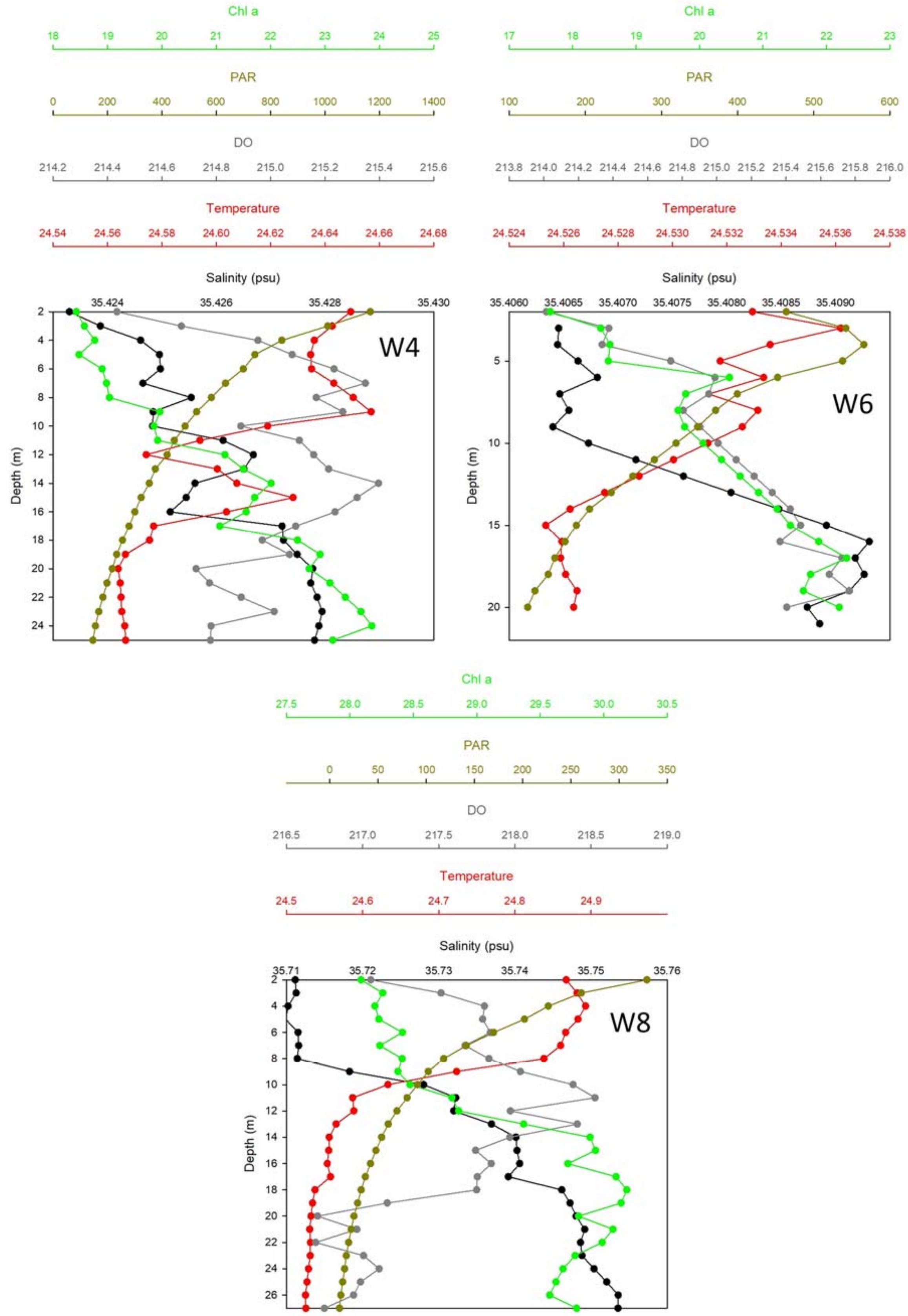


Figure 28. CTD profiles of water column parameters from stations within the Dampier MP

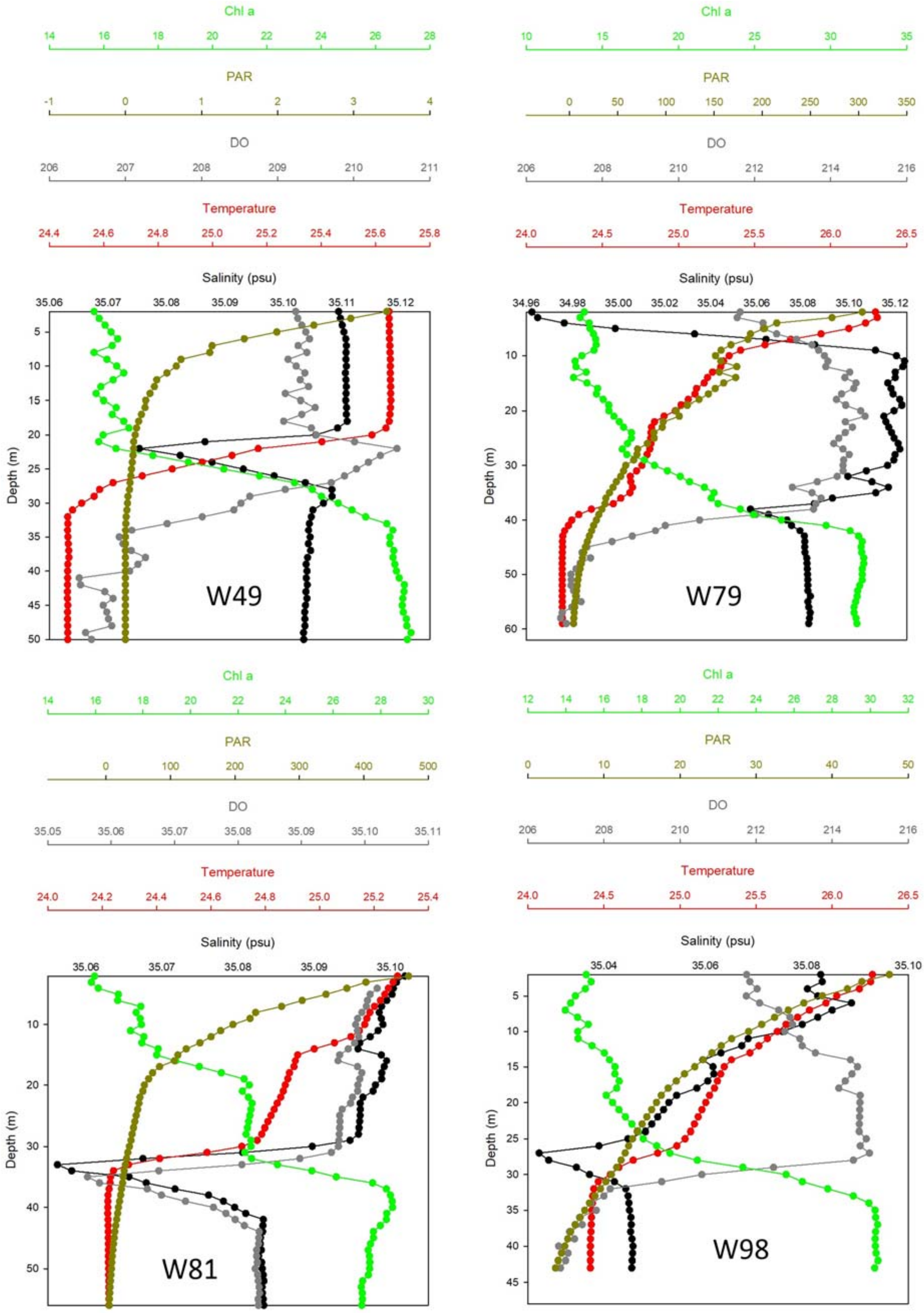


Figure 29. CTD profiles of water column parameters from stations within or nearby the Montebello MP. Note station W98 was just outside the Montebello MP but close to station W97.

3 Habitat assessment: benthic substrate and biota

3.1 Data sources

This chapter of the report makes use of data collected on the 2017 RV *Investigator* voyage (INV2017_05) and two earlier studies; the 2013 Pilbara Marine Conservation Partnership (PMCP) surveys (Pitcher et al. 2016) and the 1982–1997 CSIRO North West Shelf (NWS) Effects of Trawling project (Sainsbury 1988; 1991). The two earlier studies were conducted over large areas of the NWS and the information relating to habitat in the areas which now comprise the Dampier and Montebello MPs has not been reported on in detail. Given the INV2017_05 voyage was only able to survey 11 sites in the two MPs, the inclusion of data from those older studies in this report has significantly enhanced the spatial coverage of data now available for both MPs.

3.1.1 INV2017_05 survey sites and data sources

Figure 2 and Figure 3 show the location of the sites within the Dampier MP (3) and the Montebello MP (8) surveyed in October/November 2017. Data used to describe benthic substrates and biota are principally derived from still camera images taken from the trawl headline camera which captured images ahead of the demersal trawl net every 3 seconds. A detailed description of the methods used to collect, score and analyse the images is given in Appendix A.

3.1.2 CSIRO 1982–1997 surveys sites

Between 1982 and 1997 CSIRO conducted a series of trawl surveys aimed at evaluating the impacts of, and recovery from, demersal trawling on the NWS during the 1960s, 1970s and 1980s (Sainsbury 1988; 1991). A key feature of the project was an adaptive management experiment using a series of spatial fishing closures aimed at monitoring rates of recovery from the effects of trawling. Over the course of this project there were 28 trawl transects, which collected benthic habitat imagery, in what are now the Dampier MP (7 stations) and Montebello MP (21 stations) (Figure 30 and Figure 31) and we present data from those sites.

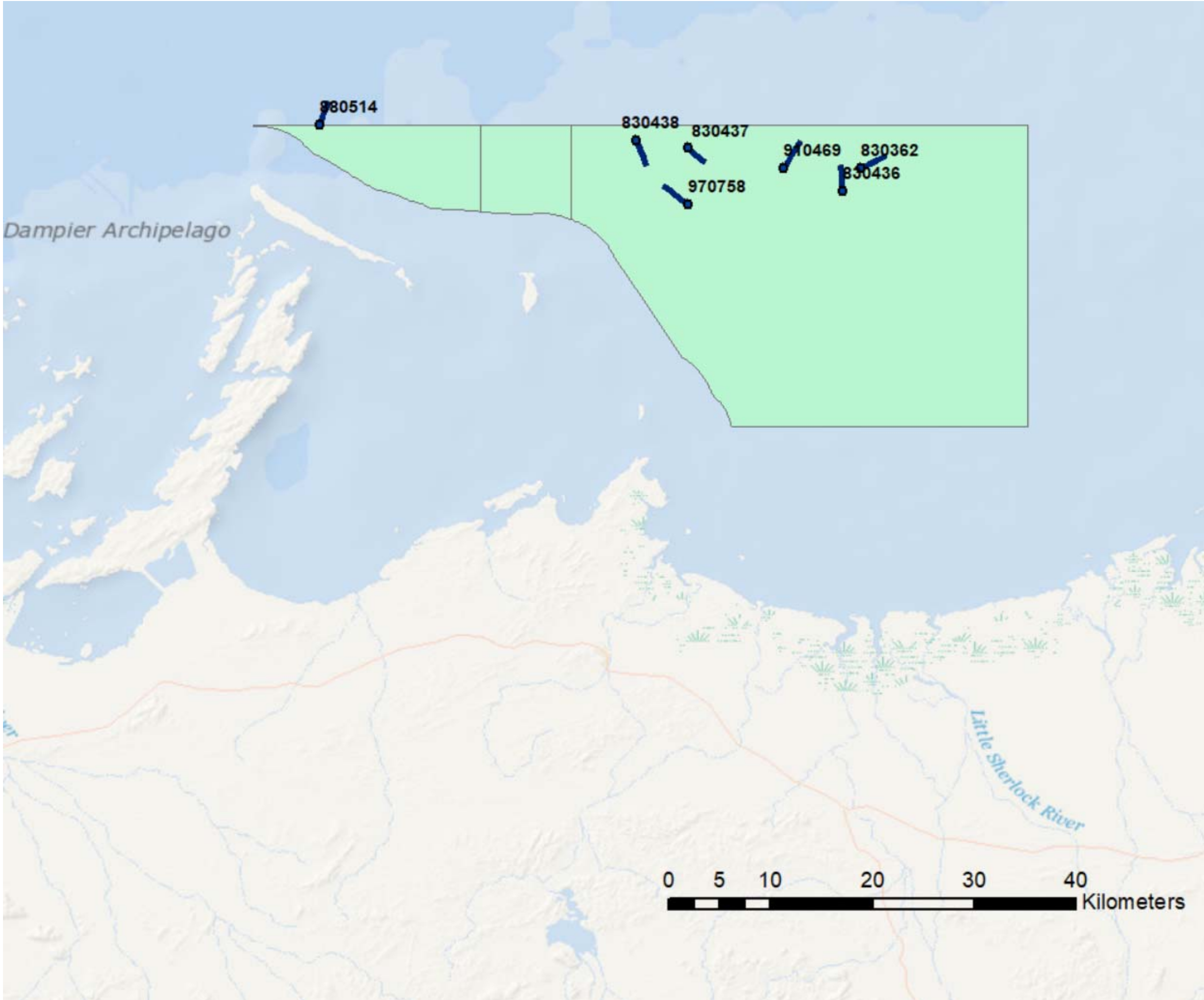


Figure 30. Location of historical trawls from 1982–1997 for which habitat data were collected in the area now forming the Dampier MP. A table showing the start and end latitude and longitude for each trawl transect is given in Appendix D. Trawl number starts with the year, followed by the voyage number for that year and then the station number (e.g. 970758 was station 58 on the seventh voyage in 1997)

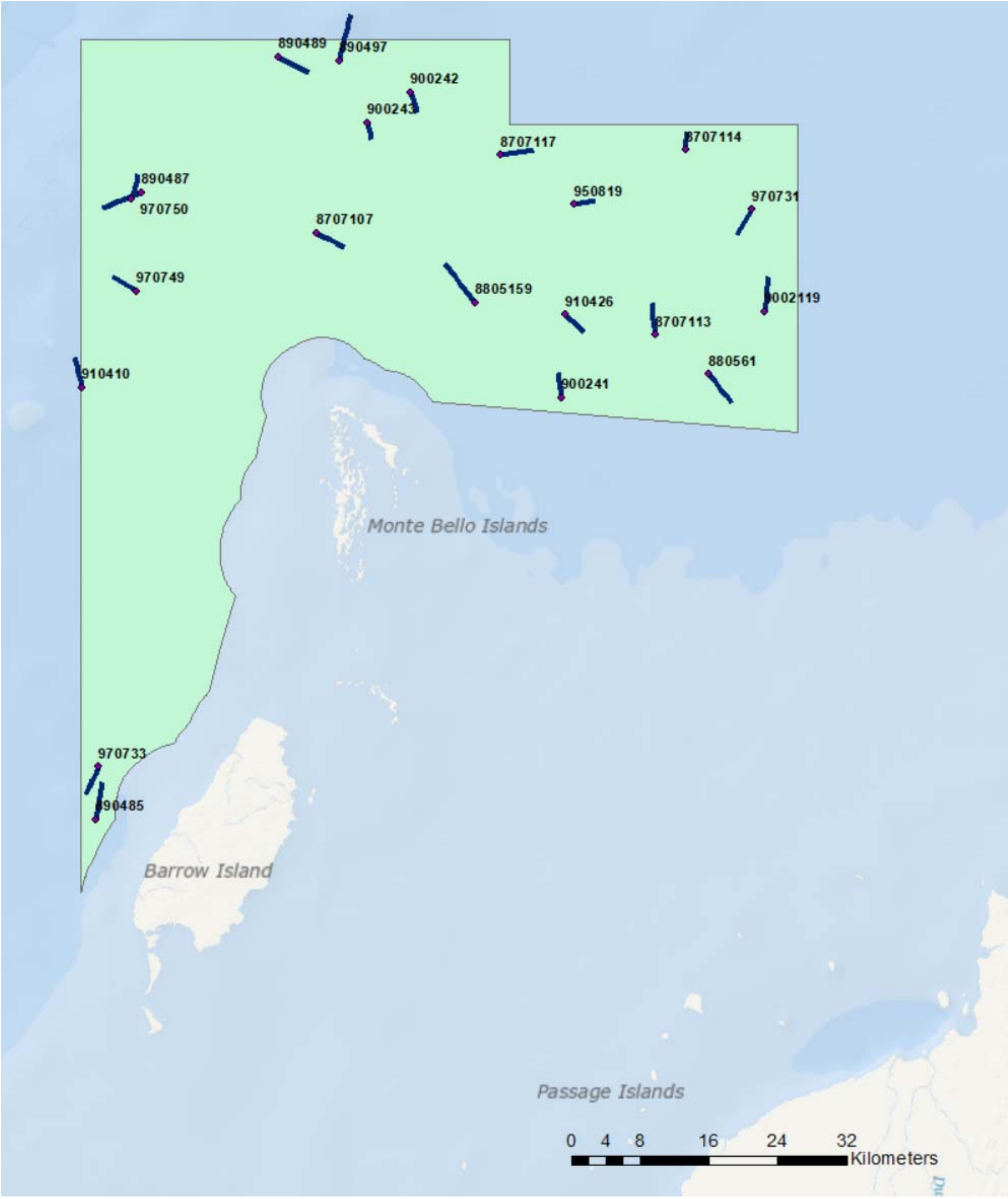


Figure 31. Location of historical trawls from 1987–1997 for which habitat data were collected in the area now forming the Montebello MP. A table showing the start and end latitude and longitude for each trawl transect is given in Appendix D Trawl number starts with the year, followed by the voyage number for that year and then the station number (e.g. 970733 was station 33 on the seventh voyage in 1997).

3.1.3 PMCP 2013 survey sites

The Pilbara Marine Conservation Partnership (PMCP) project (Babcock et al. 2017) examined a large range of topics including coastal ecology, coral reef health and habitat and biodiversity mapping in the region between North West Cape and Barrow Island and the Montebello Islands. One of the study components made an assessment of benthic habitats and biodiversity in this region (Pitcher et al. 2016) and included sites in what is now the Montebello MP. Figure 32 shows the location of these sites at which tow video, transects were undertaken. Details of the methods used are given in Pitcher et al. (2016). Here we present data collected on substrate and bio-habitat at six sites located within and around the Montebello MP.

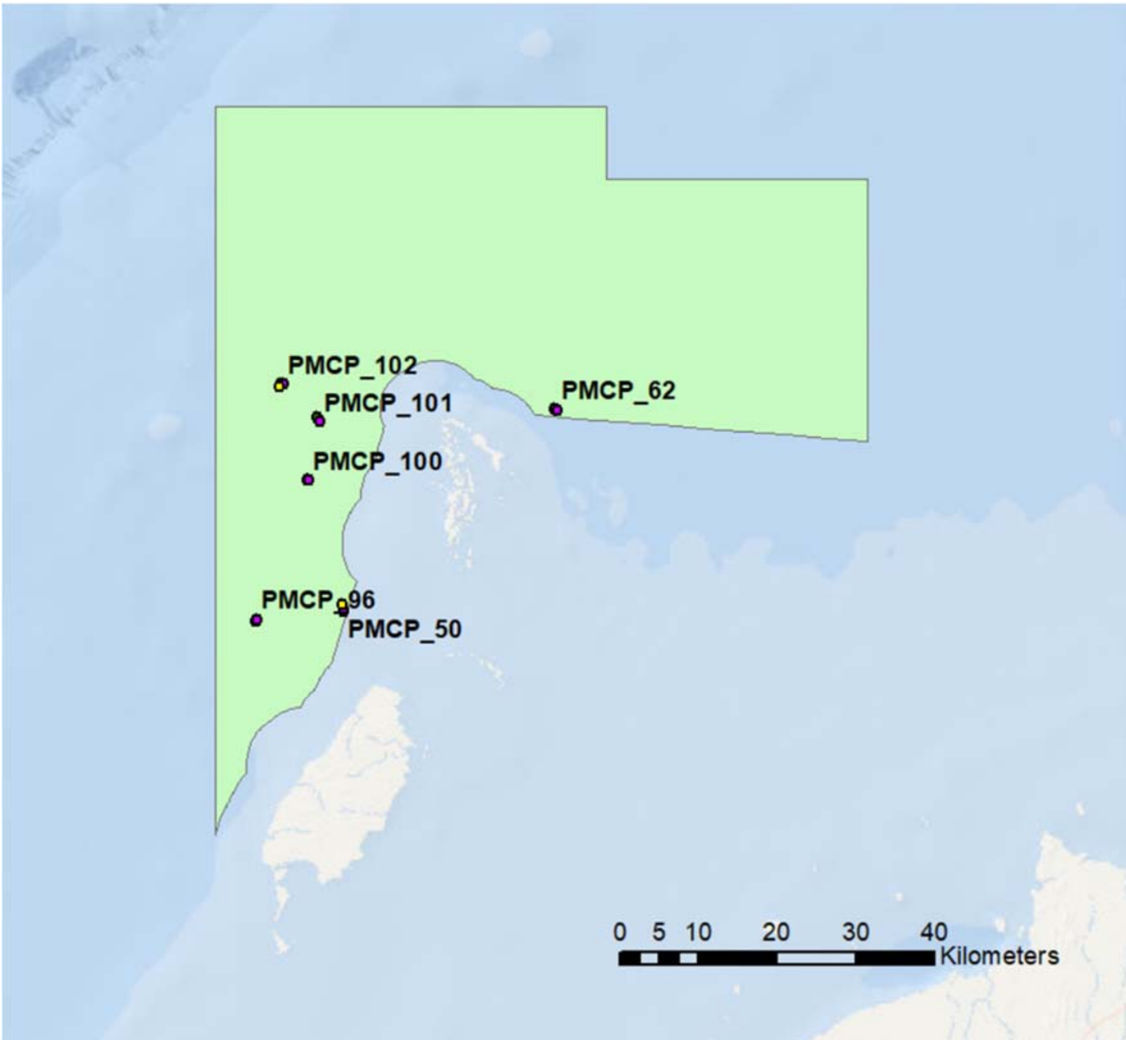


Figure 32. Location of the tow video, epibenthic sled and beam trawl stations undertaken in 2013 as part of the Pilbara Marine Conservation Partnership (PMCP) project in and around what is now the Montebello MP. Blue dots are video sites, pink are epibenthic sled sites, yellow are beam trawls. A table showing the start and end latitude and longitude for each video transect is given in Appendix D.

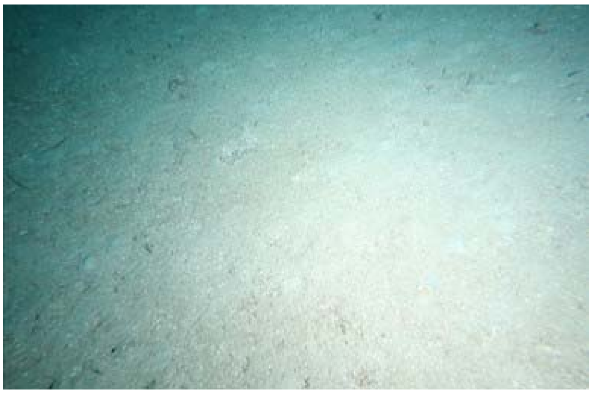
3.2 Benthic substrate and topography

3.2.1 Classification of categories of substrate and topography

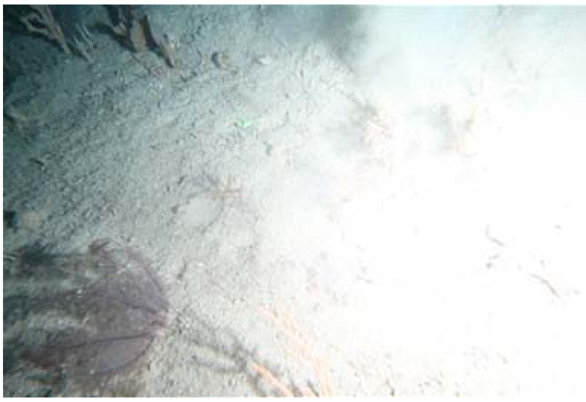
Substrate types

Five substrate types were recognised from the INV2017_05 camera images; silt, fine sand, coarse sand, rock and rubble and various combinations of these substrate types. These are illustrated in Figure 33. Similar categories were used when scoring the trawl headline camera images from the earlier CSIRO study (1982–1997).

Fine Sand



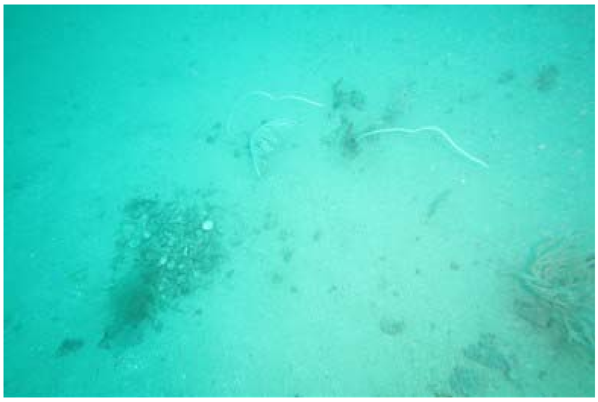
Coarse Sand



Silt

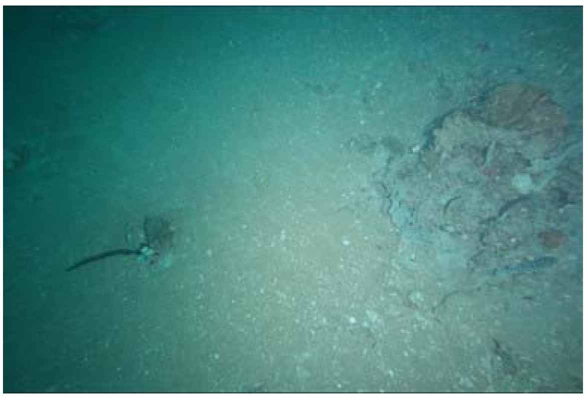
Fine Sand/Coarse Sand/Rubble

Fine Sand/Coarse Sand/Rock



Fine Sand/Rubble

Fine Sand/Rock



Fine Sand/Rubble/Rock

Figure 33. Classification of different substrate categories

Soft bottom topography types

Four types of topography were recognised from the INV2017_05 camera images of soft bottom habitats; flat bottom, flat bottom with bioturbation, fine sand ripples and fine ripples with furrows. These are illustrated in Figure 34.

Flat Bottom

Flat Bottom/Bioturbated

Fine Ripple

Fine Ripple/Furrow

Figure 34. Classification of different soft bottom topography categories

3.2.2 Dampier MP substrate and topography

INV2017_05 survey sites

The trawl headline camera images revealed that all three sites in the Dampier MP had predominantly flat or finely rippled fine sand substrate (Figure 35, Figure 50, Figure 51, and Figure 52). The sub-bottom profiler suggested that along with thin sediment, some flat hard bottom was present at sites W4 and W6, although this could have been compacted sand. The presence of benthic filter feeders at these sites also confirms the presence of hard substrate which is required for attachment.

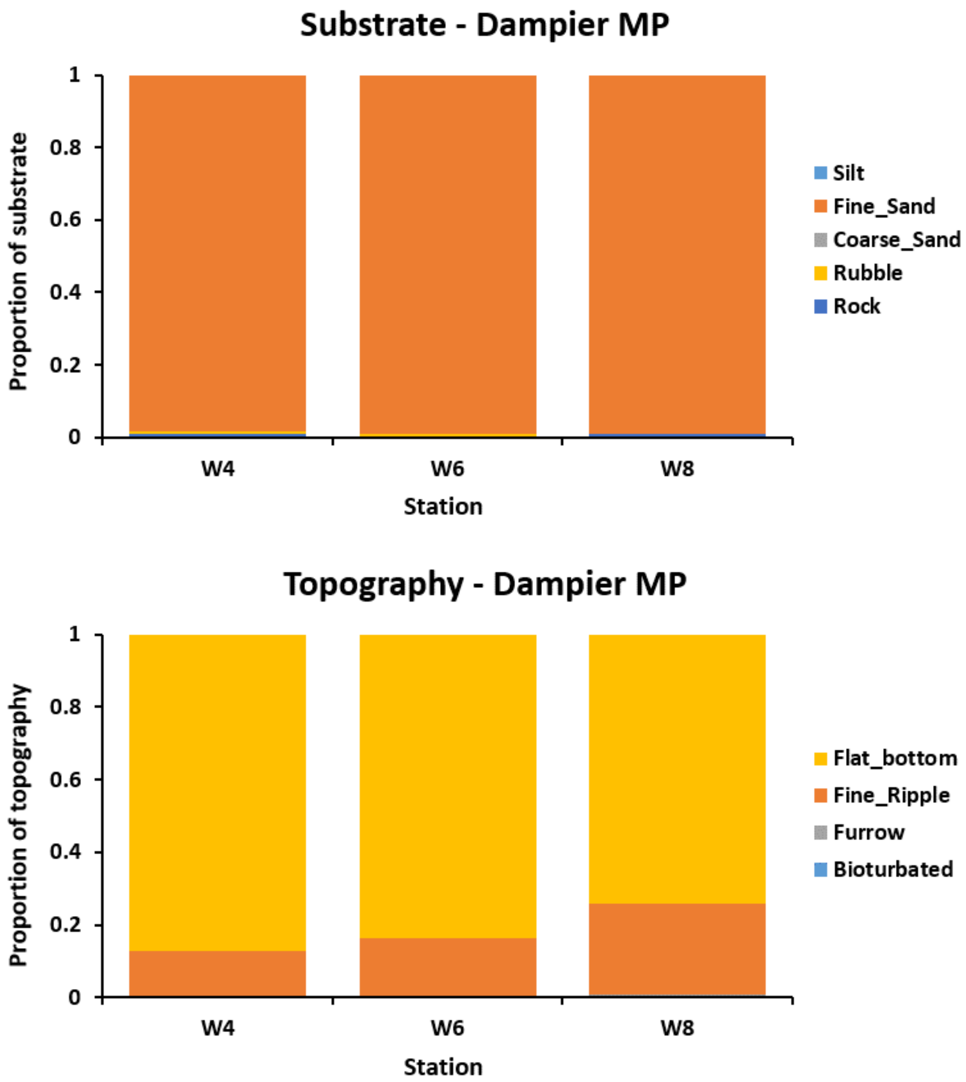


Figure 35. Proportion of substrate and topography types in seabed images along trawl lines for INV2017_05 survey site within the Dampier MP

CSIRO 1982–1997 surveys sites

Six of the seven historical sites located in the Dampier MP are now located in the Multiple Use Zone along with sites W4 and W6 (Figure 30). One of the sites (880514) is located in the Habitat Protection Zone (Figure 30). Substrate types and topography categories at the historical sites (Figure 36) are similar to those at W4, W6 and W8 being predominantly fine sand and either flat bottom or fine ripples (Figure 36, Figure 37).

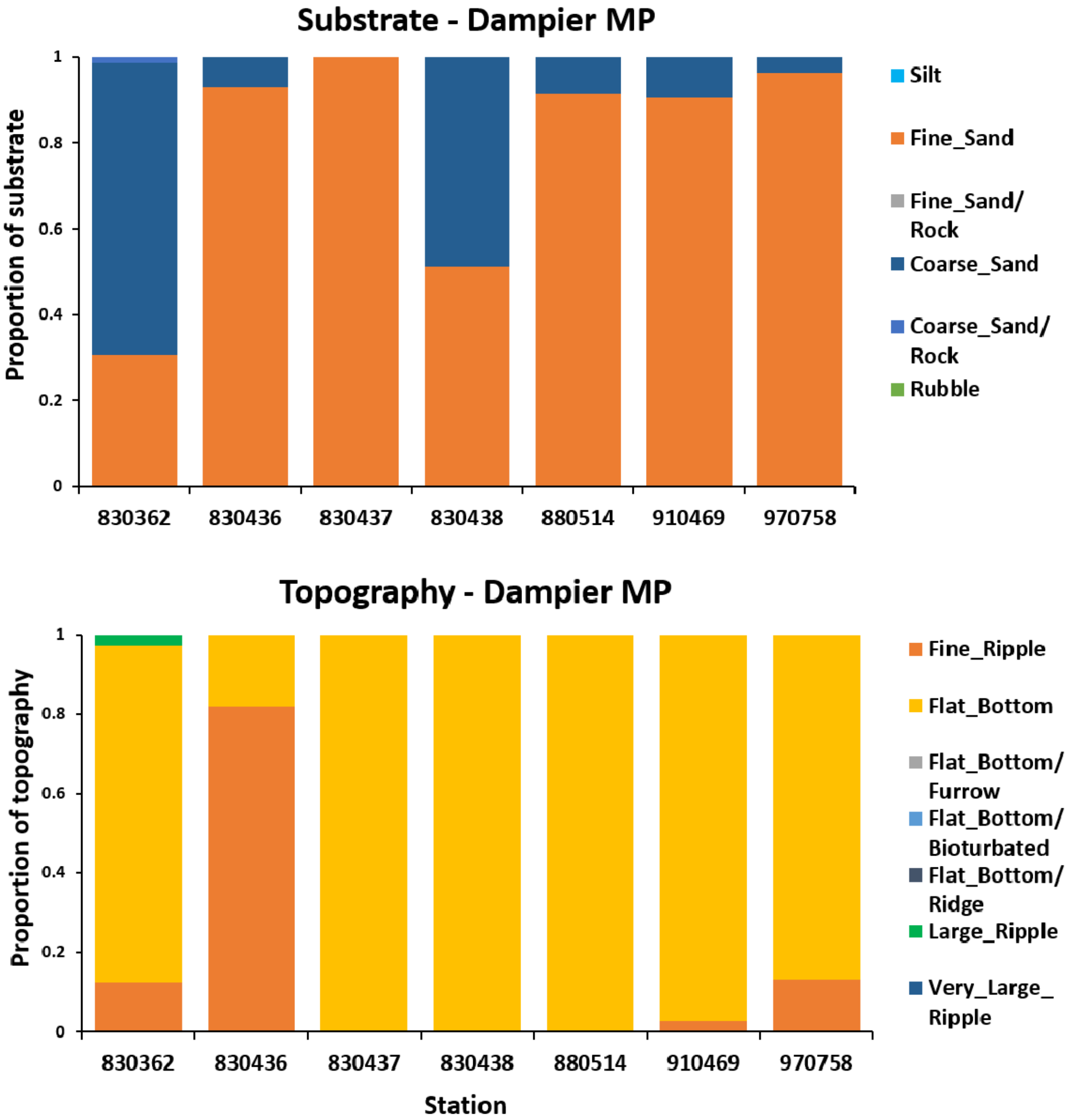


Figure 36. Proportion of substrate and topography types in seabed images along trawl lines for historical CSIRO (1982–1997) survey sites within the Dampier MP

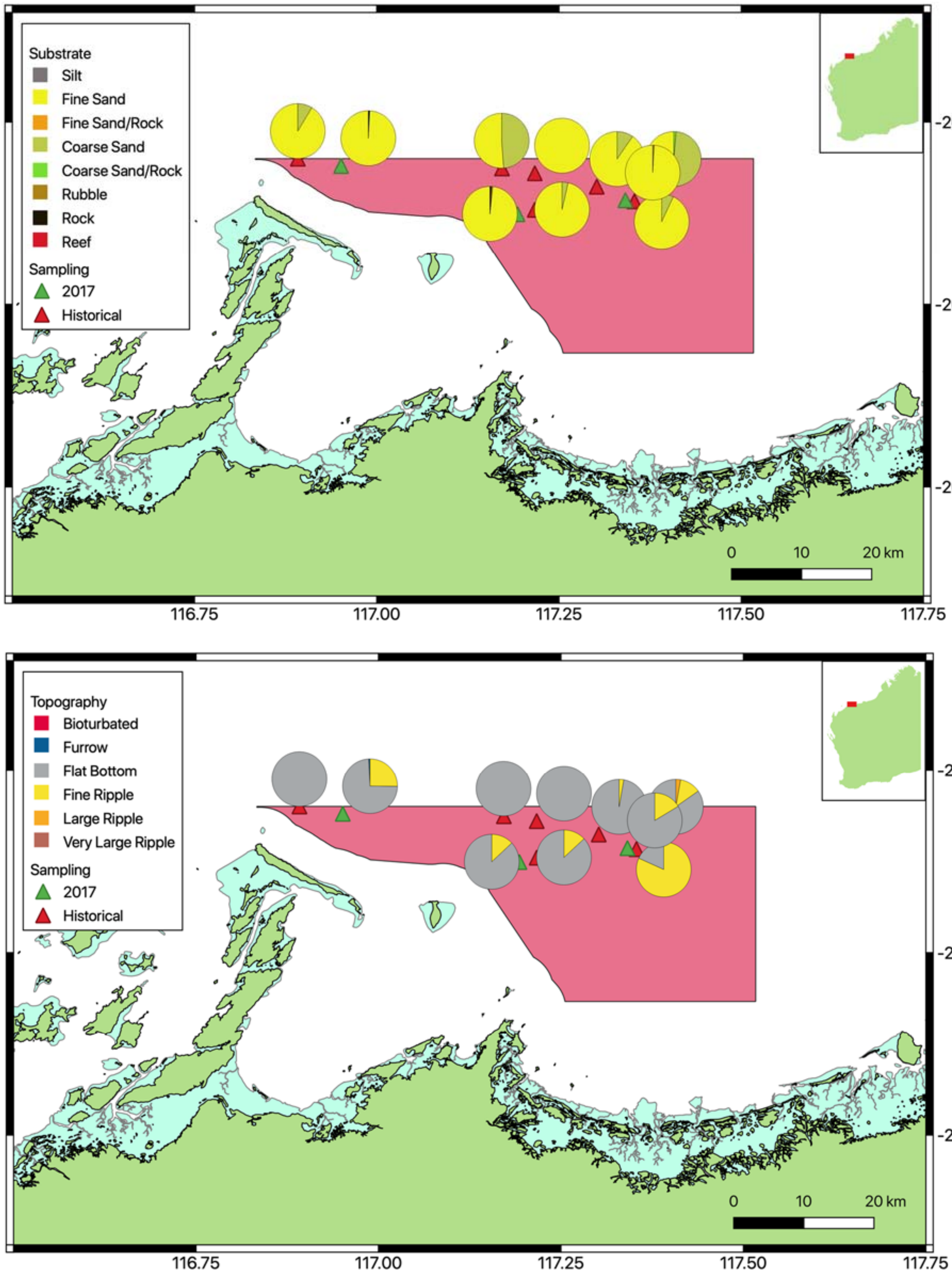


Figure 37. Proportion of substrate type and topography plotted at each site in the Dampier MP. 2017 and historical (1982–1997) data plotted together.

3.2.3 Montebello MP substrate and topography

INV2017_05 survey sites

Substrate and topography in the Montebello MP was similar to that in the Dampier MP, predominantly fine sand or a mix of fine and coarse sand (Figure 38). Site W81 was all coarse sand while some rubbly areas were observed at the shallowest sites W14 and W49. Topography was predominantly flat bottom with occasional bioturbated areas (Figure 38).

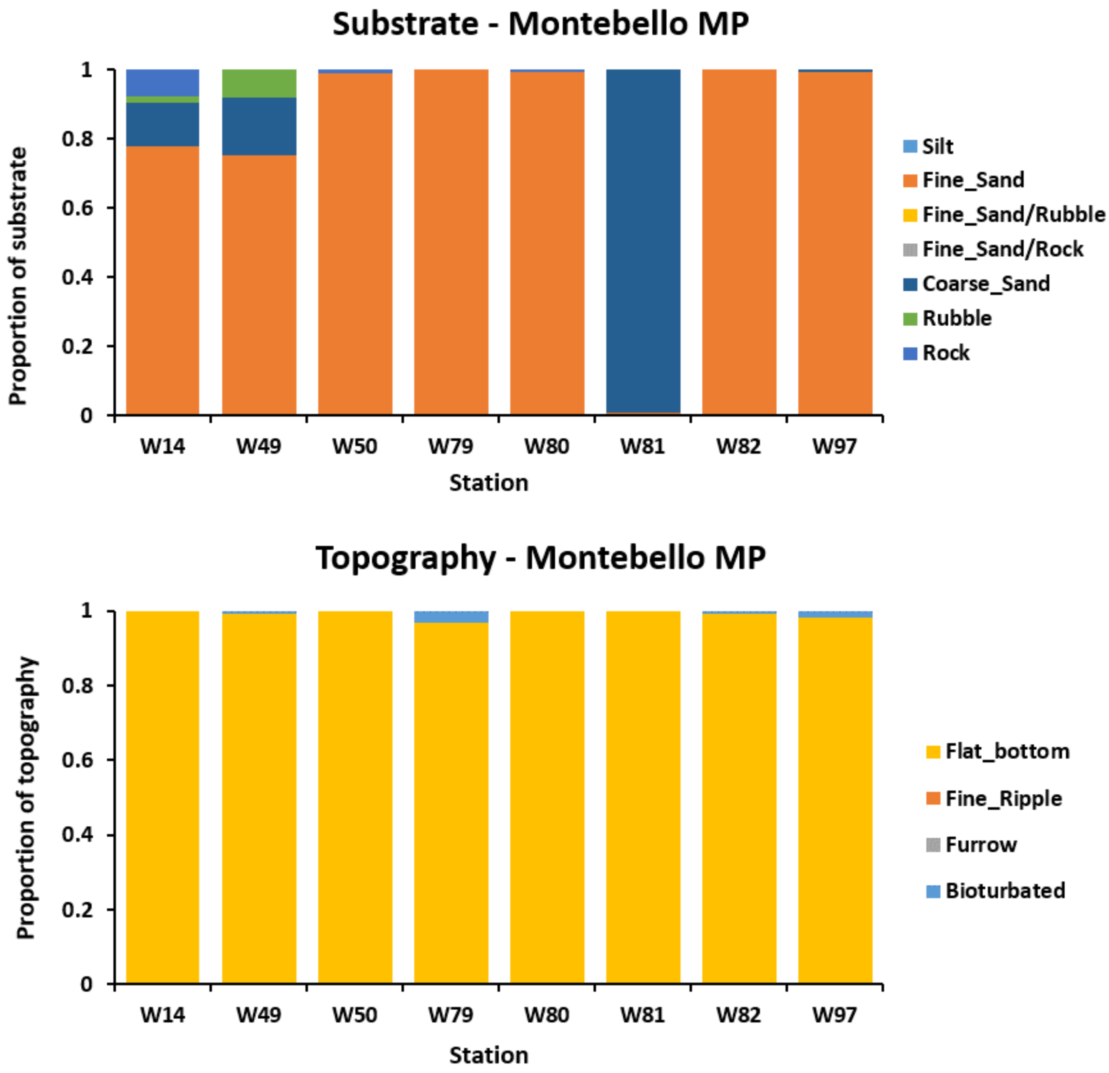


Figure 38. Proportion of substrate and topography types in seabed images along trawl lines for INV2017_05 survey site within the Montebello MP

CSIRO 1982–1997 survey sites

Substrate type at the historical sites surveyed between 1987 and 1997 was very similar across the whole of the MP and similar to the 2017 surveys, predominantly fine sand or a mix or fine and coarse sand, with some sites having rubbly areas (Figure 39). Topography was mostly fine sand or fine sand with ripples. Three sites had large proportions of ridges or large ripples or very large ripples (Figure 39). All of these sites were located at the far western side of the MP, two of these in the very south-western section of the MP (Figure 41, see Figure 31 for location map of each site).

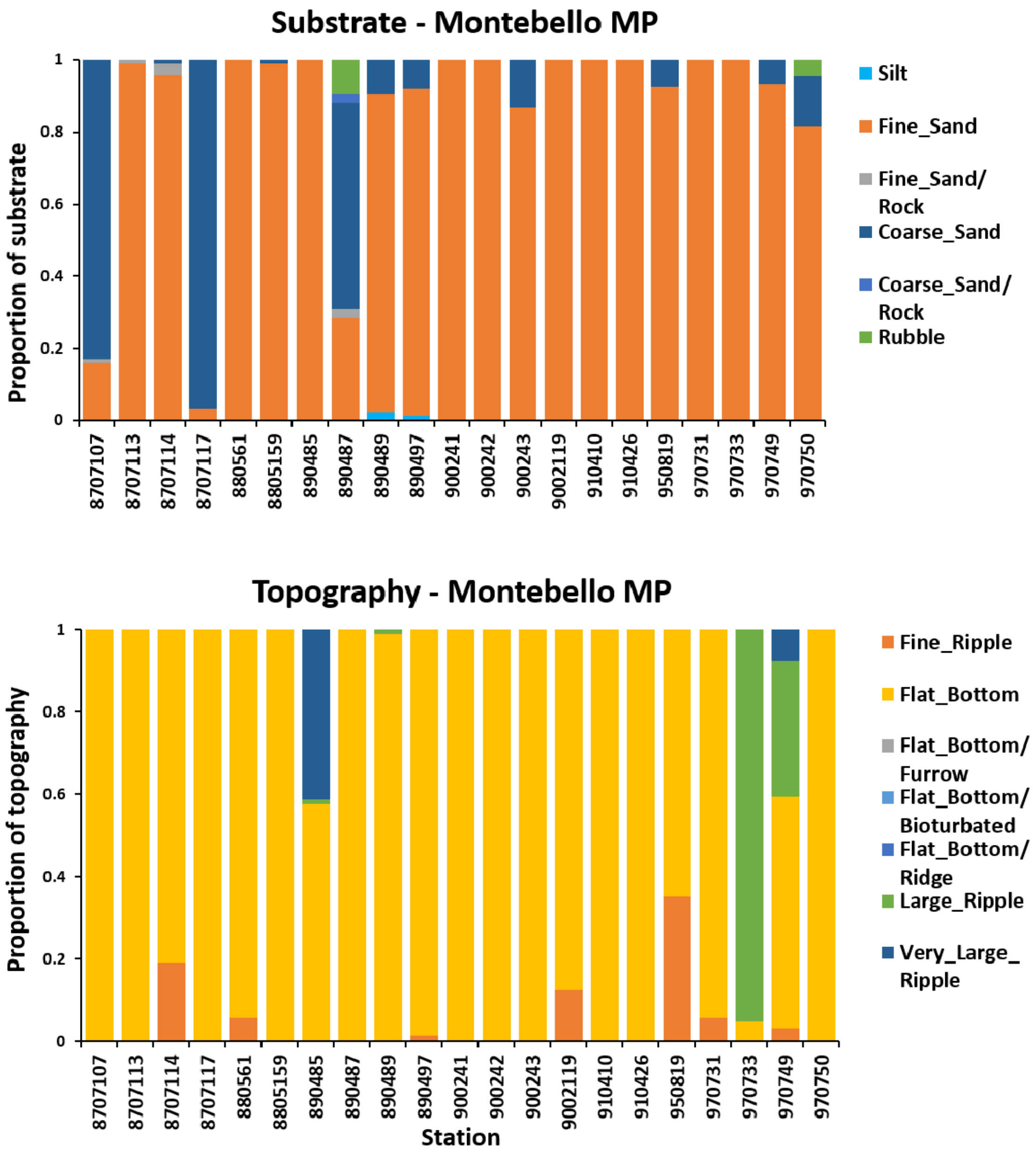


Figure 39. Proportion of substrate and topography types in seabed images along trawl lines for historical CSIRO (1982–1997) survey sites within the Montebello MP

PMCP 2013 survey sites

Substrate type recorded by video at the 2013 survey sites was either fine or coarse sand at four sites and rippled at sites PMCP 100 and PMCP102 located in the south-western section of the MP (Figure 40, see Figure 32 for site locations).

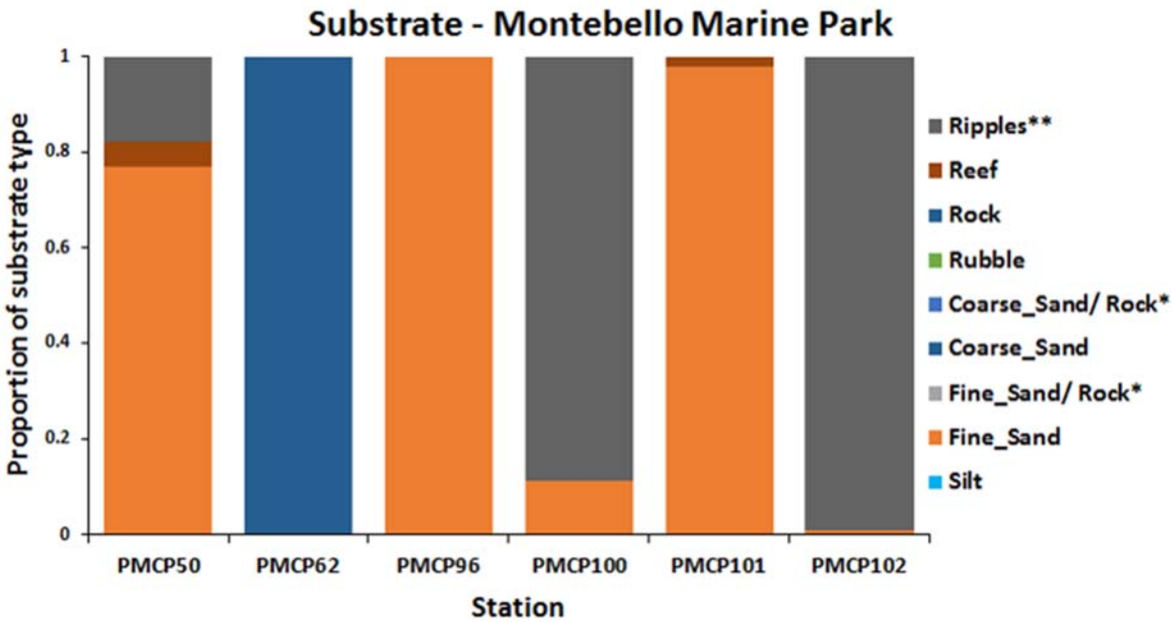
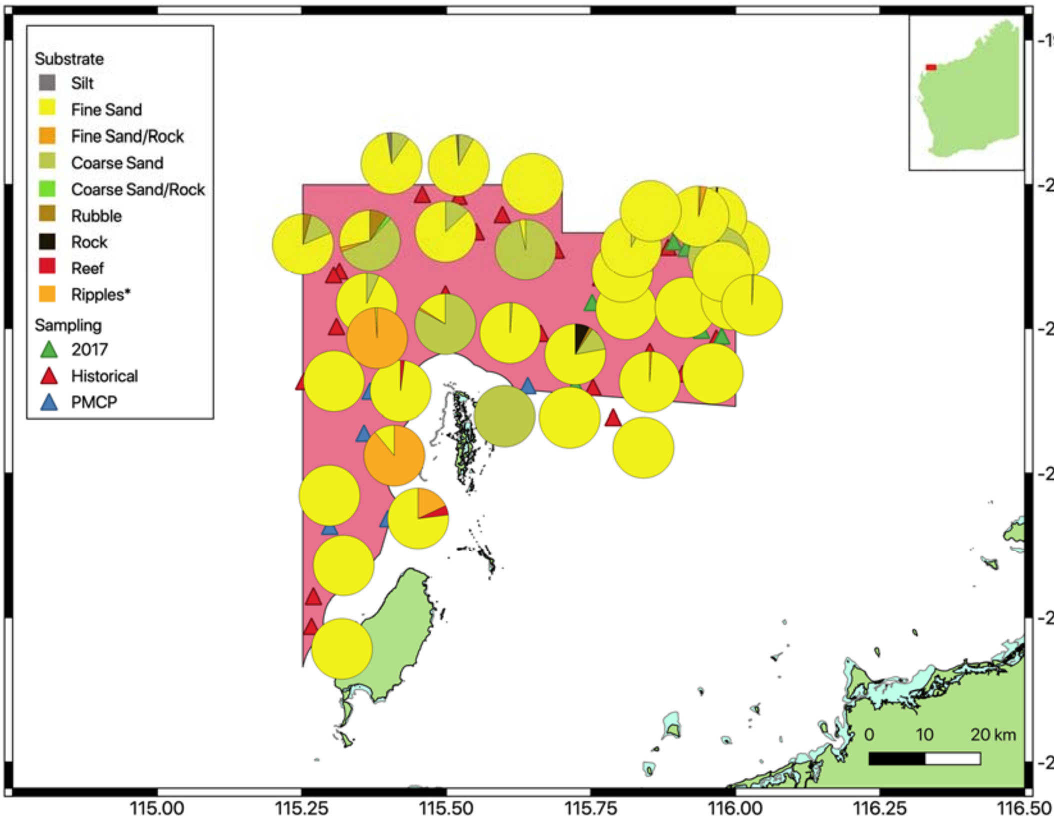


Figure 40. Proportion of substrate types from tow video imagery (2013 PMCP study) survey sites within the Montebello MP. *Coarse Sand / Rock and Fine Sand / Rock category not used. **Ripples denotes that scoring of substrate and topography was combined in the 2013 site analyses.



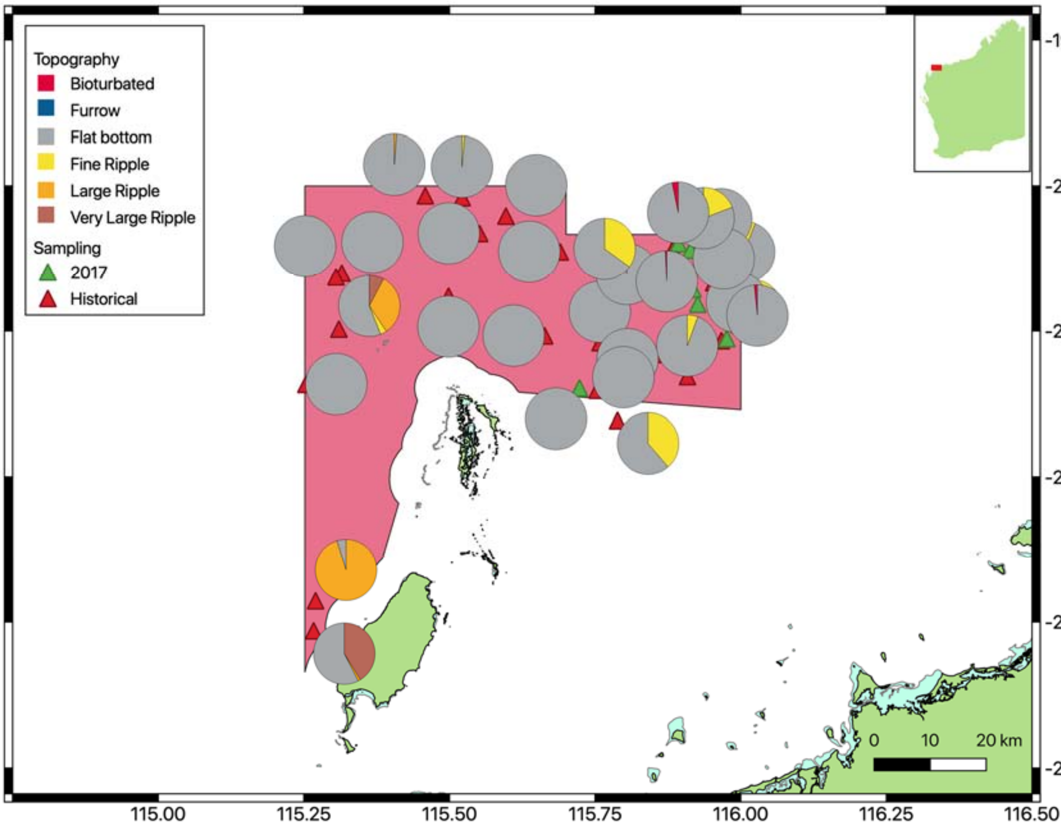


Figure 41. Proportion of substrate type and topography plotted at each site in the Montebello MP. 2017, 2013 and historical (1983–1997) data plotted together.

3.3 Benthic Biota

3.3.1 Dampier MP

INV2017_05 survey sites

Benthic filter feeders were present at all three sites surveyed in the Dampier MP and were quite abundant at sites W4 and W6 (Figure 42, Figure 45, Figure 50, Figure 51, Figure 52, and Figure 53). In particular sponges and whips such as *Junceella fragilis* (Figure 44) formed more than 70% of biota at W4. About 5% of images had no biota. Each site was dominated by different filter feeder types. Site W4 had a high biomass of very large erect and massive form sponges (Figure 46, Figure 47), site W6 had large numbers of fans while site W8 had high numbers and biomass of *Dendronephthya* soft corals (Figure 53).

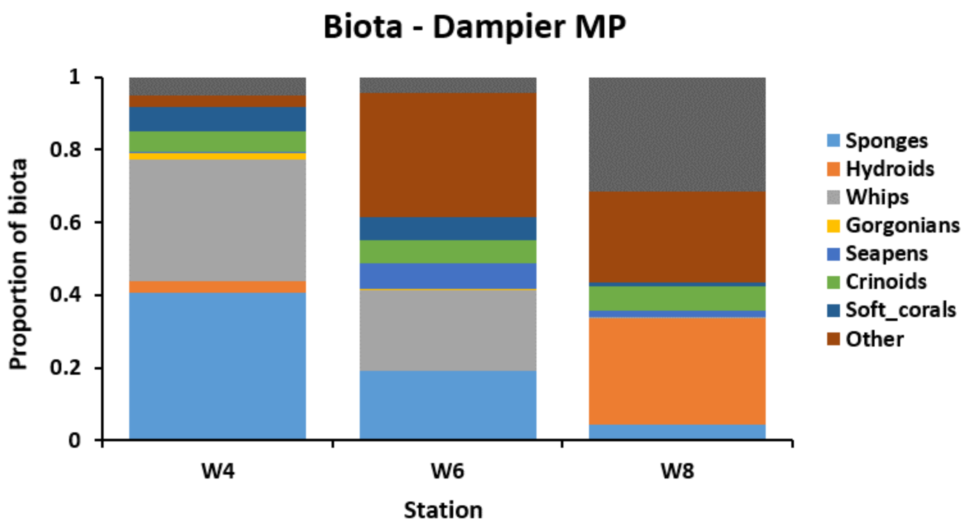


Figure 42. Proportion of biota types in seabed images along trawl lines for INV2017_05 survey sites within the Dampier MP. Dark grey is where no biota were present in the images. "Other" includes filter feeders which could not be accurately allocated to a specific group because of image quality.

Figure 43. Sponge community at site W4 in the Dampier MP.

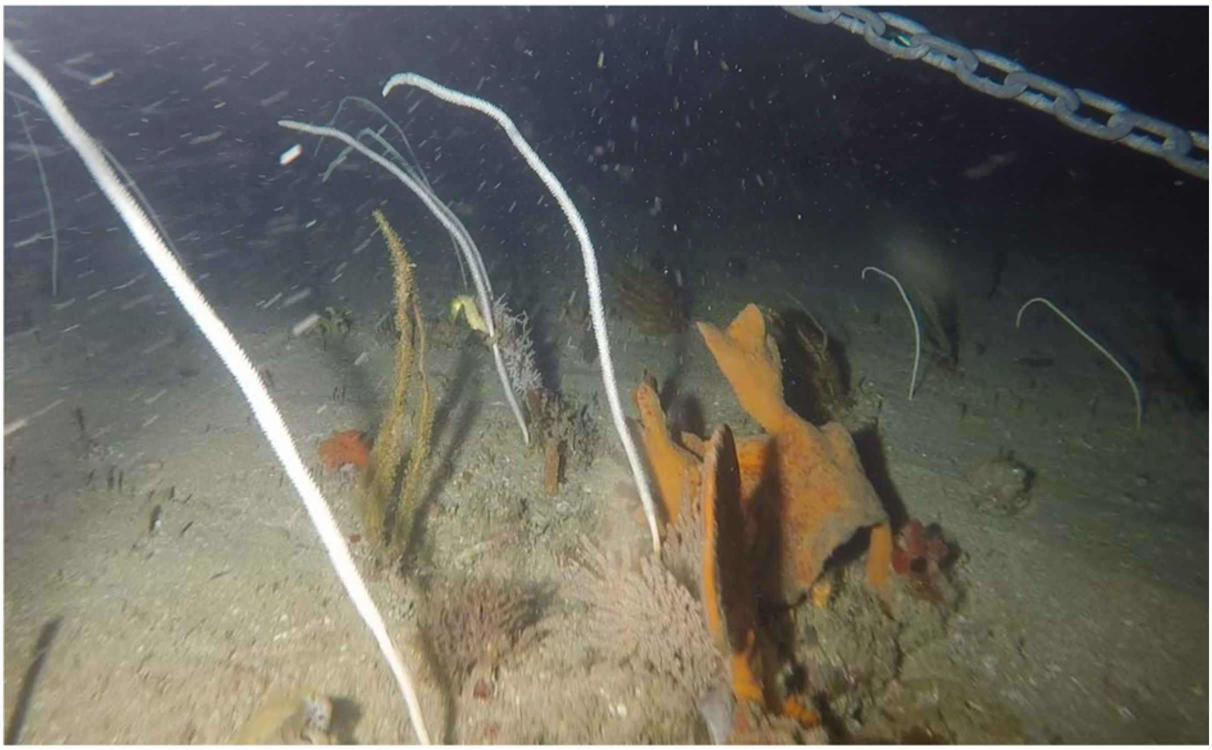


Figure 44. Sea whips *Junceella fragilis* provide an anchorage point for a sea horse at site W4 in the Dampier MP

Figure 45. Large pink *Dendronephthea* sp. soft coral at site W4 in the Dampier MP

Figure 46. Large *Ianthella flabelliformis*, an example of erect sponge from the Dampier MP

Figure 47. Massive form sponge common at site W4 in the Dampier MP

CSIRO 1982–1997 survey sites

The types of biota present in the historical surveys at the Dampier MP are shown in Figure 48. These are similar to the more recent surveys at sites W4, W6 and W8 although in general the proportion of sponge fauna was great (>35% at all sites, Figure 48). Site 880514 located in the Habitat Protection Zone was very similar to site W8 having an abundance of crinoids and more than 30% of images with no biota present (Figure 42, Figure 48, Figure 49).

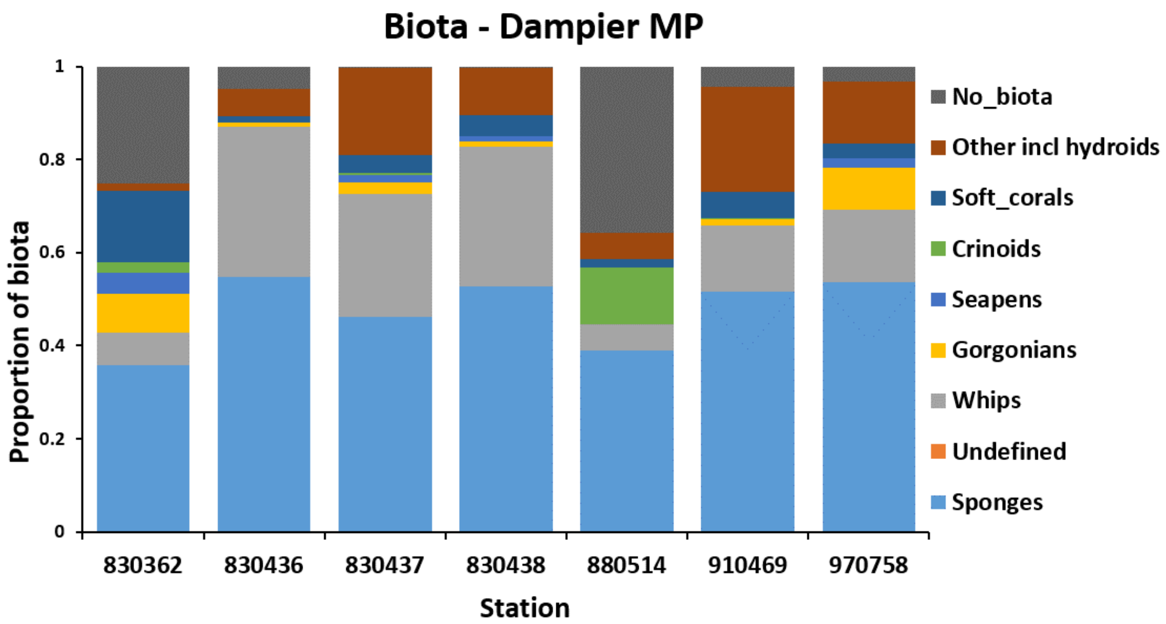


Figure 48. Proportion of substrate and topography types in seabed images along trawl lines for historical CSIRO (1982–1997) survey sites within the Dampier MP

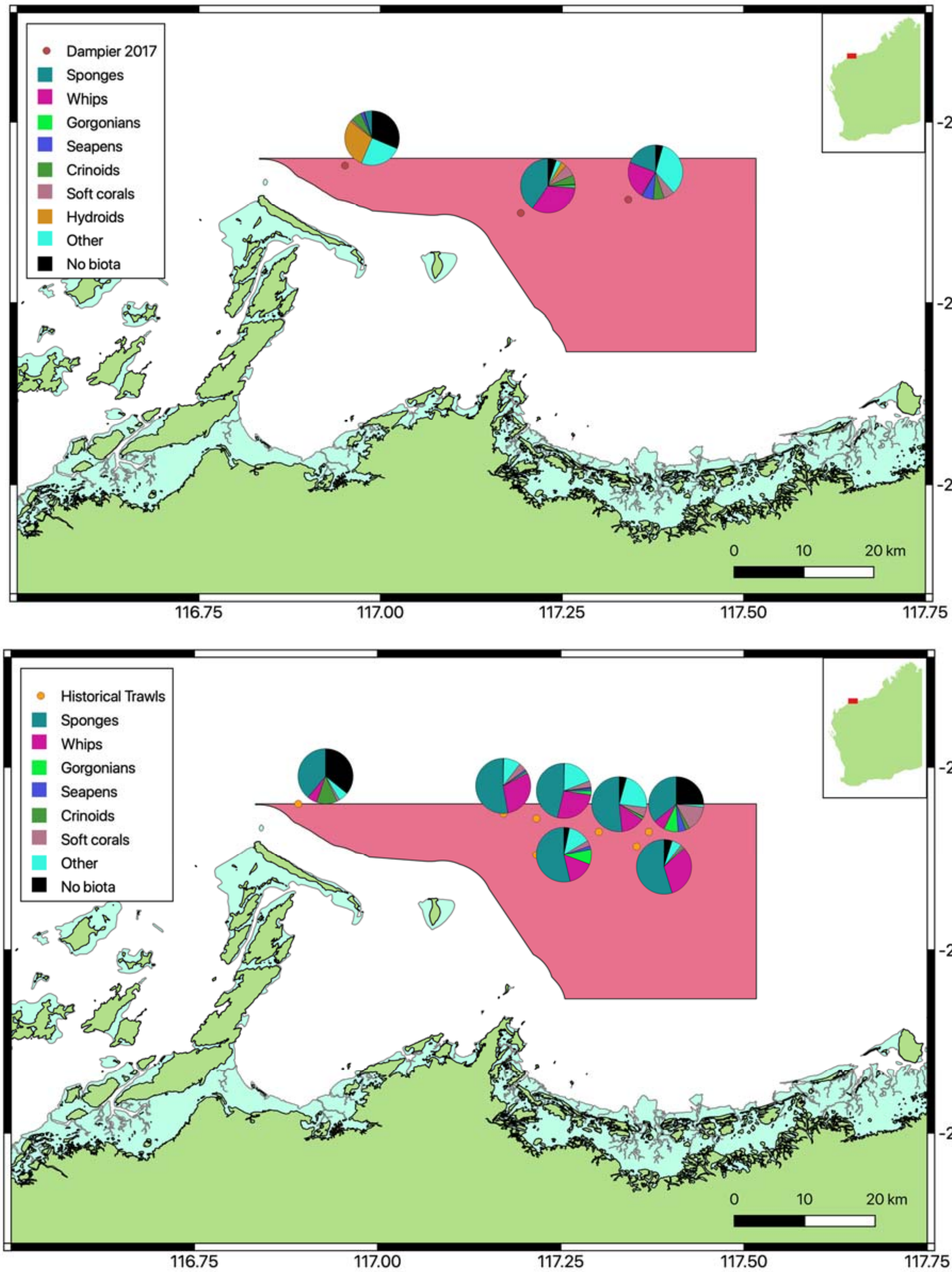


Figure 49. Proportion of biota type plotted at each site in the Dampier MP. Upper panel is 2017, lower panel are historical sites (1982–1997).

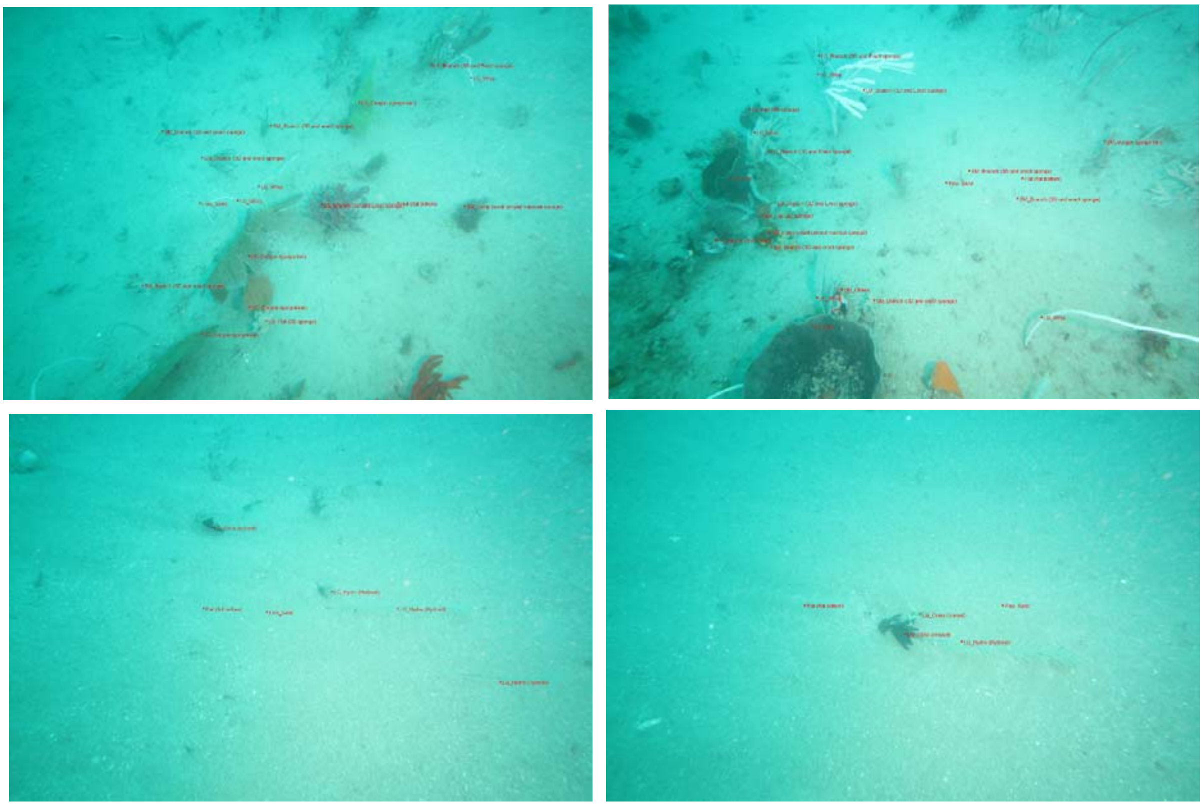


Figure 50. Station W4 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2858, subset 2 – IMG_3043, subset 3 – IMG_3318, subset 4 – IMG_3373. Labels identify biota visible in each image

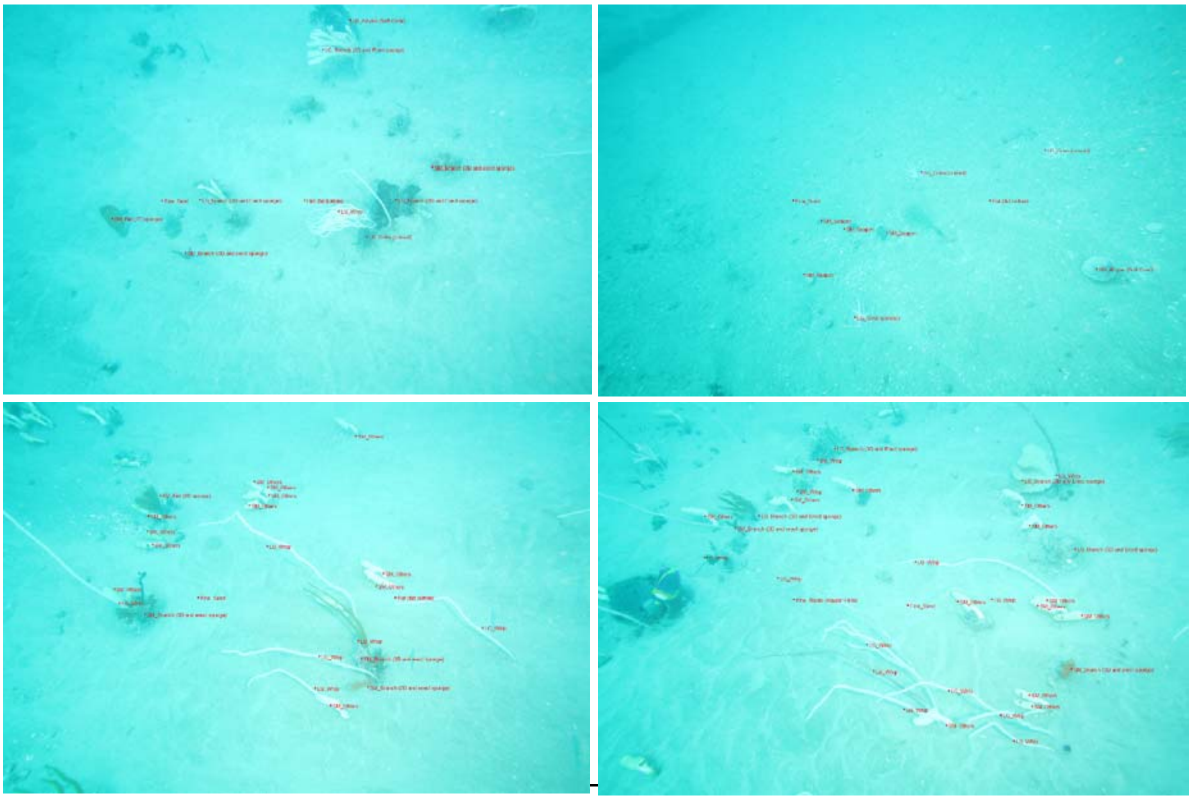


Figure 51. Station W6 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2939, subset 2 – IMG_3112, subset 3 – IMG_3296, subset 4 – IMG_3326. Labels identify biota visible in each image

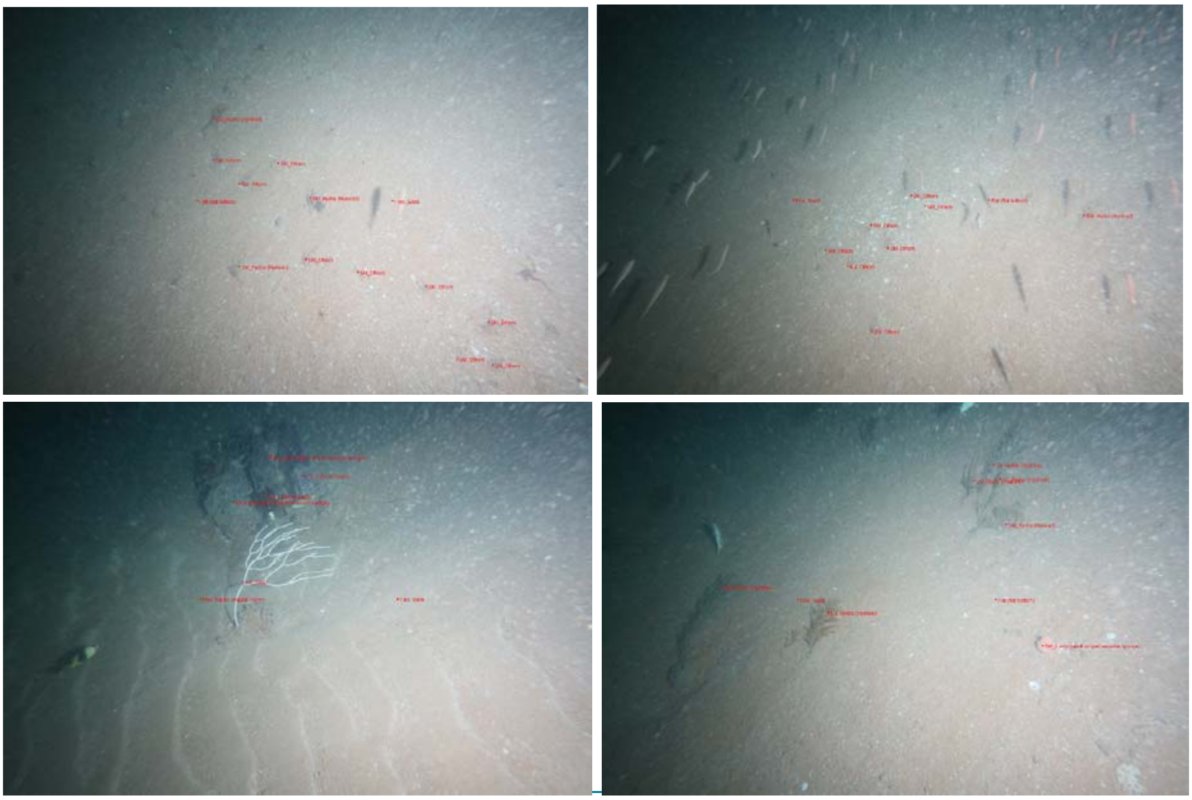


Figure 52. Station W8 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2866, subset 2 – IMG_3091, subset 3 – IMG_3197, subset 4 – IMG_3373. Labels identify biota visible in each image

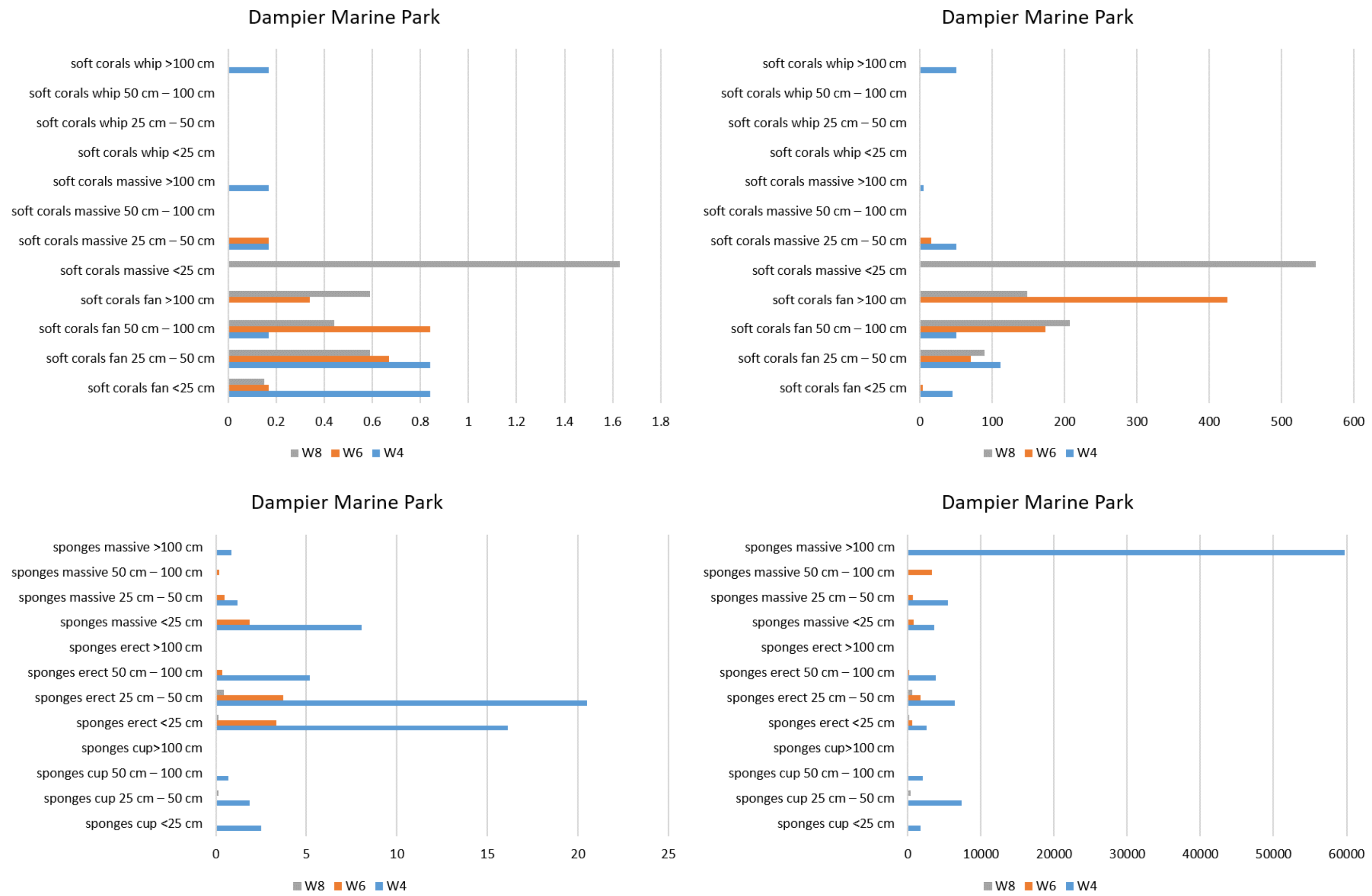


Figure 53. Density (individuals.ha^{-1}) (left panels) and biomass (g.ha^{-1}) (right panels) of size and morphology categories of soft corals and sponges in trawls for sites in the Dampier MP

3.3.2 Montebello MP

INV2017_05 survey sites

With the exception of the most inshore site W14, sites surveyed in 2017 in the eastern section of the Montebello MP had low numbers of sponges, whips and gorgonians (Figure 54, Figure 55) and as a result complex benthic filter feeder communities were largely absent (e.g. see Figure 66, Figure 67, Figure 68, Figure 69, Figure 70, Figure 71). Instead the dominant filter feeders were hydroids, seapens and crinoids. The most commonly revorded cronoid was *Comatula rotalaria* (Figure 56) which is free living on sand rather than associated with other filter feeders like gorgonians. Site W49 was notable for the large numbers of seapens present (Figure 57). Only site W81 had more than 50% of images with no biota however most sites had large areas characterised by soft sediment dwelling crinoids or hydroids and seapens rather than the complex sponge and soft coral communities observed in the Dampier MP.

Site W14 had the highest biomass of filter feeders with the Nephtheid soft corals (Figure 58, Figure 59, Figure 64) being very abundant (85 kg ha^{-1} captured in trawl net, Figure 72). It needs to be noted that this is very much an underestimate of total biomass as the trawl net is very inefficient at capturing filter feeder benthos (Wassenberg et al. 2002; personal observation based on data from 2017 voyage videos), but provides good comparative data on their abundance between sites.

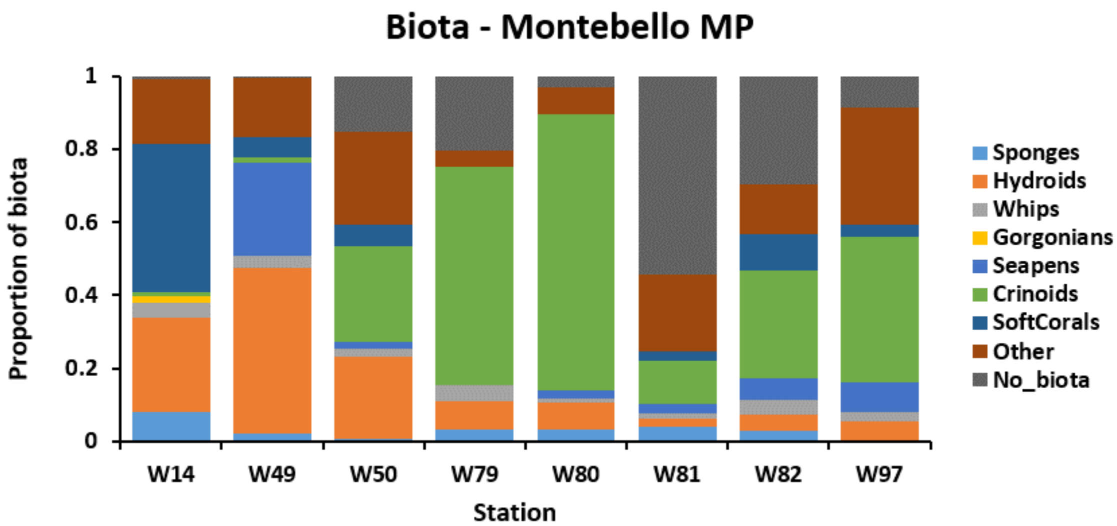


Figure 54. Proportion of biota types in seabed images along trawl lines for INV2017_05 survey sites within the Montebello MP. Dark grey is where no biota were present in the images, "Other" includes filter feeders which could not be accurately allocated to a specific group because of image quality.

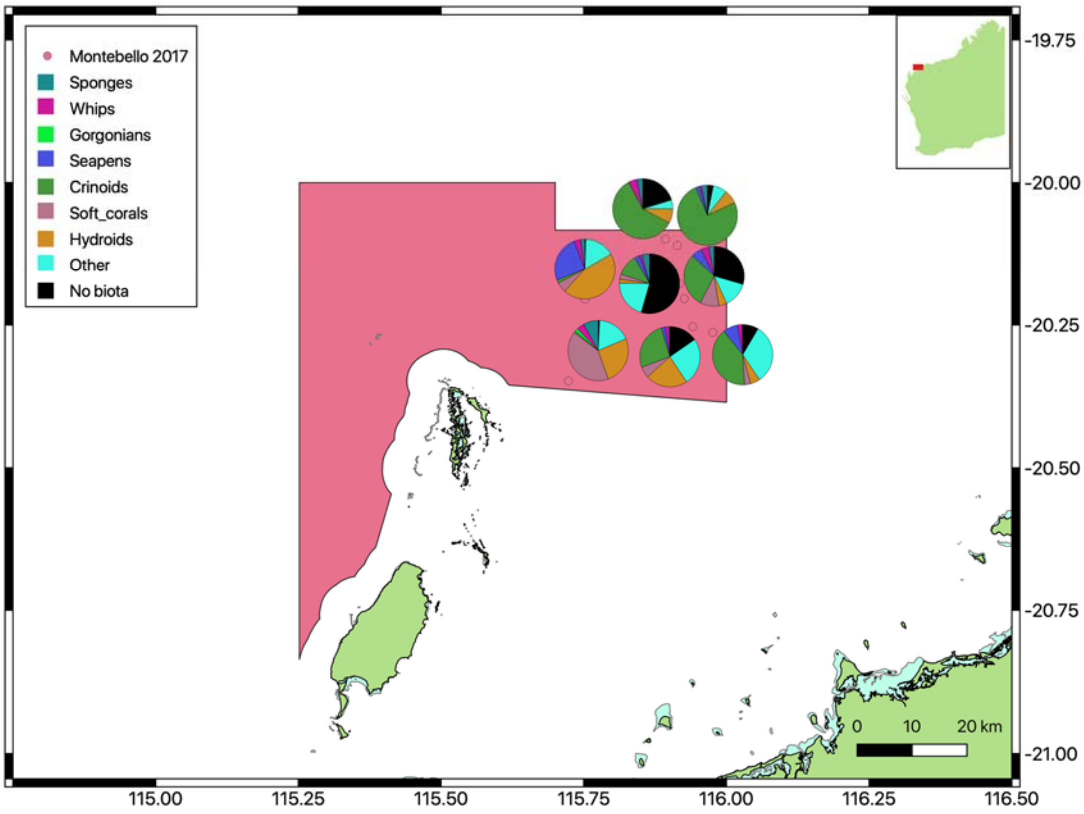


Figure 55. Proportion of biota type plotted at each site in the Montebello MP (2017 samples only).

Figure 56. Free-living crinoid *Comatula rotalaria* very common at sites W79 and W80 in the Montebello MP. The crinoid is about 20 cm in diameter.

Figure 57. Two of the common seapen species at site W49 in the Montebello MP. Left panel is the very common *Scytalium* sp. and the right panel *Pteroeides* sp.

Figure 58. *Dendronephthea* spp. soft corals at site W14 in the Montebello MP.

Figure 59. Nephtheid soft corals typical of those at site W14 in the Montebello MP. Left panel shows *Chromonephthea aldersladei* and right panel shows *Umbellifera* sp. 1.

CSIRO 1982–1997 survey sites

The biota recorded at the historical sites between 1987 and 1997 varied markedly from that during the 2017 surveys. In particular the large proportion of sponges and small proportion of crinoids seen on the historical voyages (Figure 60). However, two historical sites (950819 and 970731) located in the eastern part of the MP where the 2017 samples were taken also had a large proportion of images with no biota (Figure 60, Figure 61).

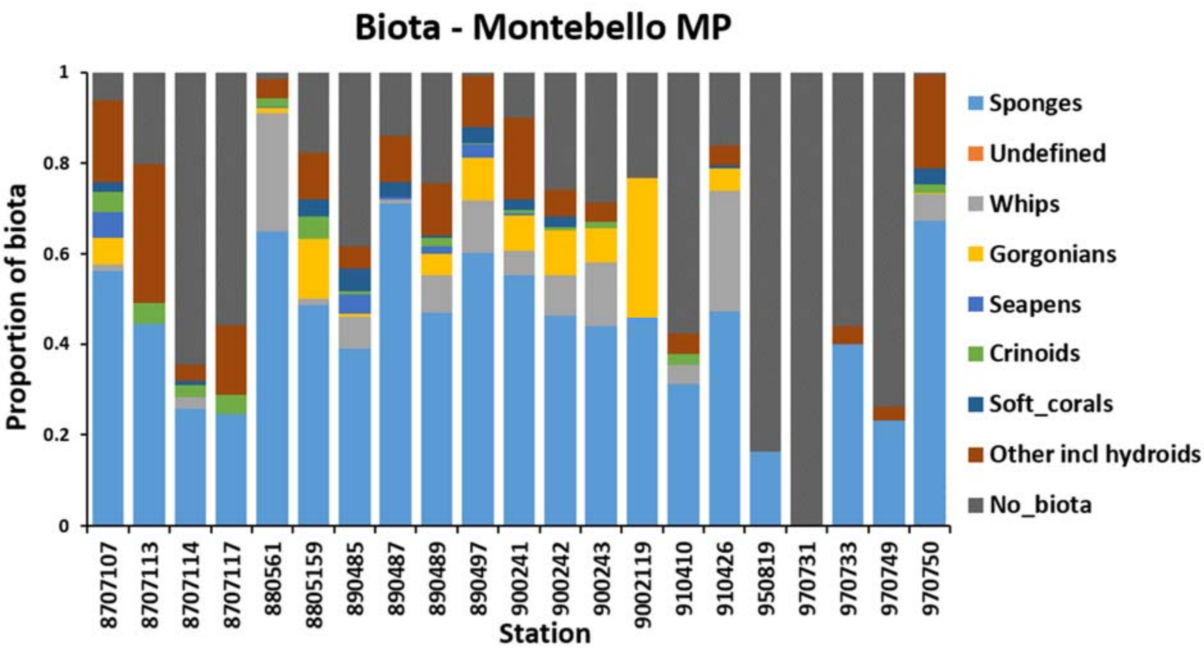


Figure 60. Proportion of substrate and topography types in seabed images along trawl lines for historical CSIRO (1982–1997) survey sites within the Montebello MP

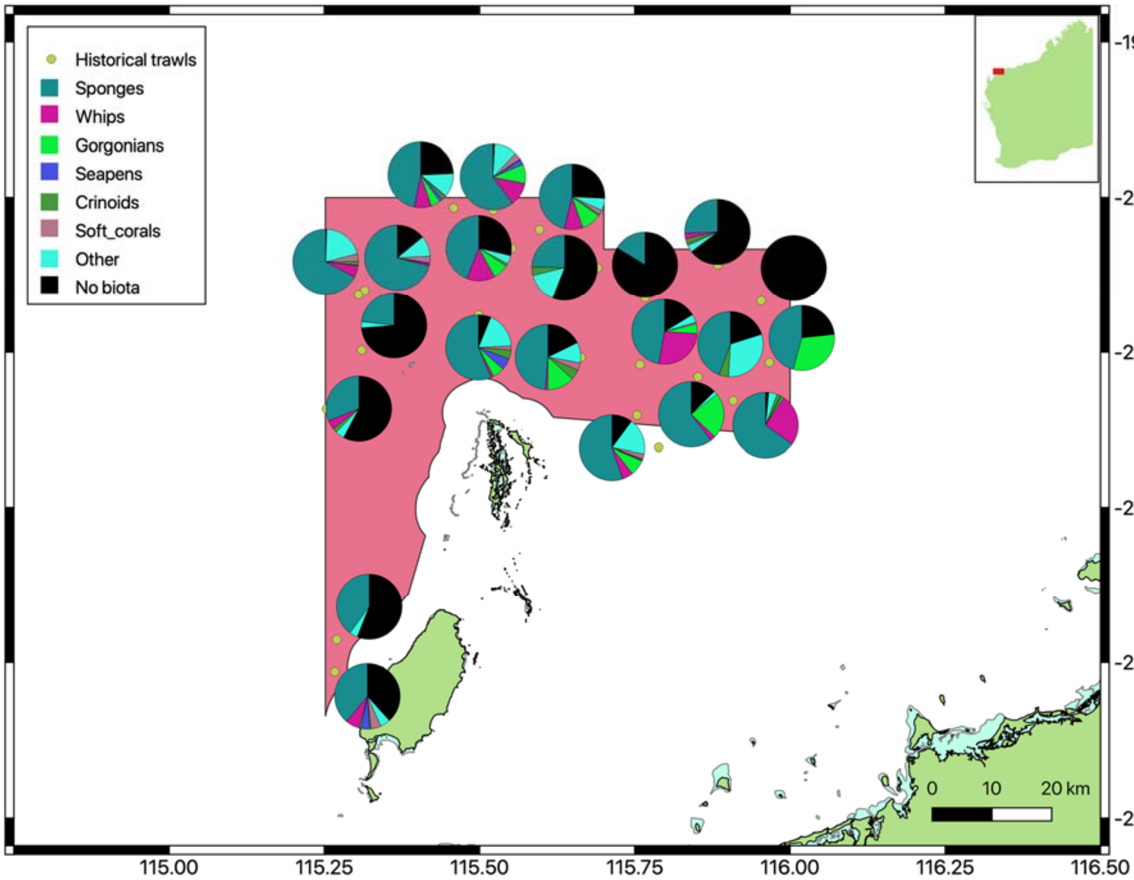


Figure 61. Proportion of biota type plotted at each site in the Montebello MP (1987–1997 sites only).

PMCP 2013 survey sites

The tow video sites surveyed in the south-western part of the MP had large proportions of the video transects where no biota was evident. Dense sponges occurred at shallower sites on the central southern (PMCP60) and south-western section of the MP, west of the islands (PMCP 50) and site PMCP 101 also in the south-western section had a large proportion of gorgonian habitat (Figure 62, Figure 63).

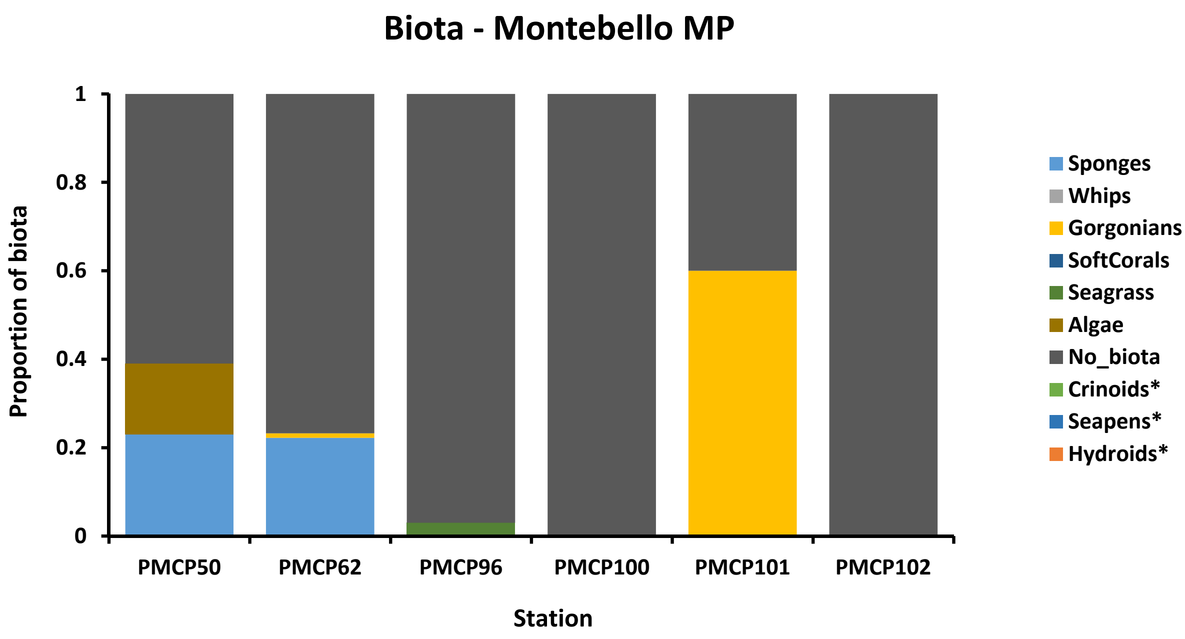


Figure 62. Proportion of habitat forming biota from tow video imagery (2013 PMCP study) survey sites within the Montebello MP. *Crinoid, hydroids and seapens were not scored in the 2013 study as they are not habitat forming.

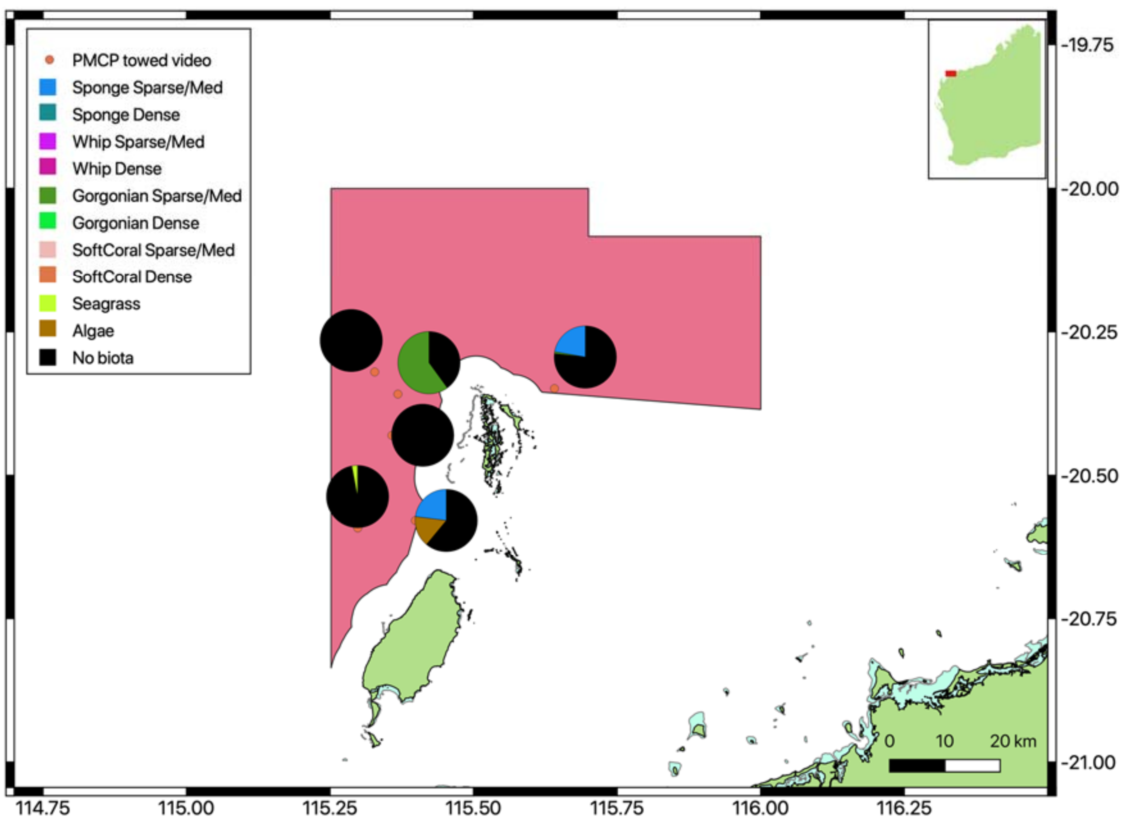


Figure 63. Proportion of biota type from tow video data plotted at each site in the Montebello MP (2013 PMCP sites only).

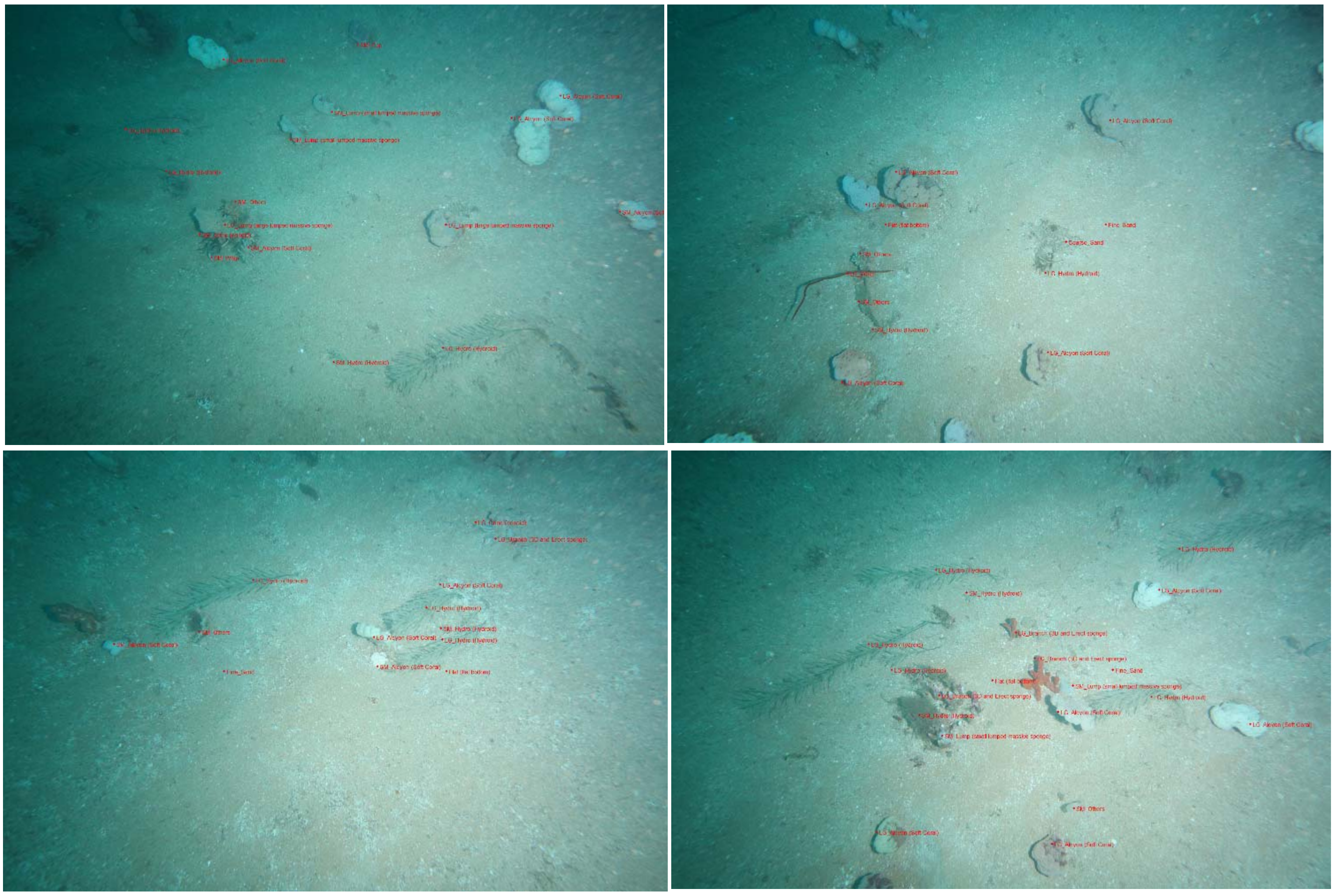


Figure 64. Station W14 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_3546, subset 2 – IMG_3771, subset 3 – IMG_3966, subset 4 – IMG_4041. Labels identify biota visible in each image

Figure 65. Station W49 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2830, subset 2 – IMG_3115, subset 3 – IMG_3241, subset 4 – IMG_3401. Labels identify biota visible in each image

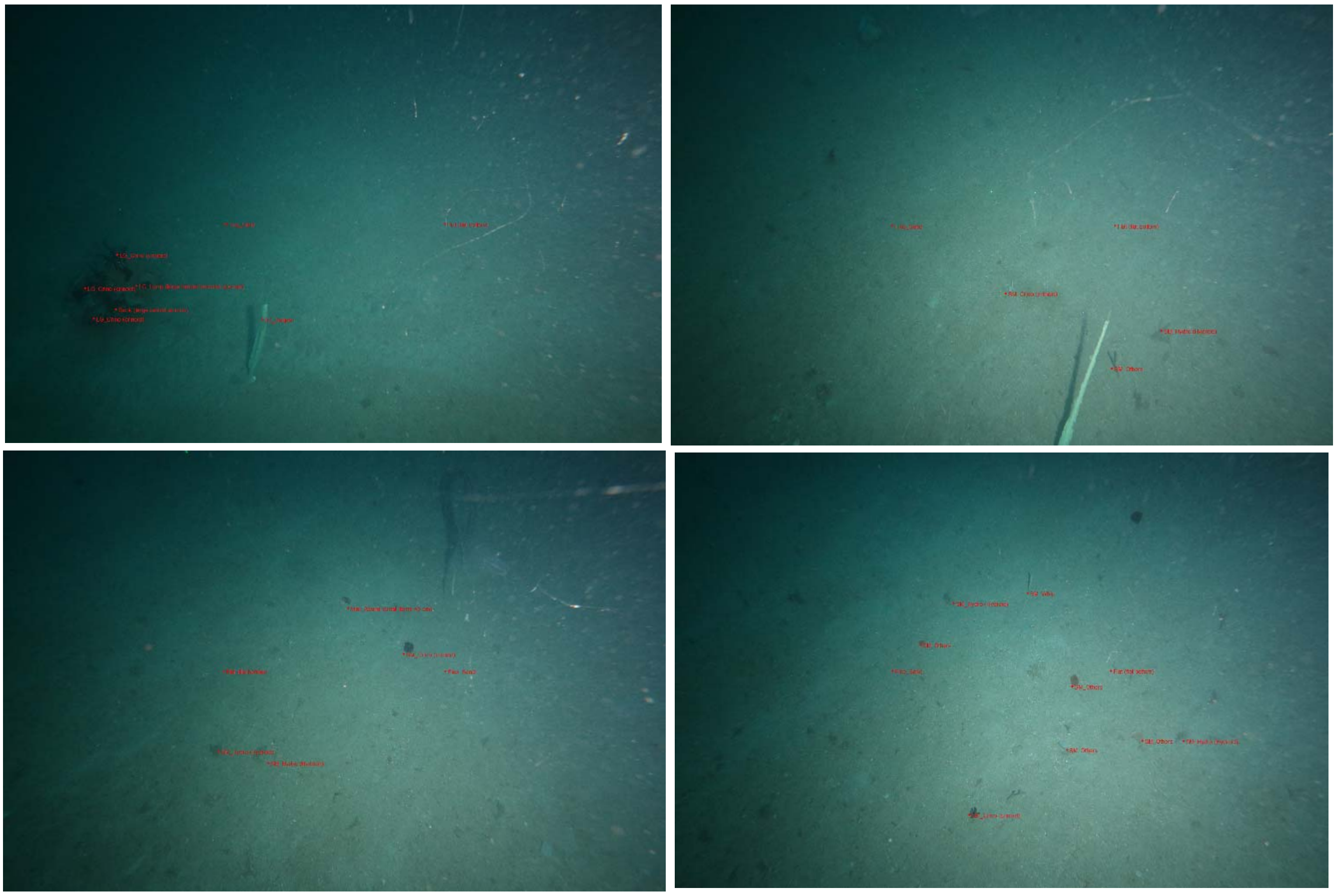


Figure 66. Station W50 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_3876, subset 2 – IMG_3936, subset 3 – IMG_4131, subset 4 – IMG_4201. Labels identify biota visible in each image

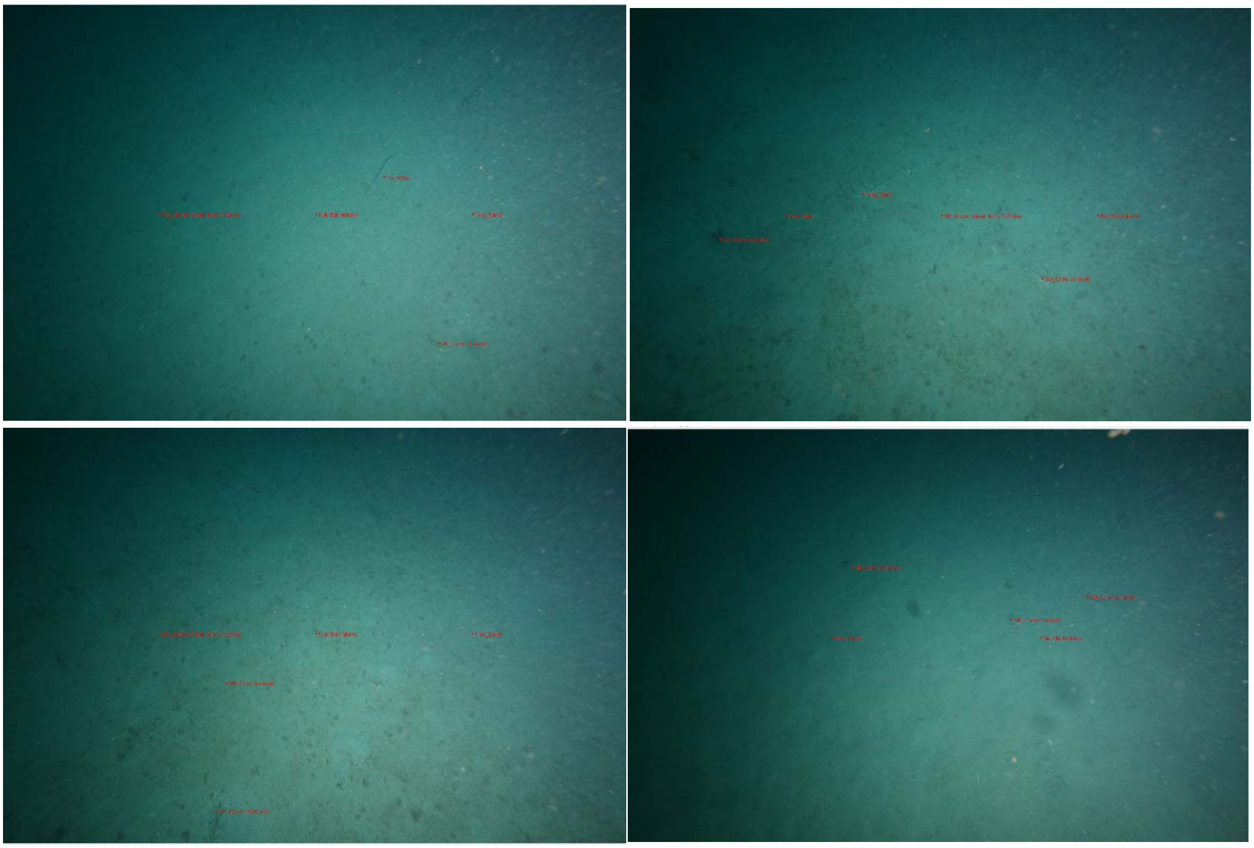


Figure 67. Station W79 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2887, subset 2 – IMG_3104, subset 3 – IMG_3204, subset 4 – IMG_3369. Labels identify biota visible in each image

Figure 68. Station W80 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_0179, subset 2 – IMG_0279, subset 3 – IMG_0434, subset 4 – IMG_0539. Labels identify biota visible in each image

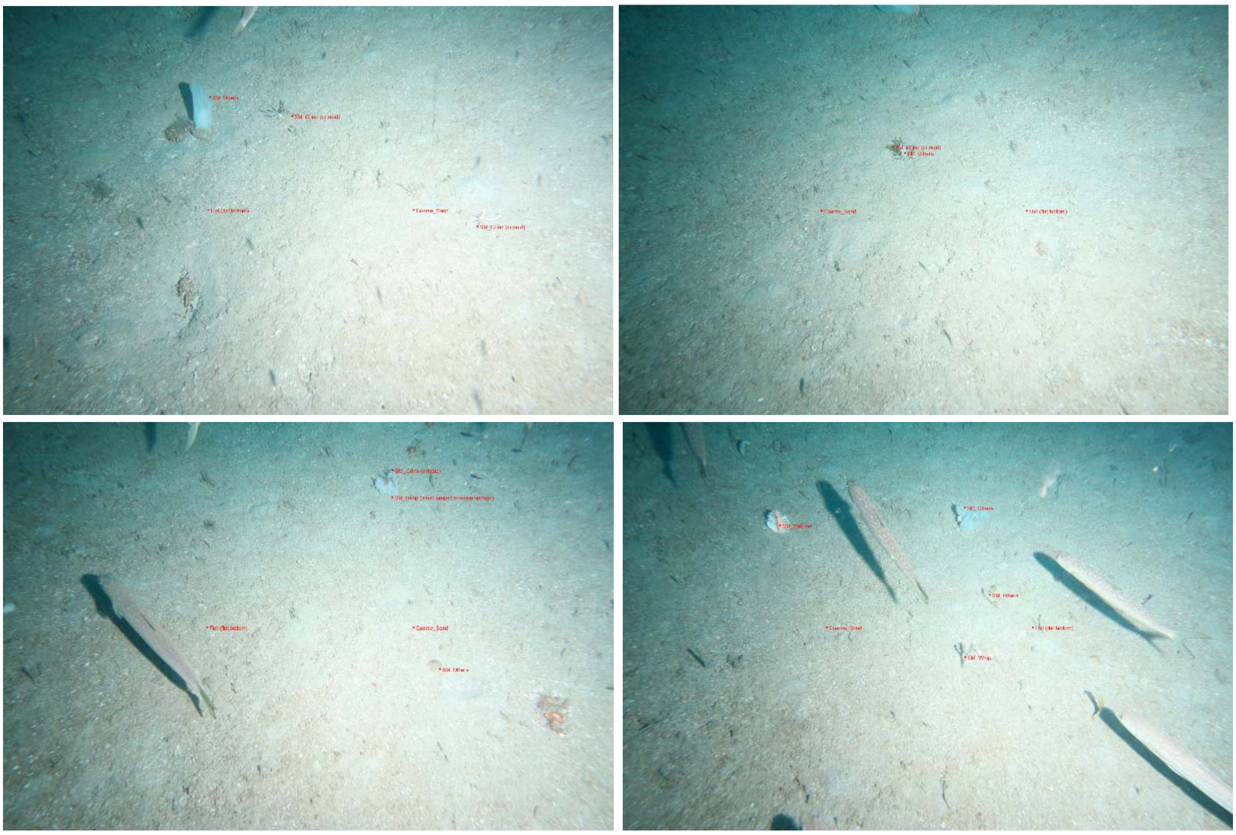


Figure 69. Station W81 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2895, subset 2 – IMG_2995, subset 3 – IMG_3170, subset 4 – IMG_3310. Labels identify biota visible in each image

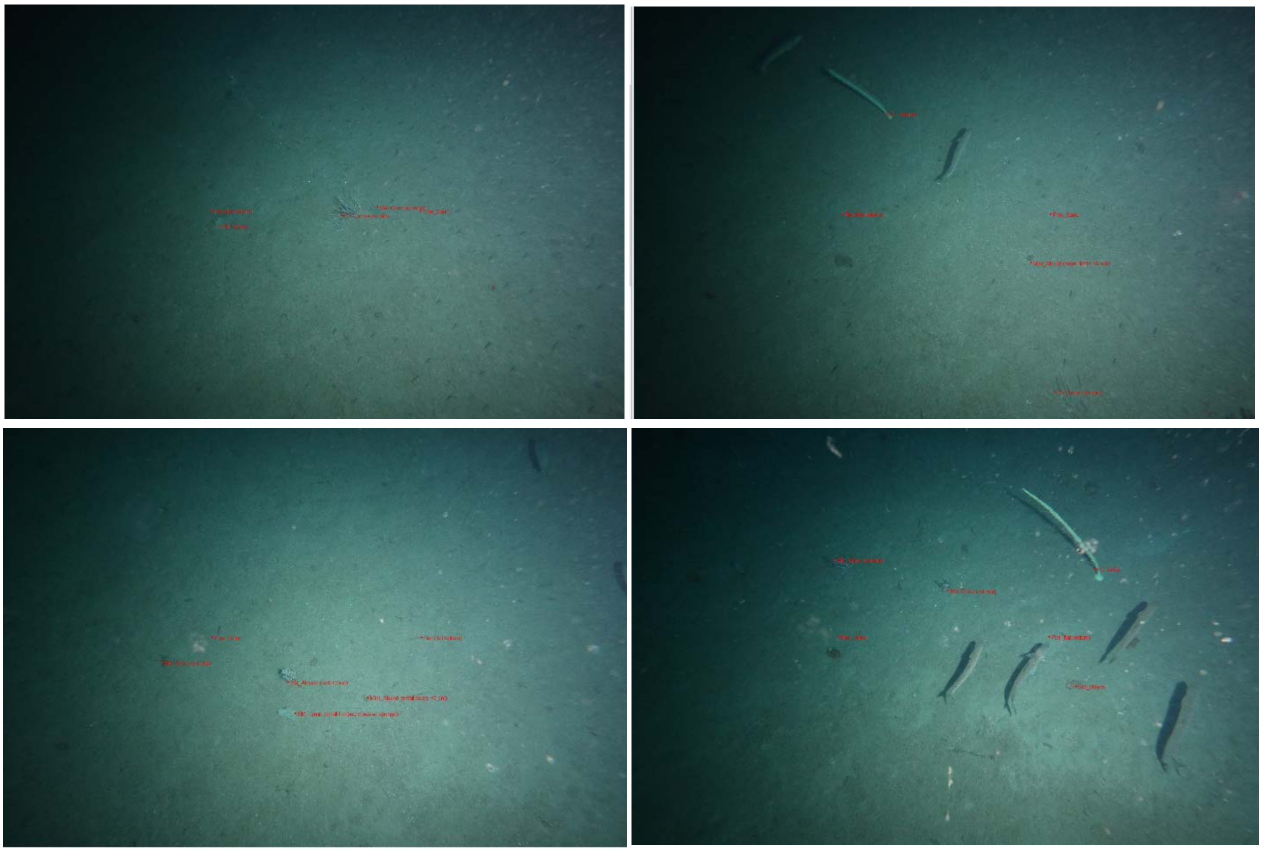


Figure 70. Station W82 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2924, subset 2 – IMG_2974, subset 3 – IMG_3114, subset 4 – IMG_3313. Labels identify biota visible in each image

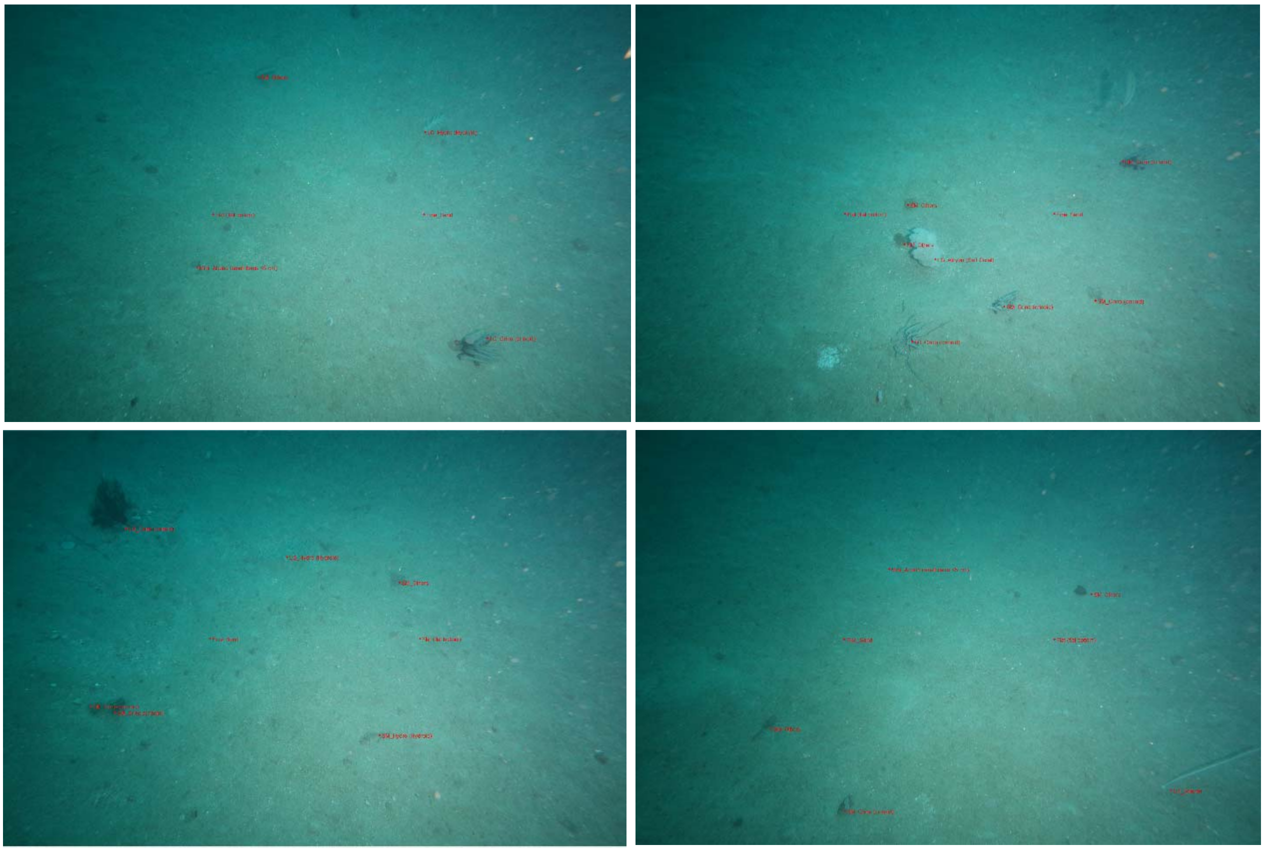


Figure 71. Station W97 sea bed images typical of each quartile subset of transect. From top left, subset 1 – IMG_2946, subset 2 – IMG_3081, subset 3 – IMG_3201, subset 4 – IMG_3387. Labels identify biota visible in each image

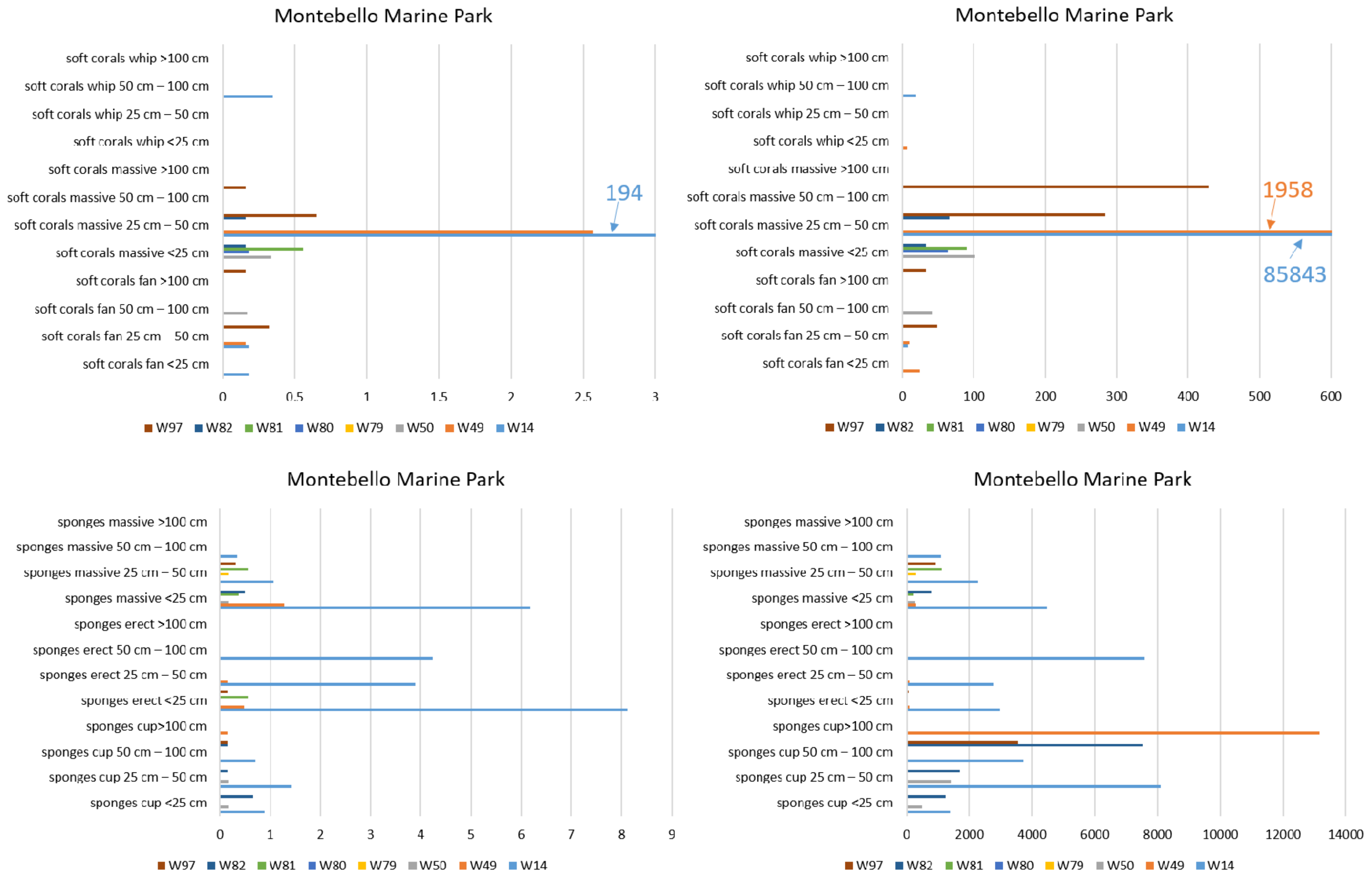


Figure 72. Density (individuals.ha^{-1}) (left panels) and biomass (g.ha^{-1}) (right panels) of size and morphology categories of soft corals and sponges in trawls for sites in the Montebello MP

4 Biodiversity assessment

4.1 Overview

This chapter details the sampling of flora and fauna for detailed biodiversity assessment for each of the major groups of fish and benthic sessile and mobile invertebrates. The analyses draw on sampling done on the 2017 RV *Investigator* voyage (3 sites in the Dampier MP and 8 sites in the Montebello MP, see Figure 2 and Figure 3) and the 2013 Pilbara Marine Conservation Partnership (PMCP) sampling (a further 6 sites in the Montebello MP, see Figure 32). The species lists and their distribution among sites is given in tables and described in the text. Any notable findings including new or rare records or new species are highlighted. In each section of this chapter, we have also tried to show the contribution these 2013 and 2017 collections have made to the knowledge of the biodiversity of the two MPs. This has been done by providing lists and comparisons of what species had previously been recorded by referencing the contents of the Atlas of Living Australia (ALA) and by comparing the collections with those in the WA Museum and the CSIRO Australian National Fish Collection. While it is possible there are samples in other museums which are not registered in the ALA we expect these will be few and it is evident that the 2013 and 2017 collections have led to a very significant increase in the knowledge of what species are present in the two MPs. Note in some of the taxonomic sections the term “lot” is used. A lot is a set of samples from the same catching operation at the same location. Depending on how well they have been sorted, they are usually the same or similar taxa, but not always. A lot might be a single animal or multiple animals of the same species or similar taxa. It is possible to have multiple lots of the same species from the same operation.

4.2 Fishes

John Pogonoski, Alastair Graham, Sharon Appleyard (CSIRO Australian National Fish Collection) and Margaret Miller (CSIRO Oceans and Atmosphere Research)

4.2.1 Taxonomic and Collection Scope

Fishes were collected using a CSIRO Semi V Wing trawl net (McKenna trawl net) or an epibenthic sled (Pitcher et al. 2016) at 11 stations within the confines of the Dampier and Montebello MPs during the RV *Investigator* Voyage (INV2017_05).

Fishes were sorted onboard into species or operational taxonomic units (OTUs), depending on level of difficulty, given time constraints to clear the catch. Voucher specimens were photographed, sampled for genetics and either preserved onboard in 10% formaldehyde or frozen for later fixation. Counts and weights of each taxon were recorded and databased. In almost all cases, large sharks and rays were photographed, measured, fin-clipped for genetic analyses and released alive. A reference collection of the vast majority of species (excluding most large elasmobranchs) has been registered and deposited into the CSIRO Australian National Fish Collection (ANFC), Hobart.

To maintain consistency with taxonomic identifications, most fishes were identified onboard by John Pogonoski, with assistance from Alastair Graham (both CSIRO ANFC). Keith Sainsbury identified all specimens of *Saurida* spp. (Synodontidae), Carangidae and Mullidae to maintain stability of identifications with those groups. For uniformity of data recording, all onboard fish data were entered by Margaret Miller (CSIRO). During and post-voyage, expert taxonomists were contacted to assist with the identification of various fish groups via the transfer of images, data and occasionally by the loan of preserved specimens. Experts who assisted (in taxonomic order) included William White and Peter Last (elasmobranchs), Yusuke Hibino (Ophichthidae), Barry Russell (Synodontidae and Nemipteridae), Rudie Kuiter (Solenostomidae), Glenn Moore (Syngnathidae and miscellaneous groups), Hiroyuki Motomura (Scorpaenidae and miscellaneous groups), Mizuki Matsunuma (Pteroidae, Synanceiidae), Martin Gomon (Triglidae and Uranoscopidae), Jeff Johnson (Aploactinidae, Haemulidae, Pinguipedidae and Acanthuridae), Hisashi Imamura (Platycephalidae), Anthony Gill (Serranidae and Pseudochromidae), Tom Fraser (Apogonidae), Chris Dowling (Sillaginidae), Bill Smith-Vaniz (Carangidae), Seishi Kimura (Leiognathidae), Yukio Iwaksuki (Sparidae), Satoshi Morishita (Sphyraenidae), Ofer Gon (Champsodontidae), Ron Fricke (Callionymidae), Doug Hoese and Helen Larson (Gobiidae), Keichii Matsuura (Tetraodontidae) and Gerry Allen (miscellaneous groups).

Approximately 364 fish taxa (342 named to species) from 89 families were identified from the breadth of the NWS voyage from 103 sites sampled in late 2017 (Appendix C). From 11 sites in the Dampier and Montebello MPs a total of approximately 185 species were collected (Table 4). For the voyage as whole, the following families had the highest number of identified taxa: Carangidae (17), Serranidae, Apogonidae and Labridae (16 species), Lutjanidae and Monacanthidae (12), Dasyatidae, Synodontidae and Nemipteridae (11). Other diverse families included Platycephalidae, Lethrinidae, Mullidae, Gobiidae, Bothidae and Tetraodontidae (9), Chaetodontidae and Paralichthyidae (8), Muraenidae, Scorpaenidae and Ostraciidae (7 each), and Syngnathidae (6 each). All other families had five or less species and 40 families were represented by a single species.

Most species could be identified to species level, but a few taxa remain unresolved due to some groups being in need of or currently in the process of taxonomic revision, including leptocephalus eel larvae (unidentified species of multiple Anguilliformes families), *Ariosoma* spp. (family Congridae), *Pterois* spp (family Scorpaenidae), *Bregmaceros* sp. (family Bregmacerotidae), *Ophidion* sp. (family Ophidiidae), *Onuxodon* sp. (family Carapidae), *Tosana* sp. (family Serranidae), *Gymnapogon* spp. and *Ostorhinchus* spp. (family Apogonidae), juveniles of *Carangoides* spp. (family Carangidae), family Gobiidae, especially *Bathygobius* spp., *Larsonella* spp. and *Sueviota* spp., some flatfishes (order Pleuronectiformes) and *Paramonacanthus* spp. (family Monacanthidae). Some other taxa of uncertain status have a 'cf' included in their name to highlight that their identity is uncertain and although the species name listed is possibly the closest species, they may not be that species. Most of these unresolved taxa made up a very small component of the catches.

4.2.2 COI barcoding

To aid the morphological identification of fish specimens, muscle samples (~ 0.5 g) were removed from all fish taxa for analysis of the Cytochrome Oxidase mitochondrial DNA barcode gene (COI). DNA was extracted and bi-directionally sequenced using the FishF1, FishF2 and FishR2 primers of Ward et al. (2005); sequencing was undertaken at the Ramaciotti Centre for Genomics, University of New South Wales - http://www.ramaciotti.unsw.edu.au/ and at the CSIRO Marine Laboratories on 3730xl and 3130xl DNA Analyzers, Thermo Fisher Scientific, USA, respectively, for at least one specimen from each taxon that had been sampled (300 taxa or 87% of all species recorded). Forward and reverse sequences were trimmed, de novo assembled, checked by eye and then converted into consensus sequences using Geneious (Biomatters Ltd, New Zealand) vers R8.1.4. Consensus sequences for each sample were compared using the Barcode of Life Data Systems v4 (BOLD) identification system (http://www.boldsystems.org/index.php/IDS_OpenIdEngine) and GenBank BLASTn (via an internal application in Geneious) to check the similarity of sample sequences against existing database sequences. Species identification was usually based on a percentage of sequence identity, with homology of ≥99% as the criterion used here for species confirmation. On some occasions the COI sequence was not obtainable or the result did not concur with morphological data. In these cases, the identification listed in Appendix C is the closest possible match to a known taxon. Sequences from this survey are available in Barcode of Life Data (BOLD) Systems, http://www.boldsystems.org/.

4.2.3 Discussion of species detection methods used

Accurate and thorough documentation of marine biodiversity for any given area is ideally required for effective marine management, especially in the designation, zoning and ongoing monitoring of Marine

Parks or areas closed to fishing. A suite of methods are available for species detection, but no single method has been reliably proven to be the ultimate answer. Although non-destructive techniques (e.g. towed video, BRUV, environmental DNA) are often favoured due to their low level of interference with the marine environment, destructive sampling is also required in areas that are poorly studied and to assist with ground-truthing of data collected by non-destructive techniques. For example, a combination of towed video or Baited Remote Underwater Videos (BRUVS) and trawl sampling would allow for greater accuracy of data extrapolation from the towed video or BRUVS alone. Voucher specimens and associated fresh colour images from the trawling allows more accurate identification of towed video or BRUV images as the trawl samples allow for consideration of spatial (distributional) and temporal (seasonal) confirmation. Environmental DNA relies on reference sequences from sampled and known specimens being available in public sequence databases.

Numerous species collected during this NWS survey could not have been reliably detected without destructive sampling. For example, the fish trawl takes advantage of the behavioural aspect of fish schooling allowing a herding effect that is not possible using a smaller beam trawl or sled, where large and/or fast-swimming fishes could easily escape. Only one of 27 sharks and rays was collected by the benthic sled, whereas all 27 species were collected by fish trawl.

BRUVS have their place for detection of large, mobile species that can outswim a trawl net (e.g. tunas, mackerels in the pelagic environment) or when species-specific/fishery-specific questions need to be answered relating to a low number of easily detectable and identifiable species.

However, BRUVS have minimal benefit for species that cannot be reliably identified from images or external appearance (many fishes can only reliably be identified from scale counts, gill raker counts or other internal features) or for cryptic and/or shy species that are not attracted to baits.

The benthic sled collected some rare (ochre-blotched perchlet, *Plectranthias* new species and cardinalfish, *Gymnapogon* new species), cryptic (e.g. the snake eels *Apterichthus* cf *nariculus* and *Scolecenchlys gymnota*) and nocturnal species (e.g. spinyeye cardinalfish, *Pristiapogon fraenatus*) not collected by the trawl.

4.2.4 Novelty

Although the vast majority of fishes collected from the present surveys have been encountered previously in WA, at least three new species were discovered and others are the first records of their species in Australia or Western Australia. Although these were sampled outside the two MPs, they were included here for completeness.

New species

Eight specimens of a new species of perchlet, *Plectranthias* n. sp. (Gill et al., in preparation) was collected in a sled at operation 358 (site W26) and two new species of cardinalfishes of the genus *Gymnapogon* are currently being described after specimens were collected in sled (Operation 310, site W93) and trawl samples (operations 278, 296, 297; sites W92, W51 and W19, respectively) (Fraser, in preparation). Additional undescribed taxa are possible within the following genera, but await further investigation: *Apogonichthyoides*, *Ariosoma*, *Chromileptes, Ostorhinchus, Solegnathus, Tosana* and *Velifer.* Undescribed species that were previously known from the survey area include one species each of *Scorpaena* (Motomura, in preparation) and *Bathygobius* (Hoese, in preparation). One specimen of a newly described species, *Iniistius opalus* Fukui 2018, was trawled (operation 581, site W3) and a single specimen of another known, but undescribed species of *Iniistius* (Fukui, in preparation) was taken in a sled (operation 411, site W49).

New Australian records

The Moluccan moray *Gymnothorax moluccensis*, previously known from Indonesia and a few other Indo-Pacific localities, has now been confirmed from Australian waters from two specimens, one each from trawl operations 109 (site W34) and 557 (site W15). The snake eel *Apterichtus nariculus* cf. (sled operation 435, site W58) is also a new record for Australia. The only other known specimens are from Indonesia (McCosker & Hibino, 2015). Numerous other species are likely to be new Australian records when more fully investigated.

New Western Australian records

Taylor's pygmy leatherjacket, *Brachaluteres taylori* was confirmed for the first time from Western Australia from a single specimen collected at trawl operation 539 (site W17).

4.2.5 Current vs historical surveys

The fish species composition for each MP was compared to historical data by importing MP boundaries into the Atlas of Living Australian Spatial tool https://spatial.ala.org.au/# and generating a species list. This allowed comparison of this short survey in 2017 to combined long-term datasets accumulated over the last few decades.

Dampier MP

Collecting effort and species composition

Historically (prior to this study), at least 212 fish taxa have been recorded from within the confines of the Dampier MP (ALA spatial tool). 128 of the 342 fish taxa named to species (37%) recorded during the NWS survey had previously been recorded from the Dampier MP and 106 taxa (31% of total recorded species) were recorded from the Dampier MP during the 2017 survey (Table 4). Twelve taxa (11%) recorded from the 2017 survey had not previously been recorded from the Dampier MP, including one species each of the following 12 genera: *Onuxodon*, *Inimicus*, *Paraploactis*, *Onigocia*, *Eurypegasus*, *Congrogadus*, *Jaydia*, *Sillago*, *Heniochus*, *Uranoscopus*, *Asterorhombus*, *Pseudorhombus*. Most of these taxa are small (less than 15 cm total length) or narrow bodied and may not have been previously recorded due to escaping through the meshes of collecting devices. Others may also have been misidentified historically (e.g. *Heniochus*, *Sillago*). Regardless of the reasons for their omission, it is clear that this survey has helped improve the resolution of fish species that occur in the Dampier MP and sometimes increased the understanding of habitat associations of individual species, e.g. pearlfishes (*Oxuxodon* sp.) discovered inside live oyster shells (family Ostreidae) and banded catsharks (*Atelomycterus fasciatus*) living inside large sponges (see 'interesting findings' below).

Of the sites in the Dampier MP, site W6 had the highest diversity (72 species or 68% of those recorded in the 2017 Dampier MP survey), followed by site W4 (65, 61%) and lastly site W8 (46, 43%). The higher diversity at sites W6 and W8 cannot be explained by depth differences as all three sites are equally shallow (31–34 m), but it may be partly explained by greater invertebrate habitat diversity. Although all three sites have fine sand substrate and flat bottom to fine ripple topography (Figure 35), site W8 had a higher proportion of hydroids and sea whips and a low proportion of sponges (Figure 42), which may be minimising the opportunities for both large open spaces and crevice habitat for marine fishes. For example, sharks, rays and moray eels were absent at this site but present at the two other sites.

Abundances

From the three stations investigated, station W8 had the highest fish abundance (1,980 individual fish caught) followed by W6 with 1,153 and W4 with 650. The most abundant species in the Dampier MP were *Diploprion bifasciatum* (18.5%) and *Upeneus guttatus* (13%).

Dampier MP – Interesting findings

On 20th October 2017 at site W6 (op 174, 32–33 m depth), a large *Ircinia* sponge (family Irciniidae) was trawled that had many holes and tunnels where animals could live. Upon closer investigation, some shark tails were seen protruding from the sponge holes. A total of 30 banded catsharks, *Atelomycterus fasciatus* were discovered living inside this single sponge (Figure 73, Figure 74), revealing an important habitat association not previously documented for this shark. Five individuals (1 juvenile male, 1 juvenile female, 2 late adolescent to mature males and 1 likely mature female) were retained for the CSIRO ANFC and the remaining 25 (9 juvenile males, 11 females and 5 late adolescent to mature males) were released alive. The fact that both adults and juveniles of both sexes were present suggests a possible small home range for this species. No egg cases were found in the sponge, so it is unknown if it is also used as an egg-laying substrate. This catshark is a north-western WA endemic, occurring from Exmouth northwards to Eighty Mile Beach in 25–125 m depth (Last & Stevens, 2009).

Figure 73. Image showing 30 banded catsharks (*Atelomycterus fasciatus*) removed from a large sponge, *Ircinia* sp. at Site W6.

Figure 74. One of the banded catsharks *Atelomycterus fasciatus* collected from Dampier MP (Site W6) retained for the CSIRO ANFC (mature male 38 cm total length).

Montebello MP

Collecting effort and species composition

Historically, at least 336 fish taxa have been recorded from within the confines of the Montebello MP (ALA spatial tool). 155 of the 342 fish taxa named to species (45%) recorded during the NWS survey had previously been recorded from the Montebello MP and 118 taxa (35% of total recorded species) were recorded from the eight Montebello MP stations (W14, W49, W50, W79, W80, W81, W82 and W97) during the 2017 survey (Table 4). Twenty-three taxa (7%) recorded from the 2017 survey had not previously been recorded from the Montebello MP, including one species each of the following 21 genera: *Megatrygon*, *Pateobatis*, *Scolecenchelys, Antennarius, Halieutaea, Bregmaceros, Ophidion, Solenostomus, Minous, Liocranium, Richardsonichthys, Lepidotrigla, Onigocia*, *Gymnapogon*, *Oxycheilinus*, *Suezichthys*, *Champsodon*, Gobiidae genera *Bathygobius*, *Larsonella*, *Lubricogobius* and *Sueviota,* and 2 species of *Ariosoma* spp.

Most of these taxa were small (less than 15 cm total length) or narrow bodied and may not have been previously recorded due to escaping through the meshes of collecting devices. Others may also have been misidentified or incompletely identified historically (e.g. Gobiidae genera listed above, *Ariosoma, Halieutaea, Bregmaceros* and *Ophidion*). Regardless of the reasons for their omission, it is clear that this survey has helped improve the resolution of fish species that occur in the Montebello MP and increased the knowledge of some charismatic elasmobranchs, including smalleye stingray *Megatrygon microps* and pink whipray *Pateobatis fai*, two large stingrays attaining greater than 2 m disc width that were observed inside and outside the Montebello MP during this survey.

Of the eight sites in the Montebello MP, site W14 had the highest diversity (50 species or 42% of those recorded in the 2017 Montebello MP), followed by site W81 (45 spp., 38%) and site W82 (39 spp., 33%). The sites with the lowest diversity were sites W79 (14 spp., 12%) and W80 (16 spp., 14%).

The higher diversity at site W14 could be explained by being the shallowest site, which would include more inshore reef fishes. A higher proportion of soft corals than other sites possibly also attracts small reef fishes. This site is notable by the absence of elasmobranchs but also by the relatively high diversity of Labridae (all 6 wrasse species recorded in Montebello MP from this survey occur at this site). The lowest fish diversity sites (W79 and W80) had the highest proportion of crinoids of all sites in the Montebello MP (Figure 54) reflecting the abundance of soft sediment benthic dwelling crinoids, not the sponge and soft coral associated species. These two sites are notable for their almost complete lack of small reef fishes that usually associate with coral or rocky outcrops (e.g. Serranidae, Apogonidae, Labridae, and Pomacentridae are absent at these sites).

A further eight species were sampled from sites in the western and southern parts of the Montebello MP in 2013 (Table 5). Note, however, that some of these species may have been recorded under different names in the 2017 survey as the 2013 and 2017 survey specimens are held at different collections (WAM and CSIRO ANFC, respectively), so cannot be closely compared.

Abundances

2,693 vouchers were collected with 96% (2,576 vouchers) of the fishes collected by trawl and 4% (63) by sled. From the eight stations investigated, W49 and W81 had the highest fish abundance with 752 and 663 vouchers respectively, followed by W97 and W14 (397 and 291 vouchers), W82 and W50 (269 and 111 vouchers) and W79 and W80 with 97 and 59 vouchers. The most abundant species in the Montebello MP were *Nemipterus furcosus* (37%) and *Saurida undosquamis* (29%).

Montebello MP - Interesting Findings

On 2nd November 2017 at site W81 (op 497, 63 m depth), a mature female smalleye stingray, *Megatrygon microps* (204 cm disc width, 230 cm total length) was captured in the trawl net (Figure 75, Figure 76). This was the second individual captured during the voyage – the other (female 218 cm disc width) being a week earlier in 68 m depth about 70 km to the north-east. This massive and distinctive semi-pelagic stingray that gives birth to a single pup is a new record for the Western Australian fish fauna. It is known from patchy records across the breadth of the Indian Ocean and western Pacific, but Australian records were previously limited to a few sightings further north and east in the Arafura Sea, Gulf of Carpentaria (Northern Territory) and north-eastern Queensland. The individuals collected on this voyage were photographed and fin-clipped for genetic analysis and released alive; the Montebello MP individual was observed actively swimming after release. Recent molecular research suggests that this species may belong in its own family, separate to the true stingrays of the family Dasyatidae (Last et al. 2016).

Figure 75. Smalleye stingray, *Megatrygon microps* captured in the Montebello MP. The hose is being used to maintain water flow over the gills before measurement, DNA sampling and release

Figure 76. Smalleye stingray, *Megatrygon microps* captured in the Montebello MP being measured. The hose is being used to maintain water flow over the gills before DNA sampling and release

4.2.6 Elasmobranchs

Twenty seven (27) species of elasmobranchs (sharks and rays) were recorded from the NWS survey, consisting of nine shark species and 18 batoid species (11 stingrays, two guitarfishes, three shovelnose rays, one eagle ray and one butterfly ray). All species were collected with the trawl net and a juvenile of one species (banded catshark, *Atelomycterus fasciatus*) was collected with the benthic sled. Eight elasmobranchs were recorded from the Montebello MP and five from the Dampier MP. Two species (banded catshark *Atelomycterus fasciatus* and whitespotted guitarfish, *Rhynchobatus australiae*) were recorded from both MP's. The small-eye stingray, *Megatrygon microps* (new record for Western Australia) and the pink whipray, *Pateobatis fai* had not previously been recorded from the Montebello MP (ALA spatial tool).

Some of the elasmobranch species collected were at maximum or near maximum known sizes of their species. These species included a number of stingrays (family Dasyatidae), e.g. reticulate whipray *Himantura australis* (Figure 77), 143 cm disc width (DW) and 480 cm total length (TL) (previously recorded to 113 cm DW and 350 cm TL by Last et al. 2016), leopard whipray, *Himantura leoparda* 183 cm DW and 360 cm TL (previously known to 140 cm DW and 410 cm TL, Last et al. 2016), blackspotted whipray, *Maculabatis astra,* 92 cm DW and 213 cm TL (previously documented to 80 cm DW and 180 cm TL by Last et al. 2016) and blotched fantail ray, *Taeniurops meyeni*, 190 cm DW, 260 cm TL (previously known to 180 cm DW and 330 cm TL, Last et al. 2016), the ornate eagle ray, *Aetomylaeus vespertilio* (family Myliobatidae), 301 cm DW and 365 cm TL (documented to at least 300 cm DW, possibly 350 cm DW and 600 cm TL by Last et al. 2016) and the whitespotted guitarfish, *Rhynchobatus australiae* (family Rhinidae, Figure 78), 287 cm TL (recorded to 300 cm TL by Last et al. 2016). The large sizes of elasmobranchs from some sites, including mature males and/or females suggests there are important feeding and/or mating areas for these species in the survey area. Very few juvenile elasmobranchs were collected which suggests that the species encountered may be giving birth in shallower, inshore waters.

Figure 77. Reticulate whipray *Himantura australis* (mature male, 143 cm disc width, 4.8 m TL). The white cloth was used as a safety measure to cover the tail spine while measurements, photos and a fin-clip for genetic analysis was taken and removed before being released alive.

Figure 78. Whitespotted guitarfish, *Rhynchobatus australiae*. Female 287 cm TL released alive after measurement, photo and genetic fin-clip.

4.2.7 Syngnathidae (seahorses, pipefishes, etc.)

Four species of Syngnathidae were collected during the survey – all were landed dead or discovered dead late in the sorting process due to their small size and/or camouflage within invertebrate debris.

A single specimen of the zebra seahorse, *Hippocampus zebra* (Figure 79) was collected during the survey (Dampier MP site W6, op 174, 32–33 m depth). This species has previously been recorded from the Dampier MP.

Four specimens of Queensland seahorse, *Hippocampus spinosissimus* (Figure 80) were collected in 54–62 m depth – two outside the MPs (sites W76, W99) and two inside the Montebello MP (site W49 – Op 573 and Op 578). This species has previously been recorded from the Montebello MP.

Five specimens of western spiny seahorse, *Hippocampus angustus* (Figure 81) were collected in 34–63 m depth – all outside the MPs (one each at sites W3, W18 and W95, and two at site W91). This species has a wide distribution in northern Australian from Shark Bay, WA (25°57`S) to east of Agnes Water (24° 11'S), Qld.

All *Hippocampus* specimens were loaned to Dr Glenn Moore (Western Australian Museum), who is undertaking taxonomic and molecular investigations into the genus with international collaborators.

Two specimens of western pipehorse, *Solegnathus* sp. 2 [of Kuiter, 2009] (Figure 82) were collected in 73–97 m depth, both outside the MPs (sites W12, W68). This species is possibly undescribed and has also been referred to as *Solegnathus hardwickii*. Its taxonomic status and distribution needs further research. The voucher specimens and associated genetic material collected from this survey will aid resolving its identity.

Figure 79. Zebra seahorse, *Hippocampus zebra* (female?, 32 mm height)

Figure 80. Queensland seahorse, *Hippocampus spinosissimus* (male, 80 mm height)

Figure 81. Western spiny seahorse, *Hippocampus angustus* (female?, 60 mm height)

Figure 82. Western pipehorse, *Solegnathus* sp. 2 [of Kuiter, 2009] (450 mm standard length)

Table 4. Fish species sampled from stations within the Dampier and Montebello MPs on 2017 voyage and historical records (Hist.) from sample locations within these MPs. 1 means the species was collected from that station or occurred in historical samples from that MP

CLASS / ORDER	FAMILY	SPECIES	AUTHORITY	Dampier MP					Montebello MP									
				W4	W6	W8	Pres. 2017	Pres. Hist.	W14	W49	W50	W79	W80	W81	W82	W97	Pres. 2017	Pres. Hist.
ELASMOBRANCHII																		
Orectolobiformes	Hemiscylliidae	*Chiloscyllium punctatum*	Müller & Henle, 1838	1			1	1										
Orectolobiformes	Stegostomatidae	*Stegostoma fasciatum*	(Hermann, 1783)										1				1	1
Carcharhiniformes	Scyliorhinidae	*Atelomycterus fasciatus*	Compagno & Stevens, 1993		1		1	1		1							1	1
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon acutus*	(Rüppell, 1837)					1							1		1	1
Carcharhiniformes	Hemigaleidae	*Hemigaleus australiensis*	White, Last & Compagno, 2005					1								1	1	1
Rhinopristiformes	Rhinidae	*Rhynchobatus australiae*	Whitley, 1939	1	1		1	1						1			1	1
Myliobatiformes	Dasyatidae	*Maculabatis astra*	(Last, Manjaji-Matsumoto & Pogonoski, 2008)	1	1		1	1										1
Myliobatiformes	Dasyatidae	*Megatrygon microps*	(Annandale, 1908)											1			1	
Myliobatiformes	Dasyatidae	*Neotrygon australiae*	Last, White & Séret, 2016	1	1		1	1										1
Myliobatiformes	Dasyatidae	*Pateobatis fai*	(Jordan & Seale, 1906)											1			1	
Myliobatiformes	Dasyatidae	*Urogymnus asperrimus*	(Bloch & Schneider, 1801)									1					1	1
ACTINOPTERYGII																		
Anguilliformes	Unknown	Unidentified Anguilliform larvae	N/A											1	1	1	1	
Anguilliformes	Muraenidae	*Gymnothorax cribroris* cf.	Whitley, 1932	1	1		1	1		1					1		1	1
Anguilliformes	Congridae	*Ariosoma meeki* cf.	(Jordan & Snyder 1900)										1				1	
Anguilliformes	Congridae	*Ariosoma* sp.	N/A								1				1		1	
Anguilliformes	Ophichthidae	*Scolecenchelys gymnota*	(Bleeker, 1857)													1	1	
Clupeiformes	Clupeidae	*Amblygaster sirm*	(Walbaum, 1792)		1		1	1										
Aulopiformes	Synodontidae	*Saurida* sp.	N/A											1	1		1	1
Aulopiformes	Synodontidae	*Saurida undosquamis*	(Richardson, 1848)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Aulopiformes	Synodontidae	*Synodus hoshinonis*	Tanaka, 1917												1		1	1
Aulopiformes	Synodontidae	*Synodus indicus*	(Day, 1873)					1					1	1		1	1	1

Aulopiformes	Synodontidae	*Synodus sageneus*	Waite, 1905	1	1	1	1	1										1
Aulopiformes	Synodontidae	*Trachinocephalus trachinus*	(Temminck & Schlegel, 1846)			1	1	1				1	1			1	1	1
Batrachoidiformes	Batrachoididae	*Halophryne ocellatus*	Hutchins, 1974						1	1							1	1
Lophiiformes	Antennariidae	*Antennarius striatus*	(Shaw, 1794)										1				1	
Lophiiformes	Ogcocephalidae	*Halieutaea indica*	Annandale & Jenkins, 1910						1								1	
Gadiformes	Bregmacerotidae	*Bregmaceros* sp.	N/A											1	1		1	
Ophidiiformes	Ophidiidae	*Ophidion* sp.	N/A													1	1	
Ophidiiformes	Carapidae	*Onuxodon* sp.	N/A	1			1											
Syngnathiformes	Fistulariidae	*Fistularia commersonii*	Rüppell, 1838	1			1	1	1								1	1
Syngnathiformes	Fistulariidae	*Fistularia petimba*	Lacépède, 1803			1	1	1				1	1		1		1	1
Syngnathiformes	Centriscidae	*Centriscus scutatus*	Linnaeus, 1758		1		1	1										1
Syngnathiformes	Solenostomidae	*Solenostomus cyanopterus*	Bleeker, 1854									1					1	
Syngnathiformes	Syngnathidae	*Hippocampus spinosissimus*	Weber, 1913							1							1	1
Syngnathiformes	Syngnathidae	*Hippocampus zebra*	Whitley, 1964		1		1	1										
Syngnathiformes	Pegasidae	*Eurypegasus draconis*	(Linnaeus, 1766)			1	1			1							1	1
Scorpaeniformes	Scorpaenidae	*Pterois* sp.	N/A		1		1	1										1
Scorpaeniformes	Scorpaenidae	*Scorpaenodes smithi*	Eschmeyer & Rama-Rao, 1972						1	1					1	1	1	1
Scorpaeniformes	Synanceiidae	*Inimicus sinensis*	(Valenciennes, 1833)	1			1											1
Scorpaeniformes	Synanceiidae	*Minous roseus*	Matsunuma & Motomura 2018								1			1			1	
Scorpaeniformes	Tetrarogidae	*Liocranium pleurostigma*	(Weber, 1913)	1	1		1	1	1								1	
Scorpaeniformes	Tetrarogidae	*Richardsonichthys leucogaster*	(Richardson, 1848)		1	1	1		1				1		1	1	1	
Scorpaeniformes	Triglidae	*Lepidotrigla japonica* cf.	(Bleeker, 1857)							1					1	1	1	
Scorpaeniformes	Aploactinidae	*Paraploactis kagoshimensis* cf.	(Ishikawa 1904)		1		1											
Scorpaeniformes	Platycephalidae	*Cymbacephalus bosschei*	(Bleeker, 1860)					1										1
Scorpaeniformes	Platycephalidae	*Cymbacephalus nematophthalmus*	(Günther, 1860)		1		1	1										1
Scorpaeniformes	Platycephalidae	*Onigocia grandisquama*	(Regan, 1908)		1		1			1							1	
Scorpaeniformes	Platycephalidae	*Platycephalus endrachtensis*	Quoy & Gaimard, 1825					1										
Scorpaeniformes	Platycephalidae	*Platycephalus westraliae*	(Whitley, 1938)			1	1	1										
Scorpaeniformes	Platycephalidae	*Rogadius tuberculatus*	(Cuvier, 1829)		1		1	1					1	1			1	1
Perciformes	Serranidae	*Cephalopholis boenak*	(Bloch, 1790)	1	1		1	1	1								1	1

Perciformes	Serranidae	*Diploprion bifasciatum*	Cuvier, 1828	1		1	1	1										1
Perciformes	Serranidae	*Epinephelus areolatus*	(Forsskål, 1775)					1	1					1	1		1	1
Perciformes	Serranidae	*Epinephelus multinotatus*	(Peters, 1876)					1	1								1	1
Perciformes	Serranidae	*Plectropomus maculatus*	(Bloch, 1790)	1	1		1	1	1								1	1
Perciformes	Serranidae	*Pseudanthias rubrizonatus*	(Randall, 1983)												1		1	1
Perciformes	Pseudochromidae	*Congrogadus spinifer*	(Borodin, 1933)		1		1				1						1	1
Perciformes	Pseudochromidae	*Pseudochromis howsoni*	Allen, 1995						1					1			1	1
Perciformes	Pseudochromidae	*Pseudochromis quinquedentatus*	McCulloch, 1926	1	1	1	1	1		1	1			1	1	1	1	1
Perciformes	Glaucosomatidae	*Glaucosoma magnificum*	(Ogilby, 1915)	1				1										
Perciformes	Priacanthidae	*Priacanthus hamrur*	(Forsskål, 1775)	1	1			1	1	1	1			1		1	1	1
Perciformes	Priacanthidae	*Priacanthus tayenus*	Richardson, 1846					1										1
Perciformes	Apogonidae	*Apogonichthyoides atripes*	(Ogilby, 1911)			1	1	1								1	1	1
Perciformes	Apogonidae	*Apogonichthyoides brevicaudatus*	(Weber, 1909)					1										
Perciformes	Apogonidae	*Gymnapogon* n. sp. 2	Fraser, in preparation												1	1	1	
Perciformes	Apogonidae	*Jaydia argyrogaster*	(Weber, 1909)		1		1											1
Perciformes	Apogonidae	*Ostorhinchus cavitensis*	(Jordan & Seale, 1907)	1			1	1										
Perciformes	Apogonidae	*Ostorhinchus fasciatus*	(White, 1790)					1										1
Perciformes	Apogonidae	*Ostorhinchus septemstriatus*	(Günther, 1880)					1						1	1		1	1
Perciformes	Apogonidae	*Ostorhinchus* sp.	N/A							1	1						1	1
Perciformes	Sillaginidae	*Sillago ingenuua*	McKay, 1985	1			1											
Perciformes	Rachycentridae	*Rachycentron canadum*	(Linnaeus, 1766)	1		1	1	1						1	1		1	1
Perciformes	Echeneidae	*Echeneis naucrates*	Linnaeus, 1758	1		1	1	1					1	1	1	1	1	1
Perciformes	Carangidae	*Carangoides caeruleopinnatus*	(Rüppell, 1830)					1		1		1		1			1	1
Perciformes	Carangidae	*Carangoides chrysophrys*	(Cuvier, 1833)		1		1	1		1		1		1			1	1
Perciformes	Carangidae	*Carangoides gymnostethus*	(Cuvier, 1833)	1	1	1	1	1	1	1	1			1	1	1	1	1
Perciformes	Carangidae	*Carangoides* sp. (juveniles)				1	1								1		1	1
Perciformes	Carangidae	*Decapterus macrosoma*	Bleeker, 1851												1		1	1
Perciformes	Carangidae	*Gnathanodon speciosus*	(Forsskål, 1775)					1							1		1	1
Perciformes	Carangidae	*Selar crumenophthalmus*	(Bloch, 1793)					1										1
Perciformes	Carangidae	*Selaroides leptolepis*	(Cuvier, 1833)	1	1	1	1	1										1

Perciformes	Carangidae	*Seriolina nigrofasciata*	(Rüppell, 1829)			1	1	1								1	1	1
Perciformes	Caesionidae	*Dipterygonotus balteatus*	(Valenciennes, 1830)					1										1
Perciformes	Caesionidae	*Pterocaesio chrysozona*	(Cuvier, 1830)	1		1	1	1										1
Perciformes	Lutjanidae	*Lutjanus erythropterus*	Bloch, 1790		1		1	1										1
Perciformes	Lutjanidae	*Lutjanus lutjanus*	Bloch, 1790					1										1
Perciformes	Lutjanidae	*Lutjanus malabaricus*	(Bloch & Schneider, 1801)		1		1	1										1
Perciformes	Lutjanidae	*Lutjanus russellii*	(Bleeker, 1849)					1										1
Perciformes	Lutjanidae	*Lutjanus sebae*	(Cuvier, 1828)	1			1	1										1
Perciformes	Lutjanidae	*Lutjanus vitta*	(Quoy & Gaimard, 1824)		1	1	1	1						1			1	1
Perciformes	Lutjanidae	*Pristipomoides multidens*	(Day, 1871)											1			1	1
Perciformes	Lutjanidae	*Symphorus nematophorus*	(Bleeker, 1860)					1										1
Perciformes	Nemipteridae	*Nemipterus celebicus*	(Bleeker, 1854)	1		1	1	1				1	1				1	1
Perciformes	Nemipteridae	*Nemipterus furcosus*	(Valenciennes, 1830)		1	1	1	1	1	1	1	1		1	1	1	1	1
Perciformes	Nemipteridae	*Pentapodus nagasakiensis*	(Tanaka, 1915)						1					1			1	1
Perciformes	Nemipteridae	*Pentapodus porosus*	(Valenciennes, 1830)	1	1	1	1	1	1	1							1	1
Perciformes	Nemipteridae	*Scolopsis meridiana*	Nakamura, Russell, Moore & Motomura, 2018			1	1	1										
Perciformes	Nemipteridae	*Scolopsis monogramma*	(Kuhl & van Hasselt, 1830)	1	1		1	1	1					1			1	1
Perciformes	Haemulidae	*Diagramma pictum*	(Thunberg, 1792)	1	1		1	1										1
Perciformes	Lethrinidae	*Gymnocranius elongatus*	Senta, 1973	1	1		1	1		1						1	1	1
Perciformes	Lethrinidae	*Lethrinus genivittatus*	Valenciennes, 1830		1	1	1	1										1
Perciformes	Lethrinidae	*Lethrinus laticaudis*	Alleyne & Macleay, 1877		1		1	1										
Perciformes	Lethrinidae	*Lethrinus nebulosus*	(Forsskål, 1775)					1	1								1	1
Perciformes	Lethrinidae	*Lethrinus punctulatus*	Macleay, 1878	1	1		1	1	1	1	1			1			1	1
Perciformes	Sparidae	*Argyrops bleekeri*	Oshima, 1927			1	1	1	1	1		1				1	1	1
Perciformes	Mullidae	*Parupeneus chrysopleuron*	(Temminck & Schlegel, 1843)					1										1
Perciformes	Mullidae	*Parupeneus heptacanthus*	(Lacépède, 1802)	1	1	1	1	1	1					1			1	1
Perciformes	Mullidae	*Parupeneus indicus*	(Shaw, 1803)					1						1			1	1
Perciformes	Mullidae	*Upeneus australiae*	Kim & Nakaya, 2002		1	1	1	1										1
Perciformes	Mullidae	*Upeneus guttatus*	(Day, 1868)	1		1	1	1						1			1	1
Perciformes	Mullidae	*Upeneus luzonius*	(Jordan & Seale, 1907)	1	1		1	1										

Perciformes	Mullidae	*Upeneus margarethae*	Uiblein & Heemstra, 2010	1	1	1	1	1										1
Perciformes	Pempherididae	*Parapriacanthus ransonetti* cf.	Steindachner, 1870					1										1
Perciformes	Ephippidae	*Platax batavianus*	Cuvier, 1831	1	1		1	1	1								1	1
Perciformes	Chaetodontidae	*Chaetodon assarius*	Waite, 1905						1					1			1	1
Perciformes	Chaetodontidae	*Chaetodon aureofasciatus*	Macleay, 1878	1	1		1	1										
Perciformes	Chaetodontidae	*Chelmon marginalis*	Richardson, 1842	1	1	1	1	1										1
Perciformes	Chaetodontidae	*Coradion altivelis*	McCulloch, 1916					1										
Perciformes	Chaetodontidae	*Coradion chrysozonus*	(Cuvier, 1831)	1	1	1	1	1	1	1				1			1	1
Perciformes	Chaetodontidae	*Heniochus acuminatus*	(Linnaeus, 1758)			1	1											1
Perciformes	Chaetodontidae	*Heniochus diphreutes*	Jordan, 1903					1	1								1	1
Perciformes	Chaetodontidae	*Parachaetodon ocellatus*	(Cuvier, 1831)					1		1					1	1	1	1
Perciformes	Pomacanthidae	*Chaetodontoplus duboulayi*	(Günther, 1867)	1	1		1	1	1					1			1	1
Perciformes	Pomacanthidae	*Chaetodontoplus personifer*	(McCulloch, 1914)		1		1	1	1	1				1		1	1	1
Perciformes	Pomacanthidae	*Pomacanthus sexstriatus*	(Cuvier, 1831)	1			1	1	1								1	1
Perciformes	Pomacentridae	*Chromis fumea*	(Tanaka, 1917)	1	1	1	1	1	1								1	1
Perciformes	Pomacentridae	*Pristotis obtusirostris*	(Günther, 1862)	1	1	1	1	1	1		1			1	1	1	1	1
Perciformes	Cirrhitidae	*Cirrhitichthys aprinus* cf.	(Cuvier, 1829)					1	1						1		1	1
Perciformes	Labridae	*Anampses lennardi*	Scott, 1959	1	1	1	1	1	1								1	1
Perciformes	Labridae	*Choerodon cauteroma*	Gomon & Allen, 1987	1	1		1	1	1					1			1	1
Perciformes	Labridae	*Choerodon cephalotes*	(Castelnau, 1875)	1	1		1	1	1								1	1
Perciformes	Labridae	*Choerodon schoenleinii*	(Valenciennes, 1839)					1	1								1	1
Perciformes	Labridae	*Choerodon sugillatum*	Gomon, 1987	1	1	1	1	1										1
Perciformes	Labridae	*Choerodon vitta*	Ogilby, 1910		1	1	1	1										1
Perciformes	Labridae	*Oxycheilinus orientalis*	(Günther, 1862)						1								1	
Perciformes	Labridae	*Suezichthys soelae*	Russell, 1985						1						1	1	1	
Perciformes	Scaridae	*Scarus ghobban*	Forsskål, 1775					1	1					1			1	1
Perciformes	Pinguipedidae	*Parapercis nebulosa*	(Quoy & Gaimard, 1825)			1	1	1										
Perciformes	Uranoscopidae	*Ichthyscopus insperatus*	Mees, 1960					1										1
Perciformes	Uranoscopidae	*Uranoscopus bicinctus* cf.	Temminck & Schlegel, 1843	1			1											
Perciformes	Champsodontidae	*Champsodon vorax* cf.	Günther, 1867													1	1	
Perciformes	Ammodytidae	*Bleekeria* sp.	N/A	1			1											

Perciformes	Callionymidae	*Dactylopus dactylopus*	(Valenciennes, 1837)		1		1	1										1
Perciformes	Gobiidae	*Bathygobius* sp.	(Hoese, in preparation)												1		1	
Perciformes	Gobiidae	Gobiidae - undifferentiated	N/A		1	1	1											
Perciformes	Gobiidae	*Larsonella* sp.	N/A												1		1	
Perciformes	Gobiidae	*Lubricogobius ornatus*	Fourmanoir, 1966											1			1	
Perciformes	Gobiidae	*Priolepis profunda*	(Weber, 1909)					1		1					1	1	1	1
Perciformes	Gobiidae	*Sueviota larsonae* cf.	Winterbottom & Hoese, 1988								1			1		1	1	
Perciformes	Siganidae	*Siganus fuscescens*	(Houttuyn, 1782)	1	1	1	1	1										1
Pleuronectiformes	Psettodidae	*Psettodes erumei*	(Bloch & Schneider, 1801)					1	1		1						1	1
Pleuronectiformes	Bothidae	*Asterorhombus intermedius* cf.	(Bleeker, 1866)	1			1											
Pleuronectiformes	Bothidae	*Engyprosopon grandisquama*	(Temminck & Schlegel, 1846)	1	1		1	1								1	1	1
Pleuronectiformes	Bothidae	*Grammatobothus pennatus*	(Ogilby, 1913)						1	1		1	1	1	1	1	1	1
Pleuronectiformes	Bothidae	*Grammatobothus polyophthalmus*	(Bleeker, 1866)												1		1	1
Pleuronectiformes	Paralichthyidae	*Pseudorhombus argus*	Weber, 1913		1		1	1										
Pleuronectiformes	Paralichthyidae	*Pseudorhombus diplospilus*	Norman, 1926					1							1	1	1	1
Pleuronectiformes	Paralichthyidae	*Pseudorhombus dupliciocellatus*	Regan, 1905					1		1	1	1	1	1	1	1	1	1
Pleuronectiformes	Paralichthyidae	*Pseudorhombus elevatus*	Ogilby, 1912			1	1											
Pleuronectiformes	Paralichthyidae	*Pseudorhombus spinosus*	McCulloch, 1914	1			1	1			1		1				1	1
Pleuronectiformes	Soleidae	*Aseraggodes melanospilos*	(Bleeker, 1854)	1			1	1										
Tetraodontiformes	Balistidae	*Abalistes stellatus*	(Anonymous, 1798)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	(Linnaeus, 1758)	1			1	1										1
Tetraodontiformes	Monacanthidae	*Anacanthus barbatus*	Gray, 1831		1	1	1	1			1						1	1
Tetraodontiformes	Monacanthidae	*Chaetodermis penicilligerus*	(Cuvier, 1817)		1		1	1	1								1	1
Tetraodontiformes	Monacanthidae	*Eubalichthys caeruleoguttatus*	Hutchins, 1977		1		1	1	1								1	1
Tetraodontiformes	Monacanthidae	*Monacanthus chinensis*	(Osbeck, 1765)		1		1	1										
Tetraodontiformes	Monacanthidae	*Paramonacanthus oblongus*	(Schlegel, 1850)	1	1	1	1	1										1
Tetraodontiformes	Monacanthidae	*Paramonacanthus* sp.	N/A												1		1	
Tetraodontiformes	Monacanthidae	*Pseudomonacanthus elongatus*	Fraser-Brunner, 1940		1		1	1										1
Tetraodontiformes	Monacanthidae	*Pseudomonacanthus peroni*	(Hollard, 1854)	1	1		1	1	1	1	1					1	1	1
Tetraodontiformes	Ostraciidae	*Lactoria cornuta*	(Linnaeus, 1758)	1	1		1	1		1	1	1	1	1	1		1	1

Tetraodontiformes	Ostraciidae	*Lactoria diaphana*	(Bloch & Schneider, 1801)	1	1		1	1			1						1	1
Tetraodontiformes	Ostraciidae	*Ostracion cubicus*	Linnaeus, 1758					1										1
Tetraodontiformes	Ostraciidae	*Ostracion nasus*	Bloch, 1785	1	1	1	1	1	1		1						1	1
Tetraodontiformes	Ostraciidae	*Ostracion rhinorhynchos*	Bleeker, 1852					1										
Tetraodontiformes	Ostraciidae	*Tetrosomus gibbosus*	(Linnaeus, 1758)					1	1	1				1			1	1
Tetraodontiformes	Tetraodontidae	*Canthigaster cyanospilota*	Randall, Williams & Rocha 2008	1			1	1										
Tetraodontiformes	Tetraodontidae	*Canthigaster rivulata*	(Temminck & Schlegel, 1850)						1								1	1
Tetraodontiformes	Tetraodontidae	*Feroxodon multistriatus*	(Richardson, 1854)					1							1		1	1
Tetraodontiformes	Tetraodontidae	*Lagocephalus sceleratus*	(Gmelin, 1789)			1	1	1						1		1	1	1
Tetraodontiformes	Tetraodontidae	*Torquigener pallimaculatus*	Hardy, 1983	1	1		1	1	1	1	1						1	1
Tetraodontiformes	Diodontidae	*Cyclichthys orbicularis*	(Bloch, 1785)											1			1	1
Tetraodontiformes	Diodontidae	*Diodon holocanthus*	Linnaeus, 1758					1										1
Tetraodontiformes	Diodontidae	*Tragulichthys jaculiferus*	(Cuvier, 1818)	1	1	1	1	1	1								1	1
			Number of taxa	**64**	**72**	**46**	**105**	**129**	**50**	**31**	**22**	**14**	**16**	**45**	**39**	**34**	**118**	**133**

Table 5. Fish sampled from Montebello MP during 2013 PMCP project. Bolded entries are those species not sampled from within Montebello MP in 2017. * indicates the species was sampled from within the Dampier MP in 2017. X means the species was collected from that station

Order	Family	Species	Authority	PMCP_50	PMCP_62	PMCP_96	PMCP_100	PMCP_101	PMCP_102
Anguilliformes	Muraenidae	*Gymnothorax cribroris*	Whitley, 1932		X				
Batrachoidiformes	**Batrachoididae**	***Batrachomoeus trispinosus***	**(Günther, 1861)**					**X**	
Lophiiformes	**Antennariidae**	***Antennarius pictus***	**(Shaw & Nodder, 1794)**					**X**	
***Perciformes**	**Apogonidae**	***Jaydia argyrogaster***	**Weber, 1909**					**X**	
***Perciformes**	**Carangidae**	***Selaroides leptolepis***	**(Cuvier, 1833)**	**X**					
Perciformes	Chaetodontidae	*Coradion chrysozonus*	(Cuvier, 1831)	X					
Perciformes	**Labridae**	***Iniistius jacksonensis***	**(Ramsay, 1881)**						**X**
***Perciformes**	**Lethrinidae**	***Lethrinus genivittatus***	**Valenciennes, 1830**	**X**					
Perciformes	**Lethrinidae**	***Lethrinus variegatus***	**Valenciennes, 1830**	**X**					
Perciformes	Lutjanidae	*Lutjanus vitta*	(Quoy & Gaimard, 1824)	X					
Perciformes	Mullidae	*Parupeneus heptacanthus*	(Lacepède, 1802)	X					
Perciformes	**Mullidae**	***Upeneus asymmetricus***	**Lachner, 1954**	**X**					
Perciformes	Nemipteridae	*Pentapodus porosus*	(Valenciennes, 1830)	X					
Perciformes	Pomacentridae	*Chromis fumea*	(Tanaka, 1917)		X				
Perciformes	Pomacentridae	*Pristotis obtusirostris*	(Günther, 1862)	X				X	
Perciformes	Pseudochromidae	*Pseudochromis spA*			X				
***Perciformes**	**Siganidae**	***Siganus fuscescens***	**(Houttuyn, 1782)**	**X**					
***Pleuronectiformes**	**Paralichthyidae**	***Pseudorhombus argus***	**Weber, 1913**						**X**
Pleuronectiformes	**Soleidae**	***Zebrias craticulus***	**(McCulloch, 1916)**		**X**				
Scorpaeniformes	**Scorpaenidae**	***Parascorpaena mossambica***	**(Peters, 1855)**					**X**	
Tetraodontiformes	**Monacanthidae**	***Paramonacanthus choirocephalus***	**(Bleeker, 1851)**	**X**	**X**				

4.3 Corals (Octocorallia, Hexacorallia, Ceriantipatharia)

Monika Bryce (CSIRO Oceans and Atmosphere Research)

4.3.1 Summary

In total 11 stations were sampled within the confines of two Commonwealth MPs on the NWS. Soft coral and sea fan (Alcyonacea, Octocorallia), sea pen (Pennatulacea, Octocorallia), hard coral (Scleractinia, Hexacorallia), and black coral (Antipatharia, Ceriantipatharia) biodiversity was assessed as part of a larger program to determine the long-term recovery of trawled benthic communities and to describe current community structures. The 155 vouchered soft coral and sea fan specimens yielded a total of 57 binomial species and morphospecies combined. Forty-six species were recorded from the Dampier MP and 32 from the Montebello MP. Twenty-one species (21) were present at sites within both MPs. The overall composition of this fauna was typical for tropical Indo-Pacific silty environments with a depth range of 30–70 m. In addition to Alcyonacea, a total of 52 specimen lots of sea pens, 20 specimen lots of hard corals, and two black corals were also sampled within the two MP areas.

Taxonomic and collection scope

Cnidarian vouchers were collected using a CSIRO Semi V Wing trawl net (McKenna trawl net) or an epibenthic sled (Pitcher et al. 2016) at 11 stations within the Dampier and Montebello MPs during the RV *Investigator* Voyage (INV2017_05). All soft corals and sea fans (Alcyonacea) were sorted into morphotypes (massive, whips, fans, *Dendronephthya*) and all cnidarian into size categories (<25 cm, 25–50 cm, 50–100 cm, >100 cm). Counts and weights of each morphotype and size category combination were recorded and databased. Cnidarian vouchers were collected at each station for further taxonomic determinations to species level utilising either the binomial species or OTU concepts. Species within the genus *Dendronephthya* (Alcyonacea, Nephtheidae) and the genus *Pteroeides* (Pennatulacea, Pennatulidae) were identified to genus level only due to high taxonomic uncertainty resulting from high level of intracolony and intraspecies variability (McFadden et al. 2009, Williams 1995). The concept of morphospecies assumes that each OTU represents a single species, which has not been identified using the Linnaean binomial system; they have differences in morphological characters from published descriptions and/or are preliminary identifications. Subsequent research will determine if they represent an undescribed species or have been previously described in historic taxonomic literature. A reference collection of all species has been registered and deposited in the Western Australian Museum, Perth.

Morphological identification

Vouchers were photographed, counted and weighed on deck and then preserved in 100% ethanol until transferred into 75% ethanol at the CSIRO laboratory. Soft coral and sea fan sclerites were prepared for microscopy by cutting small subsamples from the voucher from five different regions (polyps, surface of the polyp region, surface of the base, interior of the polyp region and interior of the base), which were put into dissolved sodium hypochlorite (13% available chlorine). After the organic material had dissolved, the sclerites were rinsed with distilled water and dried on a glass microscope slide for further investigation. *Durcupan ACM*(™) was used as a mounting medium for permanent slides (Fabricius and Alderslade 2001). Sea pen sclerites were examined by dissolving small subsamples from the voucher from the polyps, surface of the polyp region, surface of the base, and interior of the base, on a microscope slide (sodium hypochlorite, 13% available chlorine). Hard corals were bleached in sodium hypochlorite (13% available chlorine) until all organic matter was dissolved and then rinsed in water.

4.3.2 Soft corals and sea fans (Alcyonacea, Octocorallia)

Dampier MP

Collecting effort and species composition of higher octocoral taxa

Three stations were surveyed for octocorals within the Dampier MP (W4, W6, and W8). Eighty-seven (87) octocoral vouchers were collected with 30% (26 vouchers) collected by trawl and 70% (61) by sled. From the three stations investigated, station W4 had the highest octocoral abundance (67 vouchers) followed by W6 (13) and W8 (7). The most abundant morphotypes in the Dampier MP were sea fans (54%) and sea whips (20%).

Forty-six species (46) within the subclass Octocorallia, Order Alcyonacea were identified. All five suborders within the Alcyonacea were represented, covering 12 families and 26 genera (Bayer 1981; Fabricius 2001) (Table 6). The five subordinal groups comprised one Stolonifera octocoral species, 12 Alcyoniina, 8 Scleraxonia, 18 Holaxonia and 7 Calcaxonia species (Figure 83A). The following families had the highest number of identified taxa: Plexauridae (16), Nephtheidae (10) and Ellisellidae (6) (Figure 83B). All other families were represented by only one or a few species (1–3). No Alcyoniidae and Xeniidae were collected from the Dampier MP.

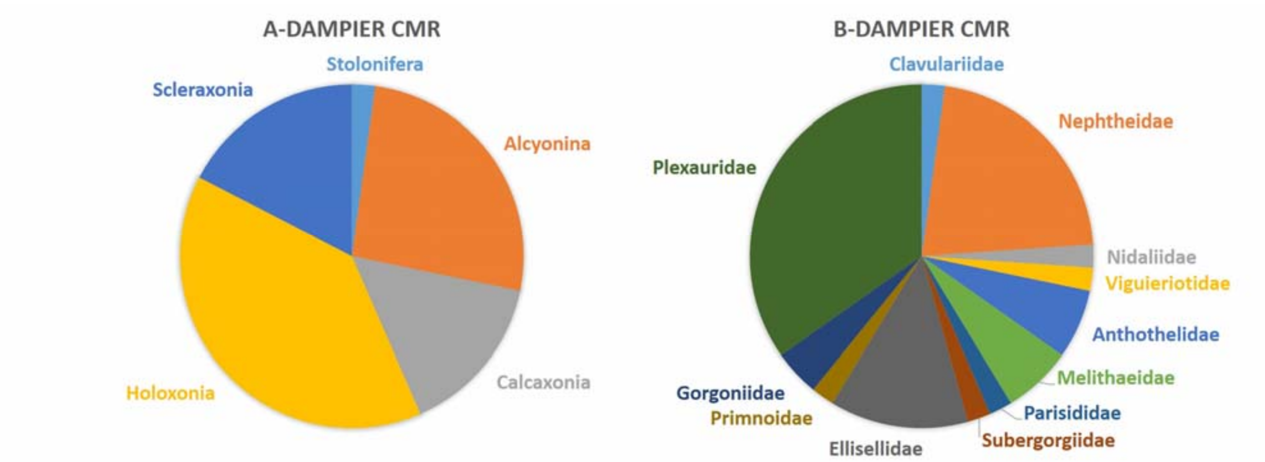


Figure 83. Percent composition of octocoral taxa comprising the 46 identified species from the Dampier MP: A) octocoral subordinal groups; B) percentages of identified octocoral taxa within Alcyonacea families (rounded to the nearest percentage)

Montebello MP

Collecting effort and species composition of higher octocoral taxa

Eight stations were surveyed for octocorals within the Montebello MP (W14, W49, W50, W79, W80, W81, W82 and W97). Sixty-seven (67) vouchers were collected with 42% (29 vouchers) of the octocorals collected by trawl and 56% (38) by sled. From the eight stations investigated station W14 and W49 had the highest octocoral abundance with 30 and 17 vouchers respectively, followed by W50 and W97 (six vouchers), W81 and W82 (three vouchers) and W79 and W80 with single vouchers. The most abundant morphotypes in the Montebello MP were sea fans (33%), massive octocorals (33%) and *Dendronephthya* (23%), while sea whips were less abundant (11%).

Thirty-two species (32) within the subclass Octocorallia, Order Alcyonacea were identified. All five suborders within the Alcyonacea were represented, covering 11 families and 21 genera (Bayer 1981;

Fabricius 2001) (Table 6). The five subordinal groups comprised one Stolonifera octocoral species, 11 Alcyoniina, 4 Scleraxonia, 7 Holaxonia, and 9 Calcaxonia (Figure 84A). The following families had the highest number of identified taxa: Nephtheidae (9), Ellisellidae (8), and Plexauridae (5) (Figure 84B). All other families were represented by only one or a few species (1–3). No Alcyoniidae and Xeniidae were collected from the Montebello MP sites.

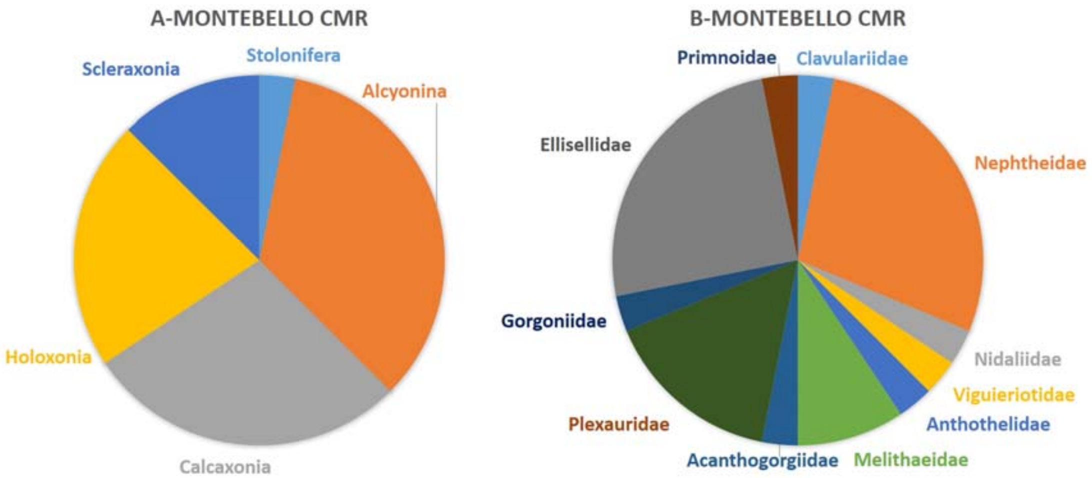


Figure 84. Percent composition of octocoral taxa comprising the 32 identified species from the Montebello MP: A) octocoral subordinal groups; B) percentages of identified octocoral taxa within Alcyonacea families (rounded to the nearest percentage)

The number of species collected in this survey in the Montebello MP area (32) was similar to the soft coral species and OTUs collected from six sites within the Montebello MP during the 2013 PMCP surveys (Table 9). Further the species composition was very similar and all five suborders within the Alcyonacea were represented in both surveys (Table 6, Table 9). The families Ellisellidae and Plexauridae showed high diversity, and many other families were represented by only one or a few species. Four genera within the family Nephtheidae were identified in the Montebello MP 2017 survey (*Chromonephthea, Dendronephthya, Scleronephthya*, and *Umbellulifera*), whereas only two genera (*Chromonephthea, Dendronephthya*) were present in the 2013 PMCP survey. In both survyes no Xeniidae were collected from the Montebello MP area and only one species within the family Alcyoniidae (*Sinularia* sp.) was collected in the 2013 PMCP survey.

4.3.3 Comparison of species assemblages between the Dampier and Montebello MPs.

In total fifty-seven species (57) were recorded from the two MPs (Table 6). Forty-six species (46) were recorded from the Dampier MP, comprising of three sites. The Montebello MP was less speciose with 32 species from eight sites. Twenty-one species (21) were present in both MPs, while 25 species were unique to the Dampier MP and 11 species were unique to the Montebello MP (Table 6).

Within the subordinal group Stolonifera, only one species (*Telesto arborea*) was recorded. This species was found in both MPs. It is known to be widespread, and found predominately in turbid coastal habitats.

The subordinal group Alcyoniina was strongly represented by the family Nephtheidae (Dampier MP 10 vouchers; Montebello MP 9 vouchers), with the genera *Chromonephthea*, *Dendronephthya*, *Scleronephthya*, and *Umbellulifera* respectively. Species within the genus *Dendronephthya* (Nephtheidae) were not identified to species level due to high taxonomic uncertainty, and have been treated in this report as ‘one species’ (McFadden et al. 2009). Nevertheless, the high variability in colony shape and colour suggests a high diversity within this genus. *Dendronephthya* was more abundant at the sites in the Montebello MP (15 vouchers: 23%) than within the Dampier MP (2 vouchers: 2%). In both MPs only one species within the families Viguieriotidae and Nidaliidae were present; (*Studeriotes crasssa*) and

(*Nephthyigorgia kükenthali*) respectively. No specimens from the families Alcyoniidae and Xeniidae were collected from either MP.

Several specimens of *Nephthyigorgia kükenthali* (Nidaliidae) were collected from a single station in the Dampier MP (W4), from 33 m depth, and one small specimen from the Montebello MP (W49) from 61 m depth. This species was first described from Cape Jaubert, south of Broome and thought rare, but can now be considered more common on sandy environments of the Pilbara region (Keesing et al. 2011; Pitcher et al. 2016; Bryce et al. 2018). Two specimens, each of the rarely reported *Studeriotes crassa*, were found in both MPss (W4, W14).

In general, Scleraxonian biodiversity in both MPs was low, with only some sea fans (*Melithaeidae*) being more abundant. Within the family Anthothelidae, *Solenocaulon tortuosum* was found in both MPs , while *Alertigorgia brunnea*, and *Iciligorgia mjoebergi*, were only found within the Dampier MP. All these species are known to be restricted to turbid, silty environments with strong currents.

The species assemblages of the two MPs differed with the family *Plexauridae* (34% of the fauna) dominating in the Dampier MP, while the families Nephtheidae (28%) and Ellisellidae (25%) dominated in the Montebello MP (Table 6; Figure 83 and Figure 84). Of the subordinal groups, Calcaxonia was the most abundant with sea whip species, *Ctenocella pectinata*, *Dichotella gemmacea*, *Junceella fragilis* and *J. juncea* (all family Ellisellidae) being most common. *Plumarella penna* (Figure 85) is a noteworthy species, with a single specimen recorded from the Dampier MP (W4) and two specimens from the Montebello MP (W14). This delicate, feather-like, soft coral has rarely been recorded from shallow waters (< 60 m).

Figure 85. *Plumarella penna* recorded from both the Dampier and Montebello MPs

4.3.4 Sea pens (Pennatulacea, Octocorallia)

Sea pens are a relatively poorly known group of octocorallia. Many sea pens occur only in deep waters and those pennatulaceans that inhabit shallow-water are completely withdrawn into the substrate during the daylight, and rarely encountered by SCUBA divers. In this survey a total of 52 Pennatulacea (Octocorallia) specimen lots were collected by trawl or sled from the 11 MP sites. Only five specimen lots were collected from the Dampier MP sites (W4, W6 and W8) and 47 from the Montebello MP sites (W14, W49, W50, W79, W80, W81, W82 and W97). Fifty percent (26 specimen lots) of all pennatulacean lots collected within the two MPs were from the two Montebello MP sites W81 and W82. The collection revealed six genera from five sea pen families (Table 7). The family Echinoptilidae was represented by a single species (*Echinoptilum macintoshi* Hubrecht, 1885). Within the suborder Sessiliflorae the family Veretillidae was represented by two species (*Lituaria australasiae* (Gray, 1860), *Lituaria* cf. *hicksoni* Thomson & Simpson, 1909) and the family Kophobelemnidae by the species *Sclerobelemnon* sp. 1 and sp. 2. With regard to the suborder Subsessiliflorae there were three species of the genus *Scytalium* and two species of *Virgularia* (family Virgulariidae), and the genus *Pteroeides* within the family Pennatulidae (specimen of *Pteroeides* were identified to genus level only). Due to the ability of sea pens to grow in marine benthic habitats comprised of unconsolidated sediments many species are able to inhabit extensive regions of the sea floor. This was confirmed by the high abundance of sea pens in both MPs as shown from the analysis of seabed imagery (see Chapter 3). All identified genera are known to occur in soft sediment, shallow-water areas within the Indo-Pacific region (Williams, 2011). Nearly half of all collected sea pens within the two MPs were from the genera *Scytalium* (46%). *Pteroeides* made 17% of the collection, *Lituaria* 15%, *Virgularia* 11% and the genera *Sclerobelemnon* and *Echinoptilum* were represented by only a few specimens. Three colonies of *Echinoptilum macintoshi* were trawled from station W82 and may represent a new record for Western Australia (Williams, 1995), but this requires further research. A further colony of *E. macintoshi* was found at station W83, just outside the Montebello MP.

4.3.5 Hard corals (Scleractinia, Hexacorallia)

A total of 20 specimen lots from within the two MPs were examined during this study. Three specimen lots were recorded from the Dampier MP and 17 from the Montebello MP. Scleractinia in the Montebello MP were represented only by azooxanthellate solitary hard corals (Cairns and Kitahara, 2012), and was distinctly different to the Dampier MP. The collection represents a very small selection of the known, shallow depth, hard coral fauna from this area. Eight species or OTUs from five families and five genera were identified from the collections (Table 8).

Solitary scleractinian genera clearly dominated the hard coral fauna and were represented by seven species (Table 8). The genus *Truncatoflabellum* (Flabellidae), which accounted for nearly half of the collection (45%), was represented by four species (*Truncatoflabellum aculeatum, T. angiostomum, T. australiensis, T. macroeschara*). All four species have previously been recorded from Western Australia (Cairns 2016). The genus *Heteropsammia* (Dendrophylliidae) accounted for a further 27% of the collection and was represented by the Indo-West Pacific species, *Heteropsammia cochlea*. This small, roundish species has a commensal relationship with a sipunculid worm, which transports the corals across the soft substrate and so helps to prevent burial. It is known to be associated with the structural and ecologically equivalent species, *Heterocyathus aquicostatus* (Caryophyllidae), as was the case at station W79. *Tubastrea coccinea* was only present in the Dampier MP where it was collected from 30 and 50 m (W14). In general hard coral abundance and biodiversity was very low.

4.3.6 Black corals (Antipatharia, Ceriantipatharia)

In this survey only two black coral (*Antipathes* sp.) lots were collected within the two MPs. One from Dampier MP site W4 and the other from Montebello MP site W49.

Table 6. Species of Octocorallia (Alcyonacea) recorded from the Dampier MP and Montebello MP survey areas. 1 means the species was collected from that station

	Dampier MP			Montebello MP							Total sites occurred
Taxa	W4	W6	W8	W14	W49	W50	W79	W81	W82	W97	
STOLONIFERA											
CLAVULARIIDAE											
Telesto arborea Wright & Studer, 1889	1				1						2
ALCYONIINA											
ALCYONIIDAE (0)											
NEPHTHEIDAE											
Chromonephthea aldersladei van Ofwegen, 2005	1		1	1		1					4
Chromonephthea benayahui van Ofwegen, 2005	1										1
Chromonephthea cf. rubra (Kükenthal, 1910)						1					1
Chromonephthea dampierensis (Verseveldt, 1977)	1										1
Dendronephthya spp.	1	1		1	1	1	1	1	1	1	9
Scleronephthya sp. 1				1							1
Scleronephthya sp. 2				1							1
Scleronephthya sp. 3	1										1
Scleronephthya sp. 4	1	1									2
Umbellulifera sp. 1	1			1							2
Umbellulifera sp. 2			1		1	1					3
Umbellulifera sp. 3									1		1
Umbellulifera sp. 4				1	1						2
Umbellulifera sp. 5	1										1
Umbellulifera sp. 6	1										1
NIDALIIDAE											
Nephthyigorgia kükenthali Broch, 1916	1				1						2
VIGUIERIOTIDAE											
Studeriotes crassa Kükenthal, 1910	1			1							2
SCLERAXONIA											
ANTHOTHELIDAE											
Alertigorgia mjöbergi Broch, 1916	1	1									2
Iciligorgia brunnea (Nutting, 1911)	1	1									2
Solenocaulon tortuosum Gray, 1862	1		1		1	1			1	1	6
SUBERGORGIIDAE											
Subergorgia suberosa (Pallas, 1766)	1										1
MELITHAEIDAE											
Melithaea sp. 1				1	1						2
Melithaea sp. 2	1			1							2
Melithaea sp. 3	1				1						2
Melithaea sp. 4	1	1									2
Parisis australis Wright & Studer, 1889	1	1									2
HOLOXONIA											
ACANTHOGORGIIDAE											
Anthogorgia sp. 1				1							1
PLEXAURIDAE											

Echinogorgia sp. 14	1		1	1							3
Echinogorgia sp. 15	1										1
Echinogorgia sp. 19	1	1									2
Echinogorgia sp. 24	1										1
Echinomuricea sp. 1	1										1
Echinomuricea sp. 2	1										1
Echinomuricea sp. 3				1							1
Echinomuricea sp. 4	1										1
Euplexaura sp. 10	1										1
Euplexaura sp. 11	1										1
Euplexaura sp. 8	1										1
Menella sp. 2	1										1
Menella sp. 7		1		1							2
Menella sp. 8	1				1						2
Paraplexaura sp. 6	1										1
Paraplexaura sp. 7	1				1						2
GORGONIIDAE											
Pseudopterogorgia australiensis (Ridley, 1884)		1									1
Guaiagorgia anas Grasshoff & Alderslade, 1997		1		1							2
CALCAXONIA											
ELLISELLIDAE											
Ctenocella pectinata (Pallas, 1766)	1	1		1							3
Dichotella gemmacea (Milne Edwards & Haime, 1857)	1	1	1	1		1				1	6
Ellisella sp. 3				1						1	2
Junceella fragilis (Ridley, 1884)	1				1						2
Junceella juncea (Pallas, 1766)	1			1							2
Verrucella sp. 3	1										1
Viminella sp. 1				1							1
Viminella sp. 2	1			1							2
Viminella sp. 3	1			1							2
PRIMNOIDAE											
Plumarella penna (Lamarck, 1815)	1			1							2
Totals per station	**42**	**13**	**6**	**23**	**12**	**7**	**1**	**2**	**4**	**4**	

Table 7. Species of Octocorallia (Pennatulacea) recorded from the MP survey areas. X means the species was collected from that station

Taxa	Dampier MP			Montebello MP							
	W4	W6	W8	W 14	W49	W50	W81	W82	W79	W97	sum
ECHINOPTILIDAE											
Echinoptilum macintoshi Hubrecht, 1885								1			1
VERETILLIDAE											
Lituaria australasiae (Gray, 1860),				1	1	1	1	1		1	6
Lituaria cf. *hicksoni Thomson & Simpson, 1909*							1				1
KOPHOBELEMNIDAE											
Sclerobelemnon sp. 1				1	1		1				3
Sclerobelemnon sp. 2								1			1
PENNATULIDAE											
Pteroeides spp.	1	1	1	1	1	1	1	1	1		9
VIRGULARIIDAE											
Scytalium sp. 1				1	1		1	1		1	5
Scytalium sp. 2	1		1								2
Scytalium sp. 3		1		1	1		1	1		1	6
Virgularia sp. 1						1		1		1	3
Virgularia sp.2							1			1	2
Totals per station	**2**	**2**	**2**	**5**	**5**	**3**	**7**	**7**	**1**	**5**	

Table 8. Species of Hexacorallia (Scleractinia) recorded from the MP survey areas

Taxa	Dampier MP			Montebello MP							
	W4	W6	W8	W14	W49	W50	W81	W82	W79	W97	sum
CARYOPHYLLIDAE											
Heterocyathus aequicostatus Milne Edwards & Haime, 1848									1		1
DENDROPHYLLIIDAE											
Heteropsammia cochlea (Spengler, 1781)					1	1	1	1	1	1	5
Tubastraea coccinea Lesson, 1829	1			1							2
FLABELLIDAE											
Truncatoflabellum aculeatum (Milne Edwards & Haime, 1848)								1			1
Truncatoflabellum angiostomum (Folkeson, 1919)					1		1	1	1		4
Truncatoflabellum australiensis Cairns, 1998							1				1
Truncatoflabellum macroeschara Cairns, 1998					1	1			1		3
FUNGIIDAE											
Cycloseris cyclolites (Lamarck, 1815)		1									1
Total per station	**1**	**1**	**0**	**1**	**3**	**2**	**3**	**3**	**4**	**1**	

Table 9. List of soft coral species and OTUs collected from six sites within the Montebello MP during the 2013 PMCP surveys.

Suborder	Family	Species	PMCP SITE 50	PMCP SITE 62	PMCP SITE 96	PMCP SITE 100	PMCP SITE 101	PMCP SITE 102
Stolonifera	Clavulariidae	*Carijoa* sp. 1		X				
Alcyoniina	Alcyoniidae	*Sinularia* sp. 6	X					
Alcyoniina	Nephtheidae	*Chromonephthea* sp.		X				
Alcyoniina	Nephtheidae	*Dendronephthya* sp.		X			X	
Alcyoniina	Nidaliidae	*Nephthyigorgia* cf. *kükenthali*	X				X	
Alcyoniina	Nidaliidae	*Nephthyigorgia kükenthali* Broch, 1916	X	X			X	
Alcyoniina	Paralcyoniidae	*Studeriotes* sp. 1		X			X	
Scleraxonia	Anthothelidae	*Iciligorgia brunnea* (Nutting, 1911)					X	X
Scleraxonia	Melithaeidae	*Acabaria* sp. 8					X	
Scleraxonia	Parisididae	*Parisis* sp. 1		X			X	
Scleraxonia	Subergorgiidae	*Subergorgia* sp.	X					
Scleraxonia	Subergorgiidae	*Subergorgia suberosa* (Pallas, 1766)	X	X				
Holoxonia	Gorgoniidae	*Pseudopterogorgia australiensis* (Ridley, 1884)	X					
Holoxonia	Plexauridae	*Bebryce* sp. 1		X				
Holoxonia	Plexauridae	*Echinogorgia* sp. 11	X					
Holoxonia	Plexauridae	*Echinogorgia* sp. 17					X	
Holoxonia	Plexauridae	*Echinomuricea* sp.	X					
Holoxonia	Plexauridae	*Echinomuricea* sp. 2					X	
Holoxonia	Plexauridae	*Euplexaura* sp. 1					X	
Holoxonia	Plexauridae	*Menella* sp.	X					
Holoxonia	Plexauridae	*Menella* sp. 5					X	
Calcaxonia	Ellisellidae	*Ctenocella pectinata* (Pallas, 1766)		X				
Calcaxonia	Ellisellidae	*Dichotella gemmacea* (Milne Edwards & Haime, 1857)	X	X				
Calcaxonia	Ellisellidae	*Junceella fragilis* (Ridley, 1884)	X			X	X	
Calcaxonia	Ellisellidae	*Junceella juncea* (Pallas, 1766)		X				
Calcaxonia	Ellisellidae	*Junceella* sp. 1					X	
Calcaxonia	Ellisellidae	*Verrucella* sp. 4		X				

Table 10. Cnidaria species listed in the Atlas of Living Australia recorded from the Montebello MP prior to this study.

Phylum	Class	Order	Family	Genus/Species/	Number of records
Cnidaria	Anthozoa	Alcyonacea	Anthothelidae	Alertigorgia sp.	1
Cnidaria	Anthozoa	Alcyonacea	Melithaeidae	Mopsella sp.	1
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	*Dendronephthya* sp. J [SS200705, 2008]	1
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	*Dendronephthya* sp. J [SS200705, 2008]	1

4.4 Sponges

Belinda Alvarez (CSIRO Oceans and Atmosphere Research)

Sponges (Phylum Porifera) are filter feeders and the oldest metazoan group on Earth. They have been found in all aquatic habitats including freshwater, from intertidal to deep water marine habitats. Sponge species grow in very distinct shapes, from encrusting to massive or large cups or barrels. They have very different colours and smells and an important source of natural chemicals for products like pharmaceuticals. Their body organisation is simple and supported by a siliceous and/or spongin skeleton which is the main characteristic used for their classification and taxonomic identification.

Sponges are one of the most abundant and diverse group of invertebrates inhabiting the NWS. The area is reported as a sponge biodiversity hotspot with approximately 344 species and a 37% of 'apparent endemics' (species counts include OTUs) one of the highest reported for Australia (Hooper et al. 2002).

Although prior to this study, limited sampling had been carried out within the area of the Dampier MP, the sponge diversity of Dampier Archipelago to the immediate west of the Dampier MP is reasonably well known. Dampier Archipelago has been surveyed previously, and sponge collections made by SCUBA and limited to shallow waters are available. Those studies (Fromont 2004; 2006) reported a range of 150 sponge species, based in quantitative survey to 275 from non-quantitative surveys. Quantitative surveys captured only 56–80% of the sponge diversity and indicated that 48% were 'apparent endemics' supporting conclusions of Hooper et al. (2002). Despite nearly half of the sponge fauna potentially being endemic, the area remains poorly known in terms of sponge biodiversity and only three species and one new genus have been named so far: *Anthotethya fromontae* Sara &Sara, 2002; *Laxotethya dampierensis* Sara & Sara, 2002, *Tetrapocilon bergquistae* Fromont, Alvarez, Gomez & Roberts, 2010.

Similarly, most previous surveys in the region of the Montebello Islands have been undertaken in the shallower areas around the islands to the south and east of the Montebello MP. As such, information on sponge biodiversity in the area as a whole, is spread through the taxonomic literature and no current diversity estimates are available for the Montebello MP. A survey of the broader area by CSIRO in 2013 (PMCP study, Pitcher et al. 2016) included six sites in the Montebello MP and showed the area holds a high diversity of sponges. Approximately 114 different species were found in that survey. At least one new species, *Ceratopsion montebelloensis* Hooper, 1993 has been described from this area.

In this report we document the sponge biodiversity of the Dampier and Montebello MPs based on non-quantitative collections carried out by the RV *Investigator* survey of the NWS in 2017. The data is compared with collection data in the Western Australian Museum, which includes the six sites surveyed by Pitcher et al. (2016).

4.4.1 Collections made and species identification

Sponge specimens were collected using a CSIRO Semi V Wing trawl net (McKenna trawl net) or an epibenthic sled (Pitcher et al. 2016) in the surveyed stations between 30 and 70 m. Once on deck they were sorted in morphotypes (i.e. Massive, Erect, Cups, see Figure 86) following the classification system developed by Christine Schoenberg (Australian Institute of Marine Sciences) and Jane Fromont (Western Australian Museum, WAM), and those into size categories (<25 cm, 25–50 cm, 50–100 cm, >100 cm) giving a total of 12 sorting categories. Fragments of specimens that could not be unambiguously assigned to any of the categories were separated in a different category. Individual counts and weights were recorded for each category. One representative specimen of each morphospecies (i.e. species that look different based on external morphology) included in the sorted categories was separated and photographed. A subsample was preserved in 100% ethanol or frozen for taxonomic identification. Selected entire specimens were preserved frozen for exhibition display or for future genetic studies. Some specimens were also selected for fluorescence studies by Dr. Peter Karuso (Macquarie University, NSW).

A thick section and spicule slide was prepared from each sponge voucher using standard methods (Rützler, 1978), identified to genus following Hooper & van Soest (2002), and assigned to valid species as listed in the current version of the World Porifera database (van Soest et al., 2018) using available taxonomic literature. Specimens that did not fully agree with all the characters described for the species were denoted with 'cf.' A unique code or OTU was assigned to unknown or undescribed species (Table 11) and matched to existing ones deposited at WAM. We used the WAM OTU code if matches were found, to facilitate future comparisons of species composition and richness in the area. A few specimens lacked characters for recognition beyond the genus level and were denoted with '?'.

Sponge collections of the WAM, Queensland Museum and Northern Territory Museum and, records from scientific literature have been published in the Atlas of Living Australia (ALA) (https://www.ala.org.au/) allowing us to find which species have been previously recorded for the area. Using the spatial search tool of that platform we listed species recorded in a demarcated area in the Pilbara bio-region and within the surveyed MPs and compared it to the species recorded in this study. We also interrogated the WAM database and extracted registered specimens that have been previously found in the surveyed area for further comparisons of the sponge biodiversity.

4.4.2 Taxa sampled

A total of 365 sponge vouchers were examined and identified to species/OTU level. Table 11 shows the list of taxa identified for the surveyed stations. Only one specimen from the Class Calcarea was represented in the collection. All the rest belonged into the class Demospongiae. A total of 153 species from 12 orders, 38 families and 87 genera were found. Only 73 of those could be assigned to previously described species, of which 12 (indicated with an asterisk in Table 12) are not recorded for the Pilbara region by the ALA.

At least 33 species, has been previously recorded for the studied MPs by the ALA and WAM database (Table 14). Of the 73 sponge species identified in this study only 14 were recorded by ALA or WAM indicating that at least 59 species are new records for these MPs or are identified under another name (see below).

Eighty species were assigned to OTUs (Table 11) as they could not be assigned to known species. Approximately 60% of those matched OTUs from WAM collections which suggest they have been found in the Western Australian waters, but not necessarily in the Dampier or Montebello MPs. OTUs labelled with the prefix '0BA' in Table 11 could not be match to existing OTUs and are likely to be either new species or new records for the area. In Table 11 we also listed the OTUs previously recorded for the study area in the WAM database. The table shows that the great majority of species and OTUs, especially in the Montebello MP, were not found in this study. This is likely to be a consequence that sponge species boundaries are fuzzy and subjective, which inevitably results in different interpretations by sponge taxonomists of the same species or OTUs. However, is also likely that the sponge diversity of this area is extremely high and has not been captured in full by this or previous surveys.

Of the 153 species, 110 were collected in the Dampier MP and 76 were collected from the Montebello MP. Species found in both MPs are shown in Table 13. These can be considered the most common species of these two areas and represent 22% of the species found. These species belong to a diverse number of families shown in Figure 87). The families with the greatest number of species were Raspailiidae, followed by the Callyspongiidae and Axinellidae (Figure 87). The most common species in these families were *Echinodictyum mesenterinum, Arenosclera WAM sp. 1 cf.* and *Axinella aruensis* (variety II) respectively (Figure 88). The remaining species (78%) occurred only once either in the Dampier MP or in the Montebello MP (Table 11).

Species did not occur evenly throughout the MPs. In the Dampier MP there were 93 species at site W4 and only 3 species at site W8 (in the Habitat Protection Zone of the MP). In the Montebello MP, 51 of the 76 species were recorded at the shallowest site W14 (48–50 m). The other sites had only between one and 15 species.

4.4.3 Conclusions

The Dampier and Montebello MPs hold a high diversity of sponge species, mostly from the Class Demospongiae with approximately 153 species reported only in this study. Thirty eight out of 101 families of this class were found in the study area. Raspailiidae, Callyspongiidae and Axinellidae are strongly represented and include species that were sorted in the morphotype category 'Erect'. Most of these species are flexible with a branching/tree-like morphology and are attached to the substrate with narrow bases. These types of species are generally found in soft bottom substrates with high currents and turbid conditions (Hooper, 1991).

Approximately 59 sponge species found here have not been recorded for this area either by ALA or by the WAM database. Despite some of those potentially having been reported under another name as a consequence of inconsistencies in the interpretation of species by sponge taxonomists, it is likely that many of the founded species and OTUs are new records for the area reflecting that the full diversity has not been captured by this or another surveys. Most species found (78%) were singletons suggesting the area has high levels of endemism.

Full taxonomic documentation and even genetic studies are necessary to fine-tune the sponge diversity knowledge of what appear to be a highly diverse area as reported by previous studies. The standardisation of sponge identifications done by different taxonomists is an essential step to achieve this. However, there is no doubt that the area supports one of the highest sponge diversities recorded for Australian waters.

Figure 86. Examples of some of the sponge morphotypes sorted by size categories during the 2017 survey

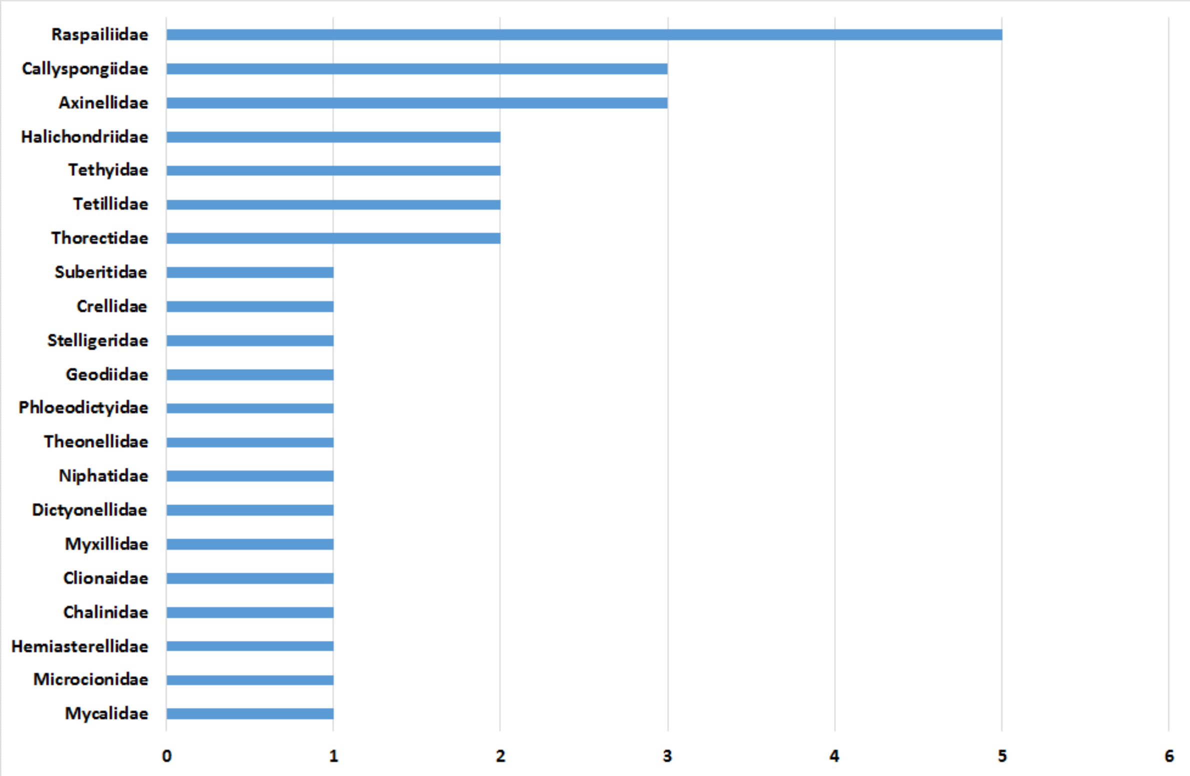


Figure 87. Sponge families found in Dampier and Montebello MPs sorted by number of occurrences.

Figure 88. Common sponge species found in Dampier and Montebello MPs. A–B *Echinodictyum mesenterinum,* B, *Arenosclera WAM sp. 1 cf.* D-E *Axinella aruensis* varieties.

Table 11. List of sponge species and their higher taxonomic classification found in the Dampier and Montebello MPs. 'cf.': specimens that lack some of the diagnostic characteristics of the species. '?': specimens that could not be identified beyond the level of genus. 1: means presence in the samples from that station. There were no sponges in station W80

CLASS	ORDER	FAMILY	GENUS	SPECIES/OTUs	Dampier MP			Montebello MP							
					W4	W6	W8	W14	W49	W50	W81	W82	W97	W79	Number of occurrences
Calcarea	Clathrinida	Leucetiidae	*Leucetta*	?	1										1
Demospongiae	Axinellida	Axinellidae	*Axinella*	*aruensis* I				1							1
Demospongiae	Axinellida	Axinellidae	*Axinella*	?			1								1
Demospongiae	Axinellida	Axinellidae	*Axinella*	*aruensis*	1										1
Demospongiae	Axinellida	Axinellidae	*Axinella*	WAM sp. Ng3 cf.	1										1
Demospongiae	Axinellida	Axinellidae	*Axinella*	*sinoxea* cf.	1										1
Demospongiae	Axinellida	Axinellidae	*Axinella*	*aruensis* II	1	1		1							3
Demospongiae	Axinellida	Axinellidae	*Dragmacidon*	0BA1		1		1							2
Demospongiae	Axinellida	Axinellidae	*Phakellia*	*tropicalis* cf.	1										1
Demospongiae	Axinellida	Axinellidae	*Phycopsis*	*pesgalli*	1										1
Demospongiae	Axinellida	Axinellidae	*Pipestela*	*occidentalis*	1										1
Demospongiae	Axinellida	Axinellidae	*Ptilocaulis*	*spiculifer* cf.	1										1
Demospongiae	Axinellida	Axinellidae	*Reniochalina*	WAM0006	1	1									2
Demospongiae	Axinellida	Axinellidae	*Reniochalina*	*stalagmitis*	1	1		1							3
Demospongiae	Axinellida	Heteroxyidae	*Myrmekioderma*	*granulata*	1										1
Demospongiae	Axinellida	Raspailiidae	*Ceratopsion*	0BA1	1										1
Demospongiae	Axinellida	Raspailiidae	*Ceratopsion*	*montebelloensis*	1	1									2
Demospongiae	Axinellida	Raspailiidae	*Ceratopsion*	*palmatum*	1	1		1	1		1				5
Demospongiae	Axinellida	Raspailiidae	*Echinodictyum*	*clathrioides*				1							1
Demospongiae	Axinellida	Raspailiidae	*Echinodictyum*	*conulosum*	1										1
Demospongiae	Axinellida	Raspailiidae	*Echinodictyum*	*cancellatum* cf.					1						1
Demospongiae	Axinellida	Raspailiidae	*Echinodictyum*	*cancellatum*	1	1									2
Demospongiae	Axinellida	Raspailiidae	*Echinodictyum*	*mesenterinum*	1	1	1	1							4
Demospongiae	Axinellida	Raspailiidae	*Ectyoplasia*	*vannus*	1										1
Demospongiae	Axinellida	Raspailiidae	*Ectyoplasia*	*tabula*	1	1			1						3

Demospongiae	Axinellida	Raspailiidae	*Raspailia*	*compressa*		1									1
Demospongiae	Axinellida	Raspailiidae	*Raspailia*	0BA1	1										1
Demospongiae	Axinellida	Raspailiidae	*Raspailia*	*vestigifera*	1				1						2
Demospongiae	Axinellida	Raspailiidae	*Raspailia (Clathriodendron)*	*keriontria*	1										1
Demospongiae	Axinellida	Raspailiidae	*Sollasella*	WAM n sp.					1						1
Demospongiae	Axinellida	Raspailiidae	*Thrinacophora*	*cervicornis*	1										1
Demospongiae	Axinellida	Raspailiidae	*Trikentrion*	*flabelliforme*	1	1		1							3
Demospongiae	Axinellida	Stelligeridae	*Higginsia*	*mixta*	1	1		1							3
Demospongiae	Bubarida	Dictyonellidae	*Acanthella*	*pulcherrima*	1										1
Demospongiae	Bubarida	Dictyonellidae	*Acanthella*	*cavernosa* cf.		1									1
Demospongiae	Bubarida	Dictyonellidae	*Acanthella*	*pulcherrima* cf.	1	1									2
Demospongiae	Bubarida	Dictyonellidae	*Phakettia*	*virgultosa*	1										1
Demospongiae	Bubarida	Dictyonellidae	*Phakettia*	*euctimena*	1			1							2
Demospongiae	Bubarida	Dictyonellidae	*Stylissa*	*carteri*	1										1
Demospongiae	Bubarida	Dictyonellidae	*Stylissa*	*carteri* cf.				1							1
Demospongiae	Clionaida	Clionaidae	*Spheciospongia*	*congenera*	1										1
Demospongiae	Clionaida	Clionaidae	*Spheciospongia*	*vagabunda*	1	1		1							3
Demospongiae	Clionaida	Placospongiidae	*Placospongia*	*melobesioides* cf.	1										1
Demospongiae	Dendroceratida	Darwinellidae	Darwinellidae_unknown genus	?	1										1
Demospongiae	Dendroceratida	Darwinellidae	*Dendrilla*	*lacunosa*	1										1
Demospongiae	Dendroceratida	Dictyodendrillidae	*Dictyodendrilla*	0BA1	1	1									2
Demospongiae	Dictyoceratida	Dysideidae	*Dysidea*	0BA1	1										1
Demospongiae	Dictyoceratida	Dysideidae	*Dysidea*	0BA2	1										1
Demospongiae	Dictyoceratida	Dysideidae	*Euryspongia*	0BA1				1							1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	0BA4					1						1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	0BA1		1									1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	0BA2							1				1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	0BA3							1				1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	*irregularis* cf.				1							1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	*pinna* cf.						1					1

Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	NTM sp. 0089/WAMSI Ircinia sp. 1	1										1
Demospongiae	Dictyoceratida	Irciniidae	*Ircinia*	*irregularis*	0	0	0	0	1	1	1	1	1		5
Demospongiae	Dictyoceratida	Irciniidae	*Sarcotragus*	WAM sp. PB1								1	1		2
Demospongiae	Dictyoceratida	Spongiidae	*Coscinoderma*	0BA1	1										1
Demospongiae	Dictyoceratida	Spongiidae	*Hippospongia*	0BA1		1									1
Demospongiae	Dictyoceratida	Spongiidae	*Hippospongia*	0BA2	1	1									2
Demospongiae	Dictyoceratida	Spongiidae	*Hyattella*	*intestinalis* cf.		1									1
Demospongiae	Dictyoceratida	Spongiidae	*Hyattella*	WAM sp. 1 cf.				1							1
Demospongiae	Dictyoceratida	Spongiidae	*Hyattella*	?	1										1
Demospongiae	Dictyoceratida	Spongiidae	*Hyattella*	WAM sp.1 cf.	1										1
Demospongiae	Dictyoceratida	Spongiidae	*Spongia*	0BA1		1									1
Demospongiae	Dictyoceratida	Thorectidae	*Aplysinopsis*	NTM sp. 017	1	1									2
Demospongiae	Dictyoceratida	Thorectidae	*Dactylospongia*	0BA1	1										1
Demospongiae	Dictyoceratida	Thorectidae	*Fascaplysinopsis*	0BA1	1										1
Demospongiae	Dictyoceratida	Thorectidae	*Hyrtios*	0BA1	1										1
Demospongiae	Dictyoceratida	Thorectidae	*Strepsichordaia*	0BA1	1							1			2
Demospongiae	Dictyoceratida	Thorectidae	*Thorectandra*	*excavatus*	1			1							2
Demospongiae	Dictyoceratida	Thorectidae	Thorectidae unknown genus_1	0BA1				1			1			1	3
Demospongiae	Dictyoceratida	Thorectidae	Thorectidae unknown genus_2	0BA1	1										1
Demospongiae	Haplosclerida	Callyspongiidae	*Arenosclera*	WAM sp. EG1	1										1
Demospongiae	Haplosclerida	Callyspongiidae	*Arenosclera*	WAM sp. 1		1									1
Demospongiae	Haplosclerida	Callyspongiidae	*Arenosclera*	WAM sp. 1 cf.	1			1							2
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia*	WAM sp. 2				1							1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Callyspongia)*	WAM sp. K1						1					1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Callyspongia)*	WAM sp. SS1 cf.				1							1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Cladochalina)*	*aerizuza* cf.				1							1
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Toxochalina)*	WAM sp.1 cf.							1				1

Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Toxochalina)*	WAM sp. 2		1		1							2
Demospongiae	Haplosclerida	Callyspongiidae	*Callyspongia (Toxochalina)*	WAM sp. 1	1								1		2
Demospongiae	Haplosclerida	Chalinidae	*Chalinula*	0BA1				1							1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Gellius)*	NTM sp. 146	1			1							2
Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Haliclona)*	0BA1				1							1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Haliclona)*	0BA2				1							1
Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Reniera)*	0BA1	1										1
Demospongiae	Haplosclerida	Niphatidae	*Amphimedon*	WAM sp.3 cf.		1									1
Demospongiae	Haplosclerida	Niphatidae	*Amphimedon*	*paraviridis* cf.	1	1		1	1						4
Demospongiae	Haplosclerida	Niphatidae	*Cribrochalina*	0BA1								1			1
Demospongiae	Haplosclerida	Niphatidae	*Gelliodes*	WAM sp. KMB1 cf.							1				1
Demospongiae	Haplosclerida	Niphatidae	*Gelliodes*	WAM sp. KMB1				1			1				2
Demospongiae	Haplosclerida	Niphatidae	*Niphates*	0BA1							1				1
Demospongiae	Haplosclerida	Petrosiidae	*Acanthostrongylophora*	*ashmorica*							1				1
Demospongiae	Haplosclerida	Petrosiidae	*Petrosia*	?	1										1
Demospongiae	Haplosclerida	Phloeodictyidae	*Oceanapia*	*ramsayi* cf.				1							1
Demospongiae	Haplosclerida	Phloeodictyidae	*Oceanapia*	*macrotoxa*				1							1
Demospongiae	Haplosclerida	Phloeodictyidae	*Oceanapia*	WAM sp. SS3	1				1	1					3
Demospongiae	Haplosclerida	Phloeodictyidae	Phloeodictyidae unknown genus_1	0BA1								1			1
Demospongiae	Haplosclerida	Phloeodictyidae	*Siphonodictyon*	WAM sp. KB1	1										1
Demospongiae	Poecilosclerida	Crellidae	*Crella (Yvesia)*	WAM sp. SS1	1	1		1							3
Demospongiae	Poecilosclerida	Desmacididae	*Desmacidon*	WAM sp. SS1 cf.				1							1
Demospongiae	Poecilosclerida	Hymedesmiidae	*Hymedesmia*	dichela ?	1										1
Demospongiae	Poecilosclerida	Hymedesmiidae	*Phorbas*	WAM CERF sp. 1 cf.	1										1
Demospongiae	Poecilosclerida	Iotrochotidae	*Iotrochota*	*baculifera* cf.	1										1
Demospongiae	Poecilosclerida	Iotrochotidae	*Iotrochota*	*baculifera*				1							1
Demospongiae	Poecilosclerida	Iotrochotidae	*Iotrochota*	NTM sp. 0233	1										1
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	*reinwardti*		1									1
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	*abietina* cf.	1										1
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	*erecta*	1	1									2

Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	WAM sp. Ng1	1	1									2
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	*abietina*	1	1									2
Demospongiae	Poecilosclerida	Microcionidae	*Clathria (Thalysias)*	*vulpina*	1	1		1							3
Demospongiae	Poecilosclerida	Mycalidae	*Mycale(Aegogropila)*	WAM sp. 2		1									1
Demospongiae	Poecilosclerida	Mycalidae	*Mycale(Aegogropila)*	WAM sp.1	1			1							2
Demospongiae	Poecilosclerida	Myxillidae	*Psammochela*	*tutiae* cf.	1										1
Demospongiae	Poecilosclerida	Myxillidae	*Psammochela*	*tutiae*	1		1	1							3
Demospongiae	Poecilosclerida	Podospongiidae	*Diacarnus*	WAM sp. SS1	1										1
Demospongiae	Poecilosclerida	Tedaniidae	*Tedania*	WAM sp. EG1				1							1
Demospongiae	Suberitida	Halichondriidae	*Amorphinopsis*	*excavans*		1		1			1	1	1		5
Demospongiae	Suberitida	Halichondriidae	*Axinyssa*	*berquistae* cf.				1							1
Demospongiae	Suberitida	Halichondriidae	*Ciocalypta*	*stalagmitis*	1										1
Demospongiae	Suberitida	Halichondriidae	*Halichondria*	*phakellioides*	1			1							2
Demospongiae	Suberitida	Halichondriidae	*Hymeniacidon*	WAM sp. SS4 c.f	1										1
Demospongiae	Suberitida	Halichondriidae	*Hymeniacidon*	WAM sp. SS4 cf.		1									1
Demospongiae	Suberitida	Suberitidae	*Aaptos*	0BA1	1										1
Demospongiae	Suberitida	Suberitidae	*Caulospongia*	*biflabellata*	1										1
Demospongiae	Suberitida	Suberitidae	*Caulospongia*	*amplexa*	1			1							2
Demospongiae	Tethyida	Hemiasterellidae	*Axos*	*flabelliformis*		1		1							2
Demospongiae	Tethyida	Tethyidae	*Tethya*	*ingalli* cf.				1	1						2
Demospongiae	Tethyida	Tethyidae	*Tethya*	*robusta* cf.	1	1		1							3
Demospongiae	Tethyida	Tethyidae	*Xenospongia*	*patelliformis*	1				1						2
Demospongiae	Tetractinellida	Ancorinidae	*Asteropus*	?	1										1
Demospongiae	Tetractinellida	Ancorinidae	*Jaspis*	WAM sp. SS2?	1	1									2
Demospongiae	Tetractinellida	Ancorinidae	*Psammastra*	WAM sp. SS1 cf.				1							1
Demospongiae	Tetractinellida	Ancorinidae	*Rhabdastrella*	*globostellata*		1									1
Demospongiae	Tetractinellida	Ancorinidae	*Stelletta*	*clavosa* cf.					1						1
Demospongiae	Tetractinellida	Ancorinidae	*Stelletta*	WAM sp.CERF 2				1	1		1	1			4
Demospongiae	Tetractinellida	Geodiidae	*Geodia*	WAM sp. CERF3	1			1							2
Demospongiae	Tetractinellida	Tetillidae	*Cinachyrella*	NTM sp. 259	1										1
Demospongiae	Tetractinellida	Tetillidae	*Cinachyrella*	WAM sp. SS2?					1						1
Demospongiae	Tetractinellida	Tetillidae	*Cinachyrella*	WAM sp. Ng1	1				1						2

Demospongiae	Tetractinellida	Tetillidae	*Cinachyrella*	*australiensis*	1	1		1							3
Demospongiae	Tetractinellida	Tetillidae	*Tetilla*	WAM sp. SS1				1							1
Demospongiae	Tetractinellida	Theonellidae	*Theonella*	*levior* cf.	1			1							2
Demospongiae	Trachycladida	Trachycladidae	*Trachycladus*	*laevispirulifer*							1				1
Demospongiae	Verongiida	Aplysinellidae	Aplysinidae unknown genus_1	?	1										1
Demospongiae	Verongiida	Ianthellidae	*Ianthella*	?	1										1
Demospongiae	Verongiida	Ianthellidae	*Ianthella*	*flabelliformis*	1	1									2
Demospongiae	Verongiida	Pseudoceratinidae	*Pseudoceratina*	0BA1				1							1
Demospongiae	Verongiida	Pseudoceratinidae	*Pseudoceratina*	0BA2	1										1
Number of occurencies					**93**	**41**	**3**	**51**	**15**	**4**	**13**	**7**	**4**	**1**	**232**

Table 12. List of sponge species previously described and their higher taxonomic classification found in the Dampier and Montebello MPs. 'cf.': specimens that lack some of the diagnostic characteristics of the species. '?': specimens that could not be identified beyond the level of genus. 1: means presence in the samples from that station. * new records for the Pilbara region.

CLASS	ORDER	FAMILY	GENUS	SPECIES/OTUs	Dampier MP			Montebello MP					
					W4	W6	W8	W14	W49	W50	W81	W82	W97
Demospongiae	Axinellida	Axinellidae	*Axinella*	*aruensis*	1			1					
				aruensis I				1					
				aruensis II	1	1		1					
				sinoxea cf.	1								
			Phakellia	*tropicalis cf.*	1								
			Phycopsis	*pesgalli**	1								
			Pipestela	*occidentalis*	1								
			Ptilocaulis	*spiculifer cf. **	1								
			Reniochalina	*stalagmitis*	1	1		1					
		Heteroxyidae	*Myrmekioderma*	*granulata*	1								
		Raspailiidae	*Ceratopsion*	*montebelloensis*	1	1							
				palmatum	1	1		1	1		1		
			Echinodictyum	*cancellatum*	1	1							
				cancellatum cf.					1				
				clathrioides				1					
				conulosum	1								
				mesenterinum	1	1	1	1					
			Ectyoplasia	*tabula*	1	1			1				
				vannus	1								
			Raspailia	*compressa*		1							
				vestigifera	1				1				
			Raspailia (Clathriodendron)	*keriontria*	1								
			Thrinacophora	*cervicornis*	1								
			Trikentrion	*flabelliforme*	1	1		1					

		Stelligeridae	*Higginsia*	*mixta*	1	1		1					
	Bubarida	Dictyonellidae	*Acanthella*	*cavernosa cf.*		1							
				pulcherrima	1								
				pulcherrima cf.	1	1							
			Phakettia	*euctimena*	1			1					
				*virgultosa**	1								
			Stylissa	*carteri*	1								
				carteri cf.				1					
	Clionaida	Clionaidae	*Spheciospongia*	*congenera**	1								
				vagabunda	1	1		1					
		Placospongiidae	*Placospongia*	*melobesioides cf.*	1								
	Dendroceratida	Darwinellidae	*Dendrilla*	*lacunosa**	1								
	Dictyoceratida	Irciniidae	*Ircinia*	*irregularis*					1	1	1	1	1
				irregularis cf.				1					
				*pinna cf.**						1			
		Spongiidae	*Hyattella*	*intestinalis cf.*		1							
		Thorectidae	*Thorectandra*	*excavatus*	1			1					
	Haplosclerida	Callyspongiidae	*Callyspongia (Cladochalina)*	*aerizuza cf.*				1					
		Niphatidae	*Amphimedon*	*paraviridis cf.*	1	1		1	1				
		Petrosiidae	*Acanthostrongylophora*	*ashmorica*							1		
		Phloeodictyidae	*Oceanapia*	*macrotoxa*				1					
				ramsayi cf.				1					
	Poecilosclerida	Hymedesmiidae	*Hymedesmia*	*dichela cf. **	1								
		Iotrochotidae	*Iotrochota*	*baculifera*				1					
				*baculifera cf.**	1								
		Microcionidae	*Clathria (Thalysias)*	*abietina*	1	1							
				abietina cf.	1								
				erecta	1	1							
				reinwardti		1							
				vulpina	1	1		1					
		Myxillidae	*Psammochela*	*tutiae**	1		1	1					

				tutiae cf.	1								
	Suberitida	Halichondriidae	*Amorphinopsis*	*excavans**		1		1			1	1	1
			Axinyssa	*berquistae cf.*				1					
			Ciocalypta	*stalagmitis*	1								
			Halichondria	*phakellioides*	1			1					
		Suberitidae	*Caulospongia*	*amplexa*	1			1					
				biflabellata	1								
	Tethyida	Hemiasterellidae	*Axos*	*flabelliformis*		1		1					
		Tethyidae	*Tethya*	*ingalli cf.**				1	1				
				*robusta cf.**	1	1		1					
			Xenospongia	*patelliformis*	1				1				
	Tetractinellida	Ancorinidae	*Rhabdastrella*	*globostellata*		1							
			Stelletta	*clavosa cf.*					1				
		Tetillidae	*Cinachyrella*	*australiensis*	1	1		1					
		Theonellidae	*Theonella*	*levior cf.*	1			1					
	Trachycladida	Trachycladidae	*Trachycladus*	*laevispirulifer*							1		
	Verongiida	Ianthellidae	*Ianthella*	*flabelliformis*	1	1							

Table 13. Species found at least once in both the Dampier MP and the Montebello MP.

ORDER	FAMILY	SPECIES
Axinellida	Axinellidae	*Axinella aruensis II*
Axinellida	Axinellidae	*Dragmacidon 0BA1*
Axinellida	Axinellidae	*Reniochalina stalagmitis*
Axinellida	Raspailiidae	*Ceratopsion palmatum*
Axinellida	Raspailiidae	*Echinodictyum mesenterinum*
Axinellida	Raspailiidae	*Ectyoplasia tabula*
Axinellida	Raspailiidae	*Raspailia vestigifera*
Axinellida	Raspailiidae	*Trikentrion flabelliforme*
Axinellida	Stelligeridae	*Higginsia mixta*
Bubarida	Dictyonellidae	*Phakettia euctimena*
Clionaida	Clionaidae	*Spheciospongia vagabunda*
Dictyoceratida	Thorectidae	*Strepsichordaia 0BA1*
Dictyoceratida	Thorectidae	*Thorectandra excavatus*
Haplosclerida	Callyspongiidae	*Arenosclera WAM sp. 1 cf.*
Haplosclerida	Callyspongiidae	*Callyspongia (Toxochalina) WAM sp. 1*
Haplosclerida	Callyspongiidae	*Callyspongia (Toxochalina) WAM sp. 2*
Haplosclerida	Chalinidae	*Haliclona (Gellius) NTM sp. 146*
Haplosclerida	Niphatidae	*Amphimedon paraviridis cf.*
Haplosclerida	Phloeodictyidae	*Oceanapia WAM sp. SS3*
Poecilosclerida	Crellidae	*Crella (Yvesia) WAM sp. SS1*
Poecilosclerida	Microcionidae	*Clathria (Thalysias) vulpina*
Poecilosclerida	Mycalidae	*Mycale(Aegogropila) WAM sp.1*
Poecilosclerida	Myxillidae	*Psammochela tutiae*
Suberitida	Halichondriidae	*Amorphinopsis excavans*
Suberitida	Halichondriidae	*Halichondria phakellioides*
Suberitida	Suberitidae	*Caulospongia amplexa*
Tethyida	Hemiasterellidae	*Axos flabelliformis*
Tethyida	Tethyidae	*Tethya robusta cf.*
Tethyida	Tethyidae	*Xenospongia patelliformis*
Tetractinellida	Geodiidae	*Geodia WAM sp. CERF3*
Tetractinellida	Tetillidae	*Cinachyrella australiensis*
Tetractinellida	Tetillidae	*Cinachyrella WAM sp. Ng1*
Tetractinellida	Theonellidae	*Theonella levior cf.*

Table 14. Sponge species and OTUs recorded by ALA and WAM for the Dampier MP and the Montebello MP. Some of those were also found in this survey and indicated in the column on the far right

Species Name/OTU	Authority	Reported by ALA	Recorded in WAM	Recorded in this work
Dampier MP				
Axinella WAM sp. Ng3			x	x
Reniochalina stalagmitis	Lendenfeld, 1888	x		x
Echinodictyum cancellatum	(Lamarck, 1814)	x		x
Trikentrion flabelliforme	Carter, 1882	x		x
Hyattella intestinalis	(Lamarck, 1814)	x		x
Psammocinia WAM sp. 6			x	
Sarcotragus WAM sp. 3			x	
Fenestraspongia WAM sp. 1			x	
Clathria (Thalysias) abietina	(Lamarck, 1814)	x		
Axos flabelliformis	Carter, 1879	x		x
Xenospongia patelliformis	Gray, 1858	x		
Montebello MP				
Axinella aruensis Type I	(Hentschel, 1912)		x	x
Axinella aruensis Type II	(Hentschel, 1912)		x	x
Axinella WAM sp.			x	x
Axinella WAM sp. Ng3			x	
Axinella WAM sp. SS2			x	
Cymbastela stipitata	(Bergquist & Tizard, 1967)		x	
Phakellia			x	
Ptilocaulis WAM sp. P1			x	
Reniochalina stalagmitis	Lendenfeld, 1888		x	x
Myrmekioderma granulatum cf.			x	
Ceratopsion montebelloensis	Hooper, 1991	x		x
Ceratopsion palmata	Hooper, 1991	x		x
Echinodictyum cancellatum	(Lamarck, 1814)		x	x
Echinodictyum clathrioides	Hentschel, 1911		x	x
Echinodictyum mesenterinum	(Lamarck, 1814)	x	x	x
Ectyoplasia tabula	(Lamarck, 1814)		x	x
Ectyoplasia vannus	Hooper, 1991		x	x
Raspailia clathrata cf.			x	
Raspailia wardi	Hooper, 1991		x	
Trikentrion flabelliforme	Hentschel, 1912		x	x
Higginsia massalis	Carter, 1885	x		
Higginsia mixta cf.			x	x
Higginsia scabra cf.	Whitelegge, 1907		x	
Higginsia WAM sp.			x	
Biemna WAM sp.			x	
Sigmaxinella WAM sp. SS1			x	
Acanthella cavernosa cf.			x	x
Acanthella pulcherrima	Ridley & Dendy, 1886		x	x

Species Name/OTU	Authority	Reported by ALA	Recorded in WAM	Recorded in this work
Phakettia euctimena	(Hentschel, 1912)		x	x
Spheciospongia WAM sp. 3 cf.			x	
Spheciospongia WAM sp. K1 cf.			x	
Spheciospongia vagabunda cf.			x	x
Spheciospongia WAM sp.			x	
Spheciospongia WAM sp. A2			x	
Spheciospongia WAM sp. PB1			x	
Placospongia melobesioides cf.			x	x
Ircinia WAM sp. cf.			x	
Psammocinia bulbosa			x	
Psammocinia WAM sp.			x	
Sarcotragus WAM sp. PB2			x	
Hippospongia WAM sp. SS1			x	
Hyattella intestinalis	(Lamarck, 1814)	x	x	x
Hyattella intestinalis cf.			x	x
Hyattella WAM sp.			x	
Cacospongia WAM sp. EG1			x	
Coscinoderma nardorus	(Lendenfeld, 1885)	x	x	
Carteriospongia WAM sp. 2			x	
Fasciospongia WAM sp. 1			x	
Arenosclera WAM sp. 1			x	x
Callyspongia WAM sp. KMB1 cf.			x	
Callyspongia WAM sp.			x	
Callyspongia WAM sp. 1			x	
Callyspongia WAM sp. 2			x	
Callyspongia WAM sp. KMB1			x	x
Callyspongia WAM sp. KMB3			x	
Haliclona WAM sp.			x	
Xestospongia testudinaria cf.			x	
Xestospongia WAM sp.			x	
Xestospongia WAM sp. 3			x	x
Xestospongia WAM sp. 5			x	x
Oceanapia ramsayi	(Lendenfeld, 1888)	x	x	
Oceanapia WAM sp. 6 cf.			x	x
Siphonodictyon WAM sp.			x	x
Chondropsis WAM sp. 1 cf.			x	
Chondropsis WAM sp. 1			x	
Lissodendoryx (Ectyodoryx) maculata	(Hentschel, 1911)	x	x	x
Crella WAM sp.			x	
Iotrochota acerata	Dendy, 1896	x	x	x
Iotrochota acerata cf.			x	x
Iotrochota WAM sp. 2			x	x
Antho frondifera			x	

Species Name/OTU	Authority	Reported by ALA	Recorded in WAM	Recorded in this work
Clathria (Thalysias) abietina	(Lamarck, 1814)	x	x	x
Clathria (Thalysias) lendenfeldi	Ridley & Dendy, 1886	x	x	
Clathria (Thalysias) vulpina	(Lamarck, 1814)	x	x	
Clathria (Thalysias) basilana	Lévi, 1961	x	x	
Clathria (Thalysias) WAM sp.			x	
Echinochalina intermedia			x	
Mycale WAM sp.			x	x
Tedania WAM sp.			x	x
Trachytedania WAM sp. EG1 cf.			x	x
Trachytedania WAM sp. EG1			x	x
Polymastia WAM sp. KMB2			x	x
Stylissa flabelliformis cf.			x	x
Stylissa flabelliformis			x	x
Stylissa WAM sp. SS1			x	x
Caulospongia plicata	Kent, 1871		x	
Ciocalypta stalagmites	Bowerbank, 1873		x	x
Aaptos aaptos	(Schmidt, 1864)	x	x	x
Aaptos WAM sp. KMB1			x	
Pseudosuberites andrewsi	Kirkpatrick, 1900	x	x	
Axos flabelliformis	Carter, 1879		x	x
Hemiasterella WAM sp.			x	
Tethya robusta cf.			x	x
Tethya robusta	(Bowerbank, 1873)		x	x
Disyringa WAM sp.			x	
Jaspis WAM sp. SS1			x	x
Stelletta clavosa	Ridley, 1884		x	x
Cinachyra WAM sp.			x	
Cinachyrella australiensis cf.			x	
Craniella WAM sp. SS1			x	

4.5 Crustaceans

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During the current survey a total of 348 lots of Crustacea were collected, from which 141 species or OTUs belonged to 40 families and 86 genera were identified (Table 15). Of these, 32 OTUs were not confidently assigned to a named species (e.g. *Gonodactylellus* sp., *Pilumnus* cf. *minutus, Periclimenes* sp.1), owing to the difficulty of identifying species in these groups, damage to specimens or the specimens being juveniles. The majority of species collected belonged to the order Decapoda (92%), as would be expected from the sampling methods used. Decapods were the most speciose group of crustaceans representing the most recognisable groups such as crabs and shrimp. Other crustacean groups such as the Isopoda and Amphipoda were not well represented in the collections, largely owing to their small size and were thus under-sampled. Other crustacean taxa, including

Stomatopoda and Cirripedia, were not as diverse. Rare species dominated the dataset with 54% and 15% of the species collected from only one or two stations, respectively. Only 3% of species were found at 10 or more stations.

The specimens were collected from 11 stations from within the Dampier MP (three) and Montebello MP (eight), which respectively, resulted in 41 and 307 crustacean lots. The difference in sampling effort was reflected in the diversity for each MP with 31 species identified from the Dampier MP with 29 of these recorded at only one station, and 128 (72 occurring at only one station) from the Montebello MP, with only 15 species shared between the two MPs. Given the adjacency of the two MPs and the similarity of habitats, a higher proportion of species were expected to be shared.Thus, the dissimilarity in samples between the two MPs in this study was largely a result of the difference in sampling effort and the high rate of singletons. In addition, sites in the Dampier MP were relatively shallow (30–35 m) compared with (50–70 m) at sites in the Montebello MP, which may also have influenced the dissimilarity. Taking into account the additional six Montebello MP stations surveyed in 2013 (Table 15) resulted in a total of 152 species of crustaceans from the 14 Montebello MP stations in 2013 (36 species) and 2017 (128 species) with just 12 species common between the two years, with 93 of these 152 species recorded at only a single station. Thus, rare species were predominant among the crustacean fauna.

4.5.1 Novelty

Over the last few decades the shallow water crustacean fauna of the NWS have been investigated under a number of biodiversity projects (Jones & Berry 2000; Hewitt 2004; Jones 2004; Peart 2004; Jones 2007; Keesing et al. 2011; Keesing et al. 2014; Hosie et al. 2015; Pitcher et al. 2016). Although there were few samples from the Dampier MP prior to this study, the crustaceans of the Dampier Archipelago have been relatively well studied, mostly because of the series of biodiversity surveys led by the WA Museum (Hewitt 2004; Jones 2004; Peart 2004 and Jones 2007) resulting in nearly 600 species recorded from the area. In contrast, the Montebello Islands have not been subjected to such intensive surveys and only 123 species were reported by Jones and Berry (2000), with an additional 172 species (or OTUs) were collected during a regional biodiversity survey in 2013 (PMCP study, Pitcher et al. 2016). This included 36 species collected from six sites within the Montebello MP (Table 15). Extrapolating from these reports show that the number of crustacean species in this part of the Pilbara coast approaches 900. Tallying an exact figure is difficult as comparing aspects of historical datasets can be problematic as taxonomic concepts change, especially when dealing with OTUs.

This the survey has yielded a significant increase in knowledge of crustaceans in the area and in the two MPs in particular. The present surveys recorded an additional 37 species in the region. From the current surveys 16 (52%) of the species identified from the Dampier MP had been not reported in previous surveys of the Dampier Archipelago. Similarly, 85 (11%) species collected from the Montebello MP were listed in Jones & Berry (2000) or identified during the study by Pitcher et al. (2016) and of these only 14 had been reported within the boundaries of the MP. Records held in the Atlas of Living Australia (ALA) prior to this project listed just 13 crustacean species recorded for the Dampier MP and 26 for the Montebello MP (Table 16). More than half of these were not recorded in our surveys perhaps due to a number of them being small nektonic species and due to the patern of rarity commented on above.

Of the newly identified records, five were new records for Australia: *Achaeus* cf. *villosus, Metapenaeopsis propinqua*, *Pagurus similis*, *Spiropagurus profundorum* (Figure 89) and *Xlumnus* cf. *nhatrangensis*, representing an extension of their known ranges from the Indo-Malay Archipelago, New Caledonia, Taiwan, Thailand and Vietnam, respectively. Among the species collected in the survey were a number of recently described species including the large spider crab *Paranaxia keesingi* Hosie & Hara, 2016*,* and the WA endemics *Galathea acerata* Macpherson & Robainas-Barcia, 2015 and *Lysmata dispar* Hayashi, 2007.

Figure 89. Examples of crustaceans sampled from Montebello MP. *Myra eudactylus* (bottom left), *Ciliopagrus krempfi* (top left) and *Spiropagurus profundorum* (right). The scale is in cm and mm and is similar in all photos.

4.5.2 Ecology

The crustacean composition reflects habitats dominated by non-scleractinian sessile organisms and/or soft sediments, with few coral reef associated species identified. This can be seen in the high diversity and abundance of groups such as the spider crabs (Majidae, Epialtidae & Inachidae) that use sessile invertebrates or macroalgae for camouflage; as well as the swimming crab genera *Lupocyclus* and *Portunus,* members of the families Pilumnidae and the Penaeidae, all of which exhibit clear preferences for sand or mudflats.

A significant number of commensal species were collected indicating a diverse sessile marine invertebrate fauna in the area. In particular the snapping shrimp *Synalpheus neomeris* was found in high abundance (58 individuals) at station W14 with only 10 other individuals collected at other stations during the study. This species is found exclusively on soft corals of the family Nephtheidae. Other cnidarian symbionts included *Porcellanella triloba*, found on sea pens, and *Xenocarcinus depressus* found on sea whips and fans. Other species such as *Allogalathea elegans*, *Gonatonotus pentagonus*, *S. comatularum*, *S. demani* and *S. stimpsoni* are all commensal with a variety of crinoid species.

While the dataset is characterised by a high proportion of rare species, the commonly collected species were typical for the habitats sampled. The top ten most common species (by site) included six species of Pilumnidae, two species of Porcellanidae, and the commercially important species *Thenus australiensis* (Moreton Bay Bug) (Figure 90) and *Metapenaeopsis mogiensis* (Velvet Prawn).

Species in these groups were among the most common numerically as well, in particular the porcellanid *Petrolisthes militaris*, a filter feeder, which is known to be a major component of the crustacean fauna in north Western Australia (Hewitt 2004; Keesing 2014; Hosie unpublished data).

Figure 90. The Moreton Bay bug *Thenus australiensis* was common in both the Dampier and Montebello MPs

Table 15. Species of crustaceans recorded from each station in the Dampier and Montebello MP survey areas. X means the species was collected from that station

Taxa	Dampier MP			Montebello MP (2017 voyage)								Montebello MP (PMCP 2013 study)					
	W8	W4	W6	W50	W49	W14	W82	W97	W81	W80	W79	PMCP 50	PMCP 62	PMCP 96	PMCP 100	PMCP 101	PMCP 102
HEXANAUPLIA																	
SESSILIA																	
ARCHAEOBALANIDAE																	
Striatobalanus amaryllis (Darwin, 1854)		X															
MALACOSTRACA																	
AMPHIPODA									X	X							
DECAPODA																	
ALBUNEIDAE																	
Paralbunea dayriti (Serène & Umali, 1965)				X													
ALPHEIDAE																	
Alpheus balaenodigitus Banner & Banner, 1982				X	X		X										
Alpheus bisincisus De Haan, 1849						X	X	X	X								
Alpheus edamensis De Man, 1888												X					
Alpheus edwardsii (Audouin, 1826)												X					
Alpheus hippothoe De Man, 1888		X															
Alpheus pareuchirus Coutière, 1905		X		X		X											
Alpheus strenuus strenuus Dana, 1952a												X					
Alpheus sp.																X	
Synalpheus comatularum (Haswell, 1882)		X		X		X											
Synalpheus demani Borradaile, 1900						X						X					
Synalpheus echinus Banner & Banner, 1975												X					
Synalpheus iocosta de Man, 1909							X										
Synalpheus neomeris (de Man, 1897)		X			X	X											
Synalpheus neptunus (Dana, 1852)		X															

Synalpheus pococki Coutière, 1898	X																
Synalpheus stimpsoni (de Man, 1888)						X	X		X			X				X	
Synalpheus streptodactylus Coutière, 1905							X	X	X								
ANCHISTIOIDIDAE																	
Anchistioides willeyi (Borradaile, 1900)						X											
CALAPPIDAE																	
Calappa capellonis Laurie, 1906				X													
Calappa woodmasoni Alcock, 1896				X							X						
Carpilius convexus (Forskål, 1775)						X											
DIOGENIDAE																	
Calcinus vachoni Forest 1958																	
Ciliopagurus krempfi (Forest, 1952)				X								X					
Dardanus crassimanus (H. Milne Edwards, 1836)												X					
Dardanus cf. imbricatus (H. Milne Edwards, 1848)	X																
Dardanus pedunculatus (Herbst, 1804)		X											X				
Dardanus setifer (H. Milne Edwards, 1836)					X		X		X		X	X					
Dardanus sp.											X						
Paguristes alcocki McLaughlin & Rahayu, 2005				X													
Paguristes cf. gonagrus (H. Milne Edwards, 1836)											X						
DORIPPIDAE																	
Dorippe quadridens (Fabricius, 1793)											X						
EPIALTIDAE																	
Austrolibinia gracilipes (Miers, 1879)											X						
Hoplophrys oatesii Henderson, 1893						X											
Huenia proteus De Haan, 1839												X					
Hyastenus borradailei (Rathbun, 1907)		X															
Hyastenus cf. planasius (Adams & White, 1848)					X												

Hyastenus diacanthus (De Haan, 1839)					X								X				
Hyastenus sebae White, 1847		X															
Paranaxia keesingi Hosie & Hara, 2016						X											
Phalangipus cf. australiensis Rathbun, 1918					X	X				X	X						
Phalangipus cf. longipes (Linnaeus, 1758)				X			X	X	X								
Phalangipus sp.										X							
Picrocerus armatus A. Milne-Edwards, 1865		X															
Xenocarcinus depressus Miers, 1874		X															
EURYPLACIDAE																	
Eucrate sp. 1		X															
GALATHEIDAE																	
Allogalathea elegans (Adams & White, 1848)				X	X			X		X		X			X		X
Galathea acerata Macpherson & Robainas-Barcia, 2015						X	X										
Galathea sp1													X				
HYMENOSOMATIDAE																	
Trigonoplax spathulifera Lucas, 1980						X											
INACHIDAE																	
Achaeus brevirostris (Haswell, 1879)						X											
Achaeus cf. villosus Rathbun, 1916					X			X			X						
Achaeus lacertosus Stimpson, 1858									X								
Oncinopus cf. araneus (De Haan, 1839)								X									
LEUCOSIIDAE																	
Myra cf. curtimana Galil, 2001											X						
Myra curtimana Galil, 2001					X		X		X	X							
Myra eudactylus (Bell, 1855)											X						
Myrine kesslerii (Paul'son, 1875)					X						X						
LYSMATIDAE																	
Lysmata dispar Hayashi, 2007					X	X											

Lysmata vittata (Stimpson, 1860)				X			X	X									
MAJIDAE																	
Prismatopus longispinus (De Haan, 1839)				X					X								
Schizophrys dama (Herbst, 1804)		X										X	X				
Schizophrys rufescens Griffin & Tranter, 1986		X				X											
MATUTIDAE																	
Izanami inermis (Miers, 1884)																	X
PAGURIDAE																	
Nematopagurus cf. australis (Henderson, 1888)						X											
Pagurus similis (Ortmann, 1892)		X		X					X								
Spiropagurus profundorum Alcock, 1905				X							X						
PALAEMONIDAE																	
Conchodytes sp													X				
Periclimenaeus sp.1					X												
Periclimenes affinis (Zehntner, 1894)	X																
PANDALIDAE																	
Procletes levicarina (Spence Bate, 1888)							X										
PARTHENOPIDAE																	
Aulacolambrus curvispinus (Miers, 1879)														X			
Parthenope chondrodes Davie & Turner, 1994					X					X							
Parthenope longimanus (Linnaeus, 1758)									X	X	X						
Pseudolambrus cf. calappoides (Adams & White, 1849)					X												
Rhinolambrus spinifer (Haswell, 1880)				X													
PASIPHAEIDAE																	
Leptochela robusta Stimpson, 1860								X									
PENAEIDAE																	
Metapenaeopsis mogiensis Rathbun, 1902				X	X	X	X	X		X							

Metapenaeopsis novaeguineae (Haswell, 1879)										X							
Metapenaeopsis palmensis (Haswell, 1879)					X	X		X		X							
Metapenaeopsis propinqua Crosnier, 1991		X															
Metapenaeopsis rosea Racek & Dall, 1965											X						
Penaeidae									X								
Penaeus latisulcatus Kishinouye, 1896				X													
Trachypenaeus curvirostris (Stimpson, 1860)											X						
Trachypenaeus fulvus (Balss, 1933)										X							
PILUMNIDAE																	
Actumnus setifer (De Haan, 1835)								X		X	X						
Actumnus squamosus (De Haan, 1835)	X			X	X		X	X	X								
Bathypilumnus cf. sinensis (Gordon, 1930)									X								
Bathypilumnus pugilator (A. Milne-Edwards, 1873)	X			X				X	X								X
Glabropilumnus seminudus (Miers, 1884)			X			X											
?*Glabropilumnus* sp. 1												X				X	
Gonatonotus pentagonus White, 1847					X				X								
Lentilumnus sp. 1				X	X		X	X	X		X						
Pilumnus digitalis Rathbun, 1923																X	
Pilumnus cf. fissifrons Stimpson, 1858		X															
Pilumnus cf. minutus De Haan, 1835		X		X				X	X								
Pilumnus cf. orbitospinis Rathbun, 1911						X											
Pilumnus cf. scabriusculus Adams & White, 1849				X			X	X	X								
Pilumnus tantulus Rathbun, 1923												X	X				
Pilumnus cf. tantulus Rathbun, 1923	X			X													
Pilumnus cf. terraereginae Haswell, 1882				X	X		X	X									
Pilumnus longicornis Hilgendorf, 1878						X											

Pilumnus pulcher Miers, 1884		X				X	X										
Pilumnus semilanatus Miers, 1884					X		X	X								X	
Pilumnus sp. 6							X										
Pilumnus sp. 9						X											
Serenolumnus?									X								
Tiaramedon spinosum (Miers, 1879)												X					
Xlumnus cf. nhatrangensis (Serène, 1971)						X											
PORCELLANIDAE																	
Aliaporcellana pygmaea (de Man, 1902)						X											
Aliaporcellana suluensis (Dana, 1852)								X									
Aliaporcellana telestophila (Johnson, 1958)					X												
Lissoporcellana furcillata (Haig, 1965)				X		X											
Lissoporcellana quadrilobata (Miers, 1884)				X	X	X		X									
Pachycheles sculptus (H. Milne Edwards, 1837)	X	X		X	X	X							X				
Petrolisthes militaris (Heller, 1862)		X			X	X	X	X	X			X	X			X	
Petrolisthes scabriculus (Dana, 1852)						X			X								
Polyonyx biunguiculatus (Dana, 1852)						X											
Polyonyx triunguiculatus Zehntner, 1894								X									
Porcellana habei Miyake, 1961													X				
Porcellanella triloba White, 1852					X		X		X								
PORTUNIDAE																	
Charybdis feriata (Linnaeus, 1758)							X										
Cycloachelous orbitosinus (Rathbun, 1911)				X	X			X									
Lupocyclus philippinensis Semper in Nauck, 1880								X		X							
Lupocyclus sexspinosus Alcock, 1899						X							X				
Monomia argentata (A Milne Edwards, 1861)				X	X		X			X	X						

Monomia pseudoargentatus (Stephenson, 1961)				X	X												
Thalamita annulipes Stephenson & Hudson, 1957				X													
Thalamita macropus Montgomery, 1931												X					
Thalamita sima H. Milne Edwards, 1834						X											
Thalamita cf spinifera Borradaile, 1902								X									
Thalamita spinifera Borradaile, 1902				X													
Xiphonectes rugosus (A. Milne-Edwards, 1861)						X											
Xiphonectes tuberculosus (A. Milne-Edwards, 1861)								X		X							
Portunus sp. 1																	X
RHYNCHOCINETIDAE																	
Rhynchocinetes						X											
SCYLLARIDAE																	
Eduarctus martensii (Pfeffer, 1881)												X					
Petrarctus rugosus (H. Milne Edwards, 1837)				X							X						
Scyllaridae unspecified							X	X									
Thenus australiensis Burton & Davie, 2007	X	X	X		X	X		X	X								
Sicyonia lancifer (Olivier, 1811)				X	X			X	X								
SOLENOCERIDAE																	
Solenocera rathbuni Ramadan, 1938					X		X										
STENOPODIDAE																	
Odontozona sculpticaudata Holthuis, 1946							X										
THALASSOCARIDIDAE																	
Thalassocaris crinita (Dana, 1852)						X											
UPOGEBIIDAE																	
Gebiacantha priochela Sakai, 1993								X									
XANTHIDAE																	
Actaea tuberculosa (Miers, 1884)													X				

Banareia sp.						X											
Calvactaea tumida Ward, 1933						X											
Epiactaea nodulosa (White, 1848)		X															
Liomera cinctimanus (White, 1847)						X											
Paramedaeus simplex (A. Milne-Edwards, 1873)						X											
Platypodia semigranosa (Heller, 1861)												X					
Xanthid sp.																	X
ISOPODA																	
CIROLANIDAE																	
Cirolanidae - unidentified		X															
Neocirolana hermitensis (Boone, 1918)					X												
CYMOTHOIDAE																	
Creniola sp.				X			X		X								
Cymothoidae									X								
Cymothoidae							X										
IDOTEIDAE																	
Lyidotea nodata Hale, 1929									X								
SPHAEROMATIDAE																	
Cilicaeopsis sp.				X													
STOMATOPODA																	
GONODACTYLIDAE																	
Gonodactylellus affinis (de Man, 1902)				X	X	X	X	X				X				X	
Gonodactylellus sp.										X	X						
PROTOSQUILLIDAE																	
Haptosquilla tuberosa (Pocock, 1893)							X	X		X	X						
SQUILLIDAE																	
Clorida cf. albolitura Ahyong & Naiyanetr, 2000							X										
Quollastria gonypetes (Kemp, 1911)								X									

Table 16. Crustacean species previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records). Only records with full species identification included. Those in bold were not recorded in the 2013 and 2017 surveys

Class	Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Malacostraca	**Amphipoda**	**Lysianassidae**	***Waldeckia enoei***	**1**	
Malacostraca	**Amphipoda**	**Phoxocephalidae**	***Birubius jirrandus***	**1**	
Malacostraca	**Cumacea**	**Gynodiastylidae**	***Gynodiastylis subtilis***		**1**
Malacostraca	**Decapoda**	**Alpheidae**	***Synalpheus locasta***		**4**
Malacostraca	Decapoda	Alpheidae	*Synalpheus neomeris*		4
Malacostraca	Decapoda	Alpheidae	*Synalpheus neptunus neptunus*		1
Malacostraca	Decapoda	Alpheidae	*Synalpheus pococki*		1
Malacostraca	Decapoda	Alpheidae	*Synalpheus streptodactylus*		1
Malacostraca	**Decapoda**	**Callianassidae**	***Cheramus propinquus***	**1**	
Malacostraca	**Decapoda**	**Crangonidae**	***Philocheras angustirostris***		**2**
Malacostraca	**Decapoda**	**Crangonidae**	***Philocheras victoriensis***		**1**
Malacostraca	Decapoda	Galatheidae	*Allogalathea elegans*	1	
Malacostraca	**Decapoda**	**Galatheidae**	***Galathea subsquamata***	**2**	
Malacostraca	**Decapoda**	**Galatheidae**	***Phylladiorhynchus pusillus***		**1**
Malacostraca	Decapoda	Hymenosomatidae	*Trigonoplax spathulifera*		1
Malacostraca	**Decapoda**	**Leucosiidae**	***Tokoyo eburnean***		**1**
Malacostraca	**Decapoda**	**Palaemonidae**	***Ancylomenes tosaensis***		**1**
Malacostraca	**Decapoda**	**Pasiphaeidae**	***Leptochela sydniensis***		**1**
Malacostraca	Decapoda	Porcellanidae	*Pachycheles sculptus*		1
Malacostraca	**Decapoda**	**Portunidae**	***Charybdis jaubertensis***		**1**
Malacostraca	**Decapoda**	**Portunidae**	***Laleonectes nipponensis***		**1**
Malacostraca	**Decapoda**	**Portunidae**	***Lissocarcinus laevis***		**1**
Malacostraca	**Decapoda**	**Portunidae**	***Lupocyclus rotundatus***		**2**
Malacostraca	**Decapoda**	**Portunidae**	***Portunus gladiator***		**1**
Malacostraca	Decapoda	Scyllaridae	*Thenus australiensis*	55	99
Malacostraca	**Decapoda**	**Upogebiidae**	***Upogebia darwinii***		**1**
Malacostraca	**Isopoda**	**Anthuridae**	***Apanthura pultenaea***		**1**
Malacostraca	**Isopoda**	**Arcturidae**	***Astacilla lewtonae***		**1**
Malacostraca	**Isopoda**	**Arcturidae**	***Neastacilla inaequispinosa***		**1**
Malacostraca	**Isopoda**	**Arcturidae**	***Neastacilla lawadi***	**2**	
Malacostraca	**Isopoda**	**Austrarcturellidae**	***Austrarcturella aphelura***	**1**	
Malacostraca	**Isopoda**	**Chaetiliidae**	***Stegidotea pinnata***		**1**
Malacostraca	**Isopoda**	**Cirolanidae**	***Cartetolana integra***	**1**	
Malacostraca	Isopoda	Idoteidae	*Lyidotea nodata*		1
Malacostraca	**Isopoda**	**Leptanthuridae**	***Accalathura triode***	**1**	
Malacostraca	**Leptostraca**	**Paranebaliidae**	***Levinebalia maria***		**1**
Malacostraca	**Stomatopoda**	**Eurysquillidae**	***Manningia australiensis***	**1**	
Malacostraca	**Stomatopoda**	**Gonodactylidae**	***Gonodactylaceus graphurus***	**1**	
Malacostraca	Stomatopoda	Protosquillidae	*Haptosquilla tuberosa*	1	

4.6 Molluscs

Lisa Kirkendale, Glad Hansen, Hugh Morrison, Corey Whisson and Nerida Wilson (Western Australian Museum)

4.6.1 Systematic summary

A total of 189 mollusc lots were collected during the 2017 expedition, from which 90 species or OTUs belonging to 53 families and 71 genera were identified (Table 17). Of these, 28 OTUs were not confidently assigned to a named species (e.g. *Sepiadarium* cf. *auritum* and *Aphelodoris* sp.), owing to the difficulty of identifying species in these groups, damage, lack of live photographs or being juvenile specimens. Approximately half of the lots were representatives from the Class Gastropoda (53%), which forms the majority of the malacofauna recovered in previous surveys in the region. Gastropods were the most speciose group of molluscs representing the most recognisable groups such as marine snails and also the popular nudibranchs or sea slugs. Bivalves comprised the next largest fraction with 41% of lots, as also found in previous expedition work in the area. Fifty four species or OTUs, approximately 29%, were singleton molluscs and observed only once. Interestingly, and in contrast with other such work, is the relatively good representation of cephalopods (6%). The trawl net used in this study, facilitated sampling of the midwater during deployment and retrieval facilitating the sampling of cephalopods such as squid.

There were 54 mollusc species (24 bivalve, 27 gastropod, 3 cephalopod) collected from the three Dampier MP sites with 48 species recorded at only one station. However the number of species at the three stations was quite uniform (17 at site W4, 24 at site W6 and 20 at site W8) (Table 17). The 2017 voyage collections have made a significant enhancement to the records of molluscs occurring in the Dampier MP. The ALA had only recorded three species from the Dampier MP prior to this study (Table 18) and the WA Museum collection only had seven species in its collection from the Dampier MP prior to this study (Table 19).

There were 75 mollusc species (21 bivalve, 47 gastropod, 7 cephalopod) collected in the Montebello MP from 14 sites in 2013 and 2017. Fifty-five (55) species were collected from only one station indicating that most species were rare or have a limited distribution. The number of species per station varied from one to 20 (Table 17). The 2017 voyage collections have made a significant enhancement to the records of molluscs occurring in the Montebello MP. The ALA had only recorded 14 species from the Montebello MP prior to this study (Table 18) and the WA Museum collection only had 24 species in its collection from the Montebello MP prior to this study (Table 19).

4.6.2 Novelty

Over the last few decades the shallow water molluscan fauna of the NWS has been investigated through a number of biodiversity initiatives (e.g. Keesing et. al. 2014; Willan et. al. 2015; Pitcher et. al. 2016). The molluscs of the Dampier Archipelago have been relatively well studied because of the biodiversity surveys collected over two expeditions in 1998 and 1999 led by the WA Museum (Slack-Smith & Bryce 2004) and an international workshop held at Dampier in 2000 (Wells et. al. 2003). These surveys at 70 stations resulted in 695 species recorded from the area. The Montebello Islands surveys recorded a similar number of species (631, Wells et. al. 2000), as did the Muiron Islands expedition (655 species, Slack-Smith & Bryce 1996). The present survey recorded many fewer species than these earlier expeditions but used only two sampling methods for subtidal benthic sampling in contrast to the previous multi-method surveys which sampled across a range of habitat types and included shallow and intertidal coral reef habitats.

Nonetheless, important taxa were recovered during the present study because of the focus on mid-deeper water sampling with emphasis on sampling soft bottom sediments using demersal ftrawl nets and the epibenthic biological sled. Highlights of the recent expedition include evolutionarily significant finds, those restricted to deeper water, as well as some unexpected abundances of certain taxa and important records from a conservation standpoint.

Bivalves

- *Limopsis (Petunculina)* sp. - there are approximately 30 members in the Limopsidae, a small family of bivalves related to the Arcidae (ark shells). These species are of evolutionary significance as they are among the few suspension feeding deep-sea bivalves. They are usually relatively small, byssate (i.e. attached to the sea floor by threads), with a thick often hairy (due to periostracum) shell. The one lot comprising two individuals taken alive during the cruise included relatively large bodied representatives of this family. Only 27 lots of live collected material exist in the WA Museum collections, most from Antarctica.

- *Pteria maccullochi* – found in abundance (18 lots) across study sites in the cruise area. This species, a NWS endemic was only recently described.

Gastropods

- Six records of deep sea Xenophoridae (carrier shell) *Xenophora cerea,* were recorded. Previously, only *Onustus indicus* was reported from the area (e.g. Slack-Smith & Bryce 2004 for Dampier). This latter species was also recorded during the cruise (one specimen).
- *Globovula cavanaghi* (ovulid) a rare species, only one of five live collected lots in WA Museum collections
- *Margovula* cf. *marginata* (ovulid) possibly a new species, only one of six lots of this genus in WA Museum collections
- *Dolomena* cf. *dilatatus* (strombid) a likely new species with this material providing the best example of the difference in morphology to Queensland/east coast forms
- *Duplicaria* n. sp. (auger) - likely a new species of Terebridae
- *Zoila decipiens* (cowrie) - rare and endemic cowrie in Western Australia (Figure 91)
- *Melo amphora* (baler)- iconic and significant volute in northern Australia
- *Syrinx aruanus* (conch) - the world's largest gastropod was found at three stations in the Montebello MP (Figure 92).

Cephalopods

- The three specimens of *Sepiadarium* cf. *auritum* from two sites in the Montebello MP are important as *S. auritum* is listed as data deficient with IUCN https://www.iucnredlist.org/species/162592/923904
- The *Sepioteuthis* group contains both the northern and southern species, suggesting a biogeographic overlap zone in the area of sampling.
- *Todarodes* cf. *pusillus* was the first registered record of this species in the WA Museum mollusc database

Much of the material was photographed and importantly,was subsequently preserved for genetic work that enables integrative (morphology and molecular) taxonomic work for comprehensive species delimitation.

4.6.3 Ecology

The faunal composition reflected habitats dominated by non-scleractinian sessile organisms and/or soft sediments, such as would be expected in sponge or soft coral rich habitats, with few molluscan coral reef specialists identified. This was seen in the high abundance of conspicuous *Pteria* or wing oysters (Pteriidae with 24 lots), which attach to sea fans and sea whips, as well as those found encrusting in rocks or limited hard substrates or islands (e.g. *Lima vulgaris*, Pectinidae, *Plicatula*) on mud/sand bottom. Heterobranch specialists, like *Philine* sp., *Euselenops luniceps* and *Armina* sp., which exhibit clear preferences for soft sediments, were also common.

Figure 91. The cone shell, *Conus trigonus* (left) and cowrie *Zoila decipiens* (right) collected from the Dampier MP.

Figure 92. The Australian trumpet shell, *Syrinx aruanus*, the world's largest gastropod was found at three stations in the the Montebello MP. This specimen is about 50 cm long.

Table 17. Species of molluscs recorded from each station in the Dampier and Montebello MP survey areas. X means the species was collected from that station

	Dampier MP			Montebello MP (2017 voyage)								Montebello MP (PMCP 2013 study)					
Taxa	W8	W4	W6	W50	W49	W14	W82	W97	W81	W80	W79	PMCP 50	PMCP 62	PMCP 96	PMCP 100	PMCP 101	PMCP 102
BIVALVIA																	
ARCIDAE																	
Barbatia stearnsi (Pilsbry, 1895)	X																
GLYCYMERIDIDAE																	
Glycymeris lamprelli Huber 2010													X				
Glycymeris persimilis (Iredale, 1939)		X															
Melaxinaea vitrea (Lamarck, 1819)							X										
LIMOPSIDAE																	
Pectunculina sp.											X						
CARDIIDAE																	
Acrosterigma sp.			X														
Cardites canaliculatus (Reeve, 1843)									X								
Megacardita nodulosa (Lamarck, 1819)			X							X							
LIMIDAE																	
Lima vulgaris		X	X	X			X		X			X	X			X	
MYTILIDAE																	
Modiolus philippinarum (Hanley, 1843)								X									
Stavelia subdistorta (Récluz, 1852)												X					
OSTREIDAE																	
Dendostrea folium (Linnaeus, 1758)		X											X				
Dendostrea sp.			X														
PTERIIDAE																	

Pteria broomei M. Huber, 2010		X	X														
Pteria cf. broomei			X														
Pteria cf. maccullochi		X															
Pteria gregata (Reeve, 1857)	X																
Pteria maccullochi (Iredale, 1939)		X	X			X							X				
Pteria sp.				X													
PECTINIDAE																	
Annachlamys flabellata (Lamarck, 1819)			X					X									
Complicachlamys wardiana Iredale, 1939		X															
Decatopecten strangei (Reeve, 1852)	X																
Mimachlamys scabricostata (Sowerby III, 1915)	X		X				X					X			X		
Semipallium dringi (Reeve, 1853)			X														
Semipallium fulvicostatum (A. Adams & Reeve, 1850)			X														
Ylistrum balloti (Bernardi, 1861)			X	X						X							
Plicatula plicata (Linnaeus, 1767)	X									X	X						
Spondylus victoriae G. B. Sowerby II, 1860	X	X	X	X	X		X		X								
TRIGONIIDAE																	
Neotrigonia uniophora (Gray in Jukes, 1847)								X									
VENERIDAE																	
Dosinia stabilis (Iredale, 1929)									X								
CHAMIDAE																	
Chama lazarus Linnaeus, 1758		X											X				
Chama cf. *lazarus*												X					
Chama pacifica Broderip, 1835		X										X					
Lutraria sp.			X														
GASTROPODA																	
PHILINIDAE																	
Philine sp.	X									X							
FISSURELLIDAE																	
Scutus unguis (Linnaeus, 1758)				X		X						X	X				
BURSIDAE																	

Bufonaria rana (Linnaeus, 1758)													X				
CAPULIDAE																	
Capulus sp.			X														
CYPRAEIDAE																	
Contradusta walkeri (G. B. Sowerby I, 1832)							X										
CYPRAEIDAE																	
Cypraeidae				X													
Erronea caurica (Linnaeus, 1758)												X					
Erronea subviridis (Reeve, 1835)				X												X	
Zoila decipiens (E. A. Smith, 1880)		X															
NATICIDAE																	
Natica sp.							X										
Natica stellata Hedley, 1913			X														
OVULIDAE																	
Globovula cavanaghi (Iredale, 1931)				X													
Margovula cf. marginata								X									
RANELLIDAE																	
Reticutriton pfeifferianus (Reeve, 1844)				X							X						
ROSTELLARIIDAE																	
Varicospira cancellata (Lamarck, 1816)			X														
STROMBIDAE																	
Dolomena cf. dilatatus							X										
Dolomena plicata (Röding, 1798)				X			X	X		X	X						
XENOPHORIDAE																	
Onustus indica				X													
Xenophora cerea (Reeve, 1845)	X			X				X									
Xenophora cf. cerea				X													
BUCCINIDAE																	
Peristernia sp.							X										
CONIDAE																	
Conus dampierensis Coomans & Filmer, 1985			X														

Conus sp.				X													
Conus trigonus Reeve, 1848		X															
FASCIOLARIIDAE																	
Fusinus colus (Linnaeus, 1758)	X		X	X													
Fusinus cf. gracillimus										X	X						
Fusinus cf. nicobaricus													X				
Nodolatirus recurvirostra (Schubert & Wagner, 1829)												X					
MITRIDAE																	
Imbricaria cf. interlirata										X							
MURICIDAE																	
Chicoreus cervicornis (Lamarck, 1822)							X	X		X							
Cronia sp.												X					
Hexaplex stainforthi (Reeve, 1843)		X															
Murex pecten Ponder & Vokes, 1988	X			X			X			X	X						
Muricidae (unidentified)	X																
Pterochelus acanthopterus (Lamarck, 1816)	X						X		X								
Pterochelus cf. acanthopterus												X					
Pterynotus alatus (Röding, 1798)	X									X	X						
cf. Morula sp.	X																
Vokesimurex multiplicatus (G.B. Sowerby III, 1895)													X				
NASSARIIDAE																	
Phos sculptilis R. B. Watson, 1886								X									
OLIVIDAE																	
Ancillista muscae (Pilsbry, 1926)								X	X						X		
TEREBRIDAE																	
Duplicaria cf. duplicata				X													
Terebra sp.											X						
TURBINELLIDAE																	
Syrinx aruanus (Linnaeus, 1758)					X		X		X								
Tudivasum inerme (Angas, 1878)								X									
TURRIDAE																	

Unedogemmula cf. indica	X																
VOLUTIDAE																	
Cymbiola nivosa (Smith, 1909)								X									
Melo amphora (Lightfoot, 1786)			X														
ARMINIDAE																	
Armina sp.					X												
DORIDIDAE																	
Aphelodoris gigas N. G. Wilson, 2003	X						X										
Aphelodoris karpa N. G. Wilson, 2003													X				
Aphelodoris sp.		X			X		X		X								
PHYLLIDIIDAE																	
Phyllidia ocellata Cuvier, 1804		X															
Phyllidia varicosa Lamarck, 1801						X											
POLYCERIDAE																	
Plocamopherus tilesii Bergh, 1877			X				X										
CF. DORIDIDAE																	
Doridina sp.		X							X								
PLEUROBRANCHAEIDAE																	
Euselenops luniceps (Cuvier, 1816)	X																X
CHILODONTAIDAE																	
Euchelus atratus (Gmelin, 1791)	X																
TROCHIDAE																	
Astele similaris (Reeve, 1863)	X						X	X									
Ethalia guamensis (Quoy & Gaimard, 1834)			X														
EPITONIIDAE																	
Amaea arabica (Nyst, 1871)	X																
CF. VELUTINIDAE																	
cf. Velutinidae									X								
CEPHALOPODA																	
LOLIGINIDAE																	
Sepioteuthis cf. australis			X														

Uroteuthis cf. edulis (Hoyle, 1885)												X					
Sepioteuthis lessoniana d'Orbigny, 1826		X						X									
OCTOPODIDAE																	
Octopodidae (unidentified)								X					X				
OMMASTREPHIDAE																	
Todarodes cf. pusillus							X										
SEPIADARIIDAE																	
Sepiadarium cf. auritum				X			X										
SEPIIDAE																	
Sepia papuensis Hoyle, 1885			X				X										
Sepia pharaonis Ehrenberg, 1831				X													

Table 18. Mollusc species previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records). Only records with full species identification included. Those in bold were not recorded in the 2013 or 2017 surveys

Class	Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Bivalvia	Pectinida	Pectinidae	*Mimachlamys scabricostata*		1
Cephalopoda	Sepiida	Sepiidae	*Sepia pharaonis*		1
Gastropoda	**Hypsogastropoda**	**Conidae**	***Conus coronatus***		**1**
Gastropoda	**Hypsogastropoda**	**Conidae**	***Conus frigidus***		**1**
Gastropoda	**Hypsogastropoda**	**Conidae**	***Conus spectrum***		**1**
Gastropoda	Hypsogastropoda	Conidae	*Conus trigonus*		1
Gastropoda	**Hypsogastropoda**	**Conidae**	***Conus victoriae***		**1**
Gastropoda	Hypsogastropoda	Fasciolariidae	*Fusinus colus*		1
Gastropoda	Hypsogastropoda	Olividae	*Ancillista muscae*	1	
Gastropoda	**Hypsogastropoda**	**Ranellidae**	***Gyrineum lacunatum***	**1**	
Gastropoda	**Hypsogastropoda**	**Turridae**	***Inquisitor odhneri***	**1**	
Gastropoda	**Nudibranchia**	**Chromodorididae**	***Ceratosoma trilobatum***		**1**
Gastropoda	**Nudibranchia**	**Chromodorididae**	***Chromodoris elisabethina***		**1**
Gastropoda	**Nudibranchia**	**Dorididae**	***Atagema spongiosa***		**1**
Gastropoda	**Nudibranchia**	**Phyllidiidae**	***Phyllidia coelestis***		**1**
Gastropoda	**Nudibranchia**	**Polyceridae**	***Plocamopherus insignis***		**1**
Gastropoda	**Nudibranchia**	**Scyllaeidae**	***Scyllaea pelagica***		**1**

Table 19. Mollusc collection records for specimens held by the Western Australia Museum taken from the Dampier MP and the Montebello MP prior to this study.

Class	Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Bivalvia	Carditida	Crassatellidae	*Crassatella ziczac*	1	
Bivalvia	Ostreida	Ostreidae	*Dendostrea folium*	1	
Bivalvia	Mytilida	Mytilidae	*Lithophaga malaccana*	1	
Bivalvia	Pectinida	Pectinidae	*Mimachlamys scabricostata* (preserved dry. 1 valve)		1
Bivalvia	Trigoniida	Trigoniidae	*Neotrigonia uniophora (preserved dry)*		2
Gastropoda	Littorinimorpha	Cypraeidae	*Talostolida teres (preserved dry)*		1
Gastropoda	Littorinimorpha	Cypraeidae			1
Gastropoda	Littorinimorpha	Ovulidae	*Cuspivolva cf. howlandae*		1
Gastropoda	Littorinimorpha	Ovulidae	*Dentiovula* sp.		1
Gastropoda	Littorinimorpha	Ovulidae	*Diminovula aboriginea*		1
Gastropoda	Littorinimorpha	Ovulidae	*Pellasimnia cf. cleaveri*		1
Gastropoda	Littorinimorpha	Ranellidae	*Gyrineum lacunatum*	1	
Gastropoda	Neogastropoda	Fasciolariidae	*Fusinus colus? (preserved dry)*		1
Gastropoda	Neogastropoda	Olividae	*Ancillista muscae*	1	
Gastropoda	Neogastropoda	Turbinellidae	*Tudivasum inerme (both records collected dead)*	1	1
Gastropoda	Neogastropoda	Turridae	*Inquisitor odhneri (preserved dry)*	1	
Gastropoda	Nudibranchia	Arminidae	*Armina* sp.		1
Gastropoda	Nudibranchia	Chromodorididae	*Ceratosoma trilobatum*		1
Gastropoda	Nudibranchia	Chromodorididae	*Chromodoris elisabethina*		1
Gastropoda	Nudibranchia	Chromodorididae			1
Gastropoda	Nudibranchia	Dorididae	*Aphelodoris* sp.		3
Gastropoda	Nudibranchia	Dorididae	*Trippa spongiosa*		1
Gastropoda	Nudibranchia	?Dorididae			1
Gastropoda	Nudibranchia	Phyllidiidae	*Phyllidia coelestis*		1
Gastropoda	Nudibranchia	Phyllidiidae	*Phyllidia* cf. *coelestis cf.*		1
Gastropoda	Nudibranchia	Phyllidiidae	*Phyllidia* sp.		1
Gastropoda	Nudibranchia	Scyllaeidae	*Scyllaea pelagica*		1
Gastropoda	Nudibranchia	Tritoniidae	*Marionopsis dakini*		1
Cephalopoda	Sepiida	Sepiidae	*Sepia pharaonic*		1
Cephalopoda	Sepiida	Sepiidae			3

4.7 Echinoderms

4.7.1 Crinoidea

Kate Naughton (Museum of Victoria)

Eleven sites were sampled across the two MPs from depths ranging from 30 to 70 m during the 2017 voyage. Three of these sites occurred within the Dampier MP and eight within the Montebello MP. Both trawling and benthic sled sampling were employed at each site, allowing a comparison between the collection methods. Crinoids were recovered at every MP site in both the sled and trawl samples, with a total of 479 individuals collected. The Dampier MP (three sampling sites) yielded a total of 16 species across 10 genera, in comparison with the Montebello MP (eight sampling sites) which yielded 25 species across 13 genera. Eleven species were restricted to one or another of the MP sites (Dampier: 1; Montebello: 10). A further five species were found in the 2013 surveys (six sites) of the Montebello MP, bringing the total to 30 species in 16 genera identified in this study.

For the 2017 survey, a total of 25 species were recorded across 13 genera, representing five families. This level of diversity and the overall species composition is typical for the tropical Indo-Pacific region. While there were no range extensions of species recorded during this survey, one new species was indicated.

Preservation and identification

Due to time and equipment limitations, few crinoid species could be identified onboard the vessel. All specimens were either preserved in 100% ethanol (most samples) or frozen at -20^{o}C (large samples). Frozen samples were thawed slowly in 100% ethanol at room temperature prior to identification.

Due to the large numbers of crinoids recovered in the trawl samples and the limitations of on-board storage, abundant morphospecies for a particular site were subsampled with up to 10 specimens being retained (dependent on size and morphological variation). An effort was made to ensure that subsamples of abundant species included a representative range of sizes and pigmentations for each collection event. All sled samples were retained as they could not be sorted onboard due to lack of relevant taxonomic expertise on the night shift when sledding was carried out. Where time allowed, good quality representative specimens or those exhibiting distinctive or unusual pigmentation were photographed prior to preservation.

Due to the paucity of recent taxonomic literature on crinoids, identifications of non-Comatulidae families relied heavily on Clark’s monograph (A. H. Clark, 1931; 1941; 1947; 1950; A. H. Clark & Clark, 1967), with the exception of recent revisions of the genus *Himerometra* (Taylor, Rouse, & Messing, 2017) and the family Mariametridae (Rankin & Messing, 2008; Taylor, Rouse, & Messing, 2018). The Comatulidae were identified largely according to revisions by Messing (2001), Rowe et al. (1986) and Summers et al. (2017) and also with reference to faunal surveys (Messing & Tay, 2016; Messing et al., 2005), although a number of species still required reference to Clark (1931). Most families of crinoids are still to be revised using modern methods, and due to such factors as overlapping morphological characteristics between taxa, phenotypic plasticity, ontogenetic variation and ecotypy (Améziane & Roux, 2005; Kohtsuka & Nakano, 2005; Owen, Messing, Rouse, & Shivji, 2009), identification of some taxa to species level remains challenging, and some uncertainty remains around those identifications.

Individuals that were damaged to the point that they could not be identified beyond genus were removed from the sample prior to calculations of biodiversity and relative biomass listed below.

Taxa sampled

A total of 479 individual crinoids were collected during the 2017 survey (Dampier MP: 195; Montebello MP: 284), comprising 26 species in 13 genera across five families (Table 20), with a total biomass of 10,387 grams. No range extensions within Australia were recorded but one new species was found. A further five species were recorded from the Montebello MP in the 2013 PMCP study (Table 20). The only species not currently listed on the Australian Faunal Directory is *Amphimetra molleri* – this has, however, previously been identified in other samples from the north-western region of Australia and in the Joseph Bonaparte Gulf (pers. obs.). Overall, one new (undescribed) species was recovered (*Capillaster*). The overall species composition was typical of other surveys from that region from similar depths. While the species composition was similar between the two MPs overall, there were some differences. The Montebello MP sites were more diverse, containing 30 species across 16 genera, whereas the Dampier MP sites contained only 16 species over 10 genera. This was most likely explained by two factors, i.e., the narrow depth range for the Dampier MP sites (30–37 m) compared to the Montebello MP sites (49–69 m), and the greater number of sites sampled in the Montebello MP where there were fourteen sites (eight on the 2017 voyage and six from the 2013 PMCP study) compared to only three sites sampled in the Dampier MP. The following analyses refer solely to the data collected on the 2017 voyage, and exclude the PMCP sites mentioned above.

The 10 species that occurred solely in the Montebello MP were not common in the sample and comprised 13% by count and 8% by weight of the Montebello MP survey region. Three of these species occurred at only one site each.

As is usual for this habitat, the Comatulidae were the dominant family in terms of both biomass and count, comprising 80% of the sample in terms of specimen count and 95% in terms of biomass. When broken down by individual MP, these values were nearly identical (Dampier MP: 81% and 95% respectively; Montebello MP: 80% and 96% respectively).

The genus *Comatula*, represented by the sympatric species *C*. *pectinata, C. rotalaria* and *C*. *solaris* at both sites, was genuinely ubiquitous, occurring at each of the eleven sampled MP sites. The genus overall comprised 56% of the individual specimen count (48% and 61% at the Dampier and Montebello MPs respectively) and 42% of the total biomass (25% and 61% respectively). The largest individuals by weight were those in the genus *Comaster* (represented by the species *multifidus* and *schlegelii*), which were also relatively common, comprising 13% of the specimen count (25% and 5% respectively) and 47% of the total biomass (67% and 22% respectively).

There were no significant differences in species composition by collection method (trawl vs. sled) when split across the two MPs.

Prior to this study only 13 crinoids were recorded from the Dampier and Montebello MPs (Table 21) and only two of these species (*Decametra parva* and *Comanthus parvicirrus*) were not recorded in either the 2013 PMCP study or the 2017 study. This brings the total number of crinoid species recorded from the two MPs to 33.

A feeding specimen of *Pontiometra andersoni* from site W4 in the Dampier MP is shown in Figure 93.

Specific taxa of interest

***Capillaster* sp. nov.**

Recent molecular work by Summers et al. (2017) has shown that the common species *Capillaster multiradiatus* is likely to represent a species complex. A number of specimens in the current collection appear to most closely key to *C. multiradiatus*, while in terms of direct resemblance are closer to *C. asterias*. However, these specimens (Figure 94) have too few cirri for the former (0–13), and the cirri bear sharp, prominent dorsal spines, which disqualify them for the latter (*C. asterias* is described as lacking any ornamentation on the cirri). It is likely that this qualifies as a new species, most likely to be closely related to *C. asterias*.

Comatula pectinata* vs. *Comatula solaris

The genus *Comatula* dominates the crinoid fauna of north-western Australia in shallow waters, and at least three sympatric species exist there in high numbers: *C. solaris, C. pectinata* and *C. rotalaria*. It is possible that *C. tenuicirra*, also exists there, although this may simply represent a juvenile form of either *C. pectinata* or *C. solaris*. While *C. rotalaria* is distinctive and straightforward, its congeners *C. pectinata* and *C. solaris* have traditionally been distinguished by size. This ultimately means that large specimens are clearly *C. solaris*, but medium and smaller individuals are more suspect. In the descriptions offered in Clark's monograph, these exhibit differences in the form of the comb teeth: *C. pectinata* has widely-separated and fewer teeth, while *C. solaris* has tall, crowded teeth in larger numbers. However, as noted by Messing & Tay (2016), this doesn't appear to be an entirely reliable or consistent character. The possibility exists that *Comatula* as a genus has been either over- or under-described. Resolving this will require further taxonomic investigation, including molecular work. Given how the genus dominates the biomass of the region, this is of significance to any ecological study that relies on accurate species delineation.

Figure 93. Crinoid, *Pontiometra andersoni* feeding at site W4 in the Dampier MP.

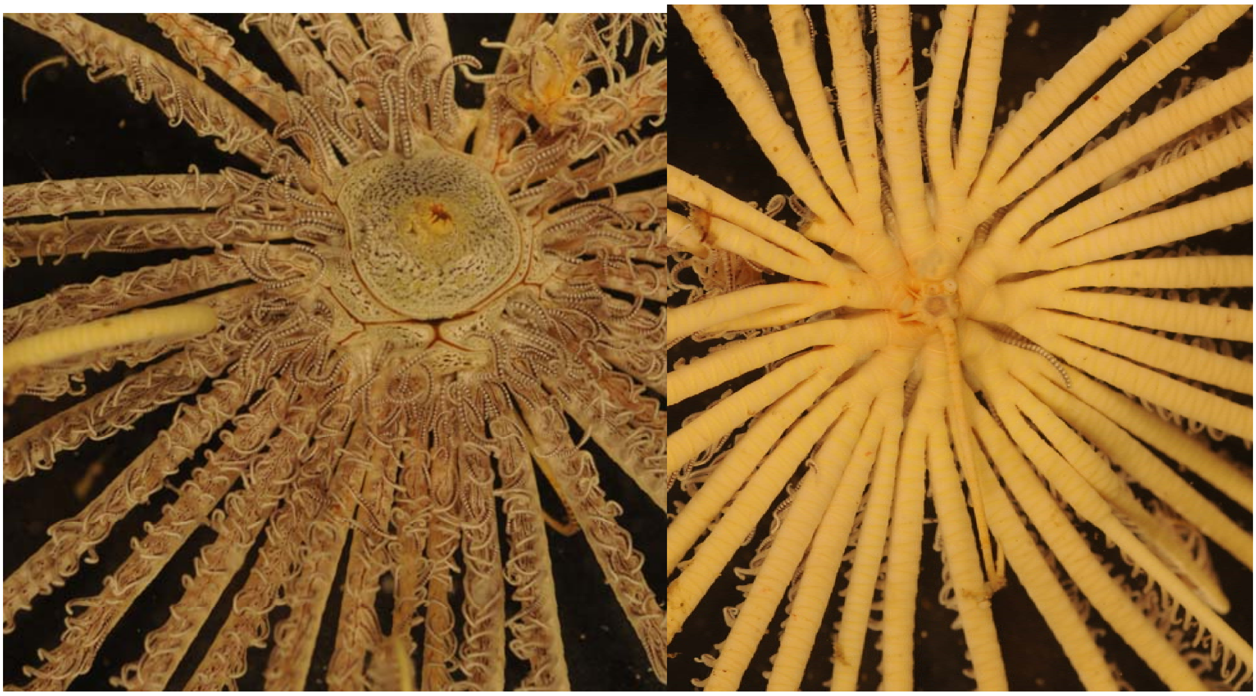

Figure 94. An undescribed species of *Capillaster* collected in samples from the Montebello MP (site W50)

Table 20. Crinoid species recorded at sites surveyed in the Dampier and Montebello MPs. X means the species was collected from that station

Taxa	Dampier MP			Montebello MP (2017 voyage)								Montebello MP (PMCP 2013 study)					
Collection Site	W8	W4	W6	W50	W49	W14	W82	W97	W81	W80	W79	PMCP 50	PMCP 62	PMCP 96	PMCP 100	PMCP 101	PMCP 102
Depth of Station (m)	35-37	32-33	30-33	53-55	60-61	48-50	59	55	61-63	66-68	68-70	27	51	48	42	37	40-41
Crinoidea - unidentified			X					X									
COMATULIDA																	
ANTEDONIDAE																	
Dorometra nana (Hartlaub, 1890)		X					X	X									
Dorometra parvicirra (Carpenter, 1888)				X			X	X			X						
Toxometra bicolor (HL Clark, 1938)							X										
COLOBOMETRIDAE																	
Oligometra carpenteri (Bell, 1884)						X						X	X			X	
Oligometrides adeonae (Lamarck, 1816)				X			X	X									
Oligometra serripinna (Carpenter, 1881)													X				
Pontiometra andersoni (Carpenter, 1889)		X							X								
COMATULIDAE																	
Capillaster AH Clark, 1909 *sp nov.*				X			X	X	X								
Capillaster multiradiatus (Linnaeus, 1758)		X	X	X		X		X					X			X	
Capillaster sentosus (Carpenter, 1888)						X			X								
Clarkcomanthus alternans (Carpenter, 1881)	X		X			X						X					
Clarkcomanthus littoralis (Carpenter, 1888)								X	X			X					
Comanthus briareus (Bell, 1882)				X													
Comanthus gisleni Rowe, Hoggett, Birtles & Vail, 1986		X		X		X						X					
Comaster multifidus (Müller, 1841)	X	X	X	X		X			X			X				X	
Comaster schlegelii (Carpenter, 1881)			X			X	X					X					
Comatella stelligera (Carpenter, 1888)													X				
Comatula micraster A.H. Clark, 1909												X					
Comatula pectinata (Linnaeus, 1758)	X	X		X	X	X	X	X	X			X	X		X	X	X

Comatula rotalaria Lamarck, 1816	X	X	X	X	X		X	X	X	X	X						
Comatula solaris Lamarck, 1816	X	X	X	X	X	X	X	X	X	X	X						
Comatula tenuicirra AH Clark, 1912								X		X							
Phanogenia cf. distincta																X	
HIMEROMETRIDAE																	
Amphimetra molleri (AH Clark, 1908)					X												
Amphimetra tessellata (Müller, 1841)	X	X		X						X					X	X	
Heterometra crenulata (Carpenter, 1882)	X	X		X	X				X	X	X						
Himerometra robustipinna (Carpenter, 1881)													X			X	
MARIAMETRIDAE																	
Lamprometra palmata (Müller, 1841)												X	X			X	
ZYGOMETRIDAE																	
Zygometra comata AH Clark, 1911				X				X		X	X						
Zygometra elegans (Bell, 1882)	X			X				X									
Zygometra microdiscus (Bell, 1882)		X										X	X		X	X	X
Zygometra punctata AH Clark, 1912		X														X	

Table 21. Crinoid species previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records). Only records with full species identification included. Those in bold were not recorded in the 2013 and 2017 surveys

Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Comatulida	**Colobometridae**	***Decametra parva***		**1**
Comatulida	Colobometridae	*Oligometra carpenteri*		2
Comatulida	Colobometridae	*Oligometrides adeonae*	2	2
Comatulida	Comasteridae	*Clarkcomanthus littoralis*	1	
Comatulida	**Comasteridae**	***Comanthus parvicirrus***	**1**	
Comatulida	Comasteridae	*Comaster multifidus*	1	1
Comatulida	Comasteridae	*Comatula pectinata*	1	1
Comatulida	Comasteridae	*Comatula purpurea (synonym of C. pectinata)*	2	
Comatulida	Comasteridae	*Comatula rotalaria*	1	
Comatulida	Himerometridae	*Amphimetra tessellata*		1
Comatulida	Himerometridae	*Himerometra robustipinna*		3
Comatulida	Mariametridae	*Lamprometra palmata*		1
Comatulida	Zygometridae	*Zygometra microdiscus*	3	2
Comatulida	Zygometridae	*Zygometra punctata*		1

4.7.2 Ophiuroids

Timothy O'Hara (Museum of Victoria)

Nineteen species of ophiuroids (two basket stars, one snake star and 16 brittle stars) were recorded from the three sites in the Dampier MP (Table 22) with the brittle stars *Ophiothrix melanosticta* and *Ophiochasma stellata* being present at all three sites. This brings the total ophiuroid diversity recorded for the Dampier MP in this study and others recorded in the Atlas of Living Australia (ALA, Table 23) to 27.

For the Montebello MP, 32 species (six basket stars, one snake star and 25 brittle stars) were recorded from 14 sites in the 2017 and 2013 PMCP surveys (Table 22). Five species were recorded at six or more sites, including the basket star *Euryale aspera* which is a commensal on sea fans and other filter feeders, and *Ophiomaza cacaotica* (which is commensal on crinoids) along with *Ophiothrix lineocaerulea, Ophiochasma stellata* and *Dictenophiura stellata*. An additional five species had been previously recorded in the Atlas of Living Australia (ALA) from the Montebello MP (Table 23) bringing the total ophiuroid diversity now recorded to 37. The collection included three other species that are commensal on crinoids, *Ophiocnemis marmorata*, *Gymnolophus obscura*, and *Ophiothrix melanosticta*. One species, *Ophiocnemis marmorata* is often transported on jellyfish. Two species (*Astroboa granulatus* and *Ophiarachnella similis*) are now known to reach the southern limits of their distribution in this area based on this study. There were two similar species of *Ophiochasma*, *O. stellata* and *O.* "undescribed species cf. *stellata*", the latter being an undescribed species known to be genetically distinct.

Figure 95. A basket star *Astrochalcis tuberculosus* feeding at site W4 in the Dampier MP

Table 22. Ophiuroid species recorded at sites surveyed in the Dampier and Montebello MPs. X means the species was collected from that station

Taxa	Dampier MP			Montebello MP (2017 voyage)								Montebello MP (PMCP 2013 study)					
	W8	W4	W6	W50	W49	W14	W82	W97	W81	W80	W79	PMCP 50	PMCP 62	PMCP 96	PMCP 100	PMCP 101	PMCP 102
EURYALIDA																	
EURYALIDAE																	
Astrobrachion adhaerens		X			X												
Euryale aspera				X	X	X	X		X	X						X	
Trichaster acanthifer					X				X								
GORGONOCEPHALIDAE																	
Astroboa ernae						X											
Astroboa granulatus					X												
Astroboa nuda	X					X					X		X				
Astrochalcis tuberculosus		X				X											
AMPHILEPIDIDA																	
OPHIACTIDAE																	
Ophiactis brevis						X											
Ophiactis fucsolineata	X																
Ophiactis savignyi		X				X											
OPHIOLEPIDIDAE																	
Ophiolepis unicolor		X										X	X			X	
OPHIOPSILIDAE																	
Ophiopsila pantherina					X			X		X							
OPHIOTRICHIDAE																	
Gymnolophus obscura						X						X					
Macrophiothrix longipeda		X										X				X	
Macrophiothrix megapoma		X	X			X										X	
Macrophiothrix variabilis		X														X	
Ophiocnemis marmorata	X			X	X												

Ophiogymna elegans			X		X	X											
Ophiomaza cacaotica	X		X	X				X	X		X	X			X	X	
Ophiopteron elegans				X	X	X											
Ophiothrix ciliaris		X	X			X						X	X			X	
Ophiothrix exigua											X						
Ophiothrix foveolata				X	X	X		X		X							
Ophiothrix lineocaerulea		X		X	X	X	X	X	X			X	X				
Ophiothrix martensi	X	X		X		X			X			X					
Ophiothrix melanosticta	X	X	X	X						X	X				X		
Ophiothrix smaragdina			X			X	X					X	X			X	
OPHIACANTHIDA																	
OPHIACANTHIDAE																	
Ophiacantha dallasi					X												
OPHIODERMATIDAE																	
Ophiochasma stellata	X	X	X	X	X	X	X	X	X	X	X		X			X	
Ophiochasma undescribed species (cf. *stellata*)	X		X	X												X	
Ophiopsammus yoldii				X	X						X						
OPHIOPEZIDAE																	
Ophiarachnella similis					X			X									
OPHIURIDA																	
OPHIOPYRGIDAE																	
Dictenophiura stellata				X	X			X	X	X	X						

Table 23. Ophiuroid species previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records). Only records with full species identification included.Those in bold were not recorded in the 2013 and 2017 surveys

Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Euryalida	Euryalidae	*Euryale aspera*	4	1
Euryalida	Gorgonocephalidae	*Astroboa granulatus*		1
Euryalida	Gorgonocephalidae	*Astroboa nuda*		2
Euryalida	Gorgonocephalidae	*Astrochalcis tuberculosus*		1
Euryalida	**Gorgonocephalidae**	***Astroglymna sculptum***		**1**
Ophiurida	**Amphiuridae**	***Amphipholis squamata***	**1**	**1**
Ophiurida	**Amphiuridae**	***Amphiura bidentata***		**1**
Ophiurida	**Amphiuridae**	***Amphiura octacantha***	**1**	
Ophiurida	**Amphiuridae**	***Ophiocentrus dilatatus***	**1**	
Ophiurida	**Ophiactidae**	***Ophiactis luteomaculata***	**1**	**1**
Ophiurida	**Ophiactidae**	***Ophiactis macrolepidota***	**1**	**1**
Ophiurida	**Ophiactidae**	***Ophiactis modesta***	**1**	
Ophiurida	Ophiactidae	*Ophiactis savignyi*	1	
Ophiurida	**Ophiocomidae**	***Ophiocomella sexradia***	**1**	
Ophiurida	Ophiodermatidae	*Ophiochasma stellata*	1	
Ophiurida	Ophiodermatidae	*Ophiopsammus yoldii*	1	
Ophiurida	Ophiotrichidae	*Macrophiothrix variabilis*	1	
Ophiurida	Ophiotrichidae	*Ophiocnemis marmorata*	1	
Ophiurida	Ophiotrichidae	*Ophiomaza cacaotica*		1
Ophiurida	Ophiotrichidae	*Ophiopteron elegans*		1
Ophiurida	**Ophiotrichidae**	***Ophiothela danae***	**2**	
Ophiurida	Ophiotrichidae	*Ophiothrix ciliaris*	1	
Ophiurida	Ophiotrichidae	*Ophiothrix exigua*	1	
Ophiurida	Ophiotrichidae	*Ophiothrix smaragdina*		2
Ophiurida	Ophiuridae	*Dictenophiura stellata*	1	

4.8 Sea snakes

John Keesing (CSIRO Oceans and Atmosphere Research)

Ten specimens of five species of sea snakes were sampled from the two MPs (Table 24). Sea snakes were captured from all three sites in the Dampier MP and from two sites in the Montebello MP. The horned sea snake (*Acalyptophis peronii*, four individuals at three sites) and the brown lined sea snake (*Aipysurus tenuis*, three individuals at two sites) were the most common with just single specimens caught of the golden sea snake (*Aipysurus laevis*), the olive headed sea snake (*Disteira major*) and the spotted sea snake (*Hydrophis ornatus ocellatus*). All sea snakes collected from the two MPs were released alive with the exception of one *Acalyptophis peronii* which died in the net during capture.

All five species have previously been recorded from the NWS, with *Aipysurus tenuis* being endemic to the region and *Hydrophis ornatus ocellatus* being regarded as uncommon (Guinea 2007; Commonwealth of Australia 2012).

Table 24. Sea snake species captured in trawls in the Dampier MP and Montebello MP. Taxonomic names according to the World Register of Marine Species (WoRMS Editorial Board 2018)

	Dampier MP sites			Montebello MP sites	
Sea snake species	W4	W6	W8	W14	W49
Acalyptophis peronii (Duméril, 1853)	2	1			1
Aipysurus laevis Lacépède, 1804				1	
Aipysurus tenuis Lönnberg & Andersson, 1913	1	2			
Disteira major (Shaw, 1802)			1		
Hydrophis ornatus ocellatus (Gray, 1849)		1			

4.9 Turtles

John Keesing (CSIRO Oceans and Atmosphere Research)

Only one turtle was captured in trawls during the Dampier and Montebello MP surveys. This was a hawksbill turtle (*Eretmochelys imbricata*) captured at site W6 (Dampier MP). It was released alive and unharmed.

4.10 Algae and seagrass

John Huisman (Western Australian Herbarium)

One species of seagrass *Halophila spinulosa* (only at site W6) and 15 species of algae were collected from the Dampier MP (Table 25). Algae were present in samples from all three stations in the Dampier MP (Table 25). Most (11 species) were at station W6 while six species were found at station W4 and five at station W8. In the Montebello MP there was one species of seagrass *Halophila ovalis* and 37 species of algae (Table 25). Algae were only present at four of eight stations sampled in 2017 and five of six stations sampled in 2013. Nine species were found at station W49, three species at stations W14 and W50 and two species at station W97. The samples included *Aneurianna lorentzii*, which has a widespread Indo-Pacific distribution but has not been found previously in Western Australia. Several of the species (*Halymenia lunata*, *Gracilaria webervanbosseae* and *Erythroclonium elongatum*) were new species recently described in Huisman (2018). Otherwise, the species recorded are typical components of the Pilbara marine flora (Huisman 2015, 2018). Relative to more broadly sampled studies, for example the Dampier Archipelago survey by Huisman & Borowitzka (2003) where 205 species of algae and seagrasses were recorded, the diversity recorded here is low. This is undoubtedly due to the shallower sites, where marine flora are more common, being under sampled.

There are two other species of algae that were previously recorded from the Montebello MP (Table 26) but not sampled in our study. The diversity of algae in both MPs is likely to remain undersampled, especially in the shallower areas.

Table 25. List of algae species sampled from the Dampier and Montebello MPs. Data represent the number of sites each species was recorded at within the MP sampled

Phylum	Class	Order	Family	Species	Dampier MP (3 sites sampled)	Montebello MP (8 sites sampled in 2017)	Montebello MP (6 sites sampled in 2013)
Tracheophyta	Magnoliopsida	Alismatales	Hydrocharitaceae	*Halophila ovalis*			1
Tracheophyta	Magnoliopsida	Alismatales	Hydrocharitaceae	*Halophila spinulosa*	1		
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyopteris australis*	1		1
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyopteris serrata*			1
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyopteris woodwardia*			3
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota ciliolata*			1
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Lobophora variegata*			3
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina sanctae-crucis*	1		
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina* sp.	1		
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Spatoglossum macrodontum*			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Hormophysa cuneiformis*			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassopsis decurrens*			4
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum aquifolium*	1		
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum carpophyllum?*			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum ilicifolium*			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum polycystum*			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sargassum* sp.			1
Ochrophyta	Phaeophyceae	Fucales	Sargassaceae	*Sirophysalis trinodis*			4
Ochrophyta	Phaeophyceae	Sphacelariales	Sphacelariaceae	*Sphacelaria rigidula*			2
Ochrophyta	Phaeophyceae	Sporochnales	Sporochnaceae	*Sporochnus pedunculatus*	2	2	
Chlorophyta	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa corynephora*		1	
Chlorophyta	Ulvophyceae	Bryopsidales	Codiaceae	*Codium* sp.	1		

Chlorophyta	Ulvophyceae	Bryopsidales	Halimedaceae	*Halimeda discoidea*			2
Chlorophyta	Ulvophyceae	Bryopsidales	Halimedaceae	*Halimeda* sp.		1	
Chlorophyta	Ulvophyceae	Bryopsidales	Udoteaceae	*Udotea argentea*	1	2	
Rhodophyta	Florideophyceae	Ceramiales	Dasyaceae	*Heterosiphonia* sp.			1
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Aneurianna lorentzii*	1	2	
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Leveillea jungermannioides*			1
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Amansia* sp.			1
Rhodophyta	Florideophyceae	Ceramiales	Spyridiaceae	*Spyridia filamentosa*			1
Rhodophyta	Florideophyceae	Gigartinales	Areschougiaceae	*Erythroclonium elongatum*		2	1
Rhodophyta	Florideophyceae	Gigartinales	Areschougiaceae	*Erythroclonium sonderi*	1	2	
Rhodophyta	Florideophyceae	Gigartinales	Areschougiaceae	*Rhabdonia sp.*	1	1	
Rhodophyta	Florideophyceae	Gigartinales	Solieriaceae	*Solieria sp.*	3	2	
Rhodophyta	Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria* sp.		1	
Rhodophyta	Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria vieillardii*	1		
Rhodophyta	Florideophyceae	Gracilariales	Gracilariaceae	*Gracilaria webervanbosseae*	3		
Rhodophyta	Florideophyceae	Halymeniales	Halymeniaceae	*Halymenia lunata*	2		
Rhodophyta	Florideophyceae	Halymeniales	Halymeniaceae	*Halymenia* sp.		1	
Rhodophyta	Florideophyceae	Halymeniales	Halymeniaceae	*Halymenia* sp. 2			1
Rhodophyta	Florideophyceae	Halymeniales	Halymeniaceae	*Corynomorpha prismatica*			1
Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaceae	*Leptofauchea* sp.			1
Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Coelarthrum opuntia*	1		
Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Rhodymenia* sp.			1
Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Hydrolithon farinosum*			1
Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Jania* sp.			1
Rhodophyta	Florideophyceae	Peyssonneliales	Peyssonneliaceae	*Peyssonnelia* sp.			1

Table 26. Algae species previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records). Those in bold were not recorded in the 2017 surveys

Phylum	Class	Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyopteris australis*	2	
Chlorophyta	**Ulvophyceae**	**Bryopsidales**	**Udoteaceae**	***Penicillus nodulosus***		**1**
Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Amansia* sp.		1
Rhodophyta	**Florideophyceae**	**Ceramiales**	**Wrangeliaceae**	***Anotrichium tenue***		**2**
Rhodophyta	Florideophyceae	Rhodymeniales	Faucheaceae	*Leptofauchea* sp.		1
Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Rhodymenia* sp.		1

4.11 Other taxa

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Not all taxa retained could be identified. Notably worms, holothurians, pyncnogonids, bryozoans and ascidians. These collections have been retained pending donation to museums interested in the material (Table 27). For completeness, taxa in these groups previously recorded for the Dampier and Montebello MPs (Atlas of Living Australia) are shown in Table 28.

Table 27. Other taxa with the number of vouchered specimens collected from the Dampier and Montebello MPs

Phylum	Class	Dampier MP	Montebello MP
Annelida		3	7
Arthropoda	Pycnogonida	1	0
Bryozoa		9	45
Chordata	Ascidiacea	12	71
Cnidaria	Anthozoa (Zoanthids, Anemones)	4	8
Cnidaria	Scyphozoa	0	14
Cnidaria	Hydrozoa	5	14
Echinodermata	Holothuroidea	10	34
Echinodermata	Asteroidea	14	127
Echinodermata	Echinoidea	6	19

Table 28. Other taxa previously recorded from the Dampier and Montebello MPs (on the basis of Atlas of Living Australia records)

Phylum	Class	Order	Family	Species	Dampier MP Number of records	Montebello MP Number of records
Annelida	Hirudinida	Rhynchobdellida	Piscicolidae	*Stibarobdella macrothela*	1	
Annelida	Polychaeta	Amphinomida	Amphinomidae		1	2
Annelida	Polychaeta	Amphinomida	Euphrosinidae			1
Annelida	Polychaeta	Eunicida	Dorvilleidae		1	
Annelida	Polychaeta	Eunicida	Eunicidae	*Marphysa* sp.	1	
Annelida	Polychaeta	Eunicida	Eunicidae		3	1
Annelida	Polychaeta	Eunicida	Lumbrineridae		1	1
Annelida	Polychaeta	Eunicida	Onuphidae		4	
Annelida	Polychaeta	Phyllodocida	Aphroditidae		1	1
Annelida	Polychaeta	Phyllodocida	Chrysopetalidae		2	1
Annelida	Polychaeta	Phyllodocida	Glyceridae		1	1
Annelida	Polychaeta	Phyllodocida	Nephtyidae		1	
Annelida	Polychaeta	Phyllodocida	Nereididae	*Neanthes* sp.	1	

Annelida	Polychaeta	Phyllodocida	Nereididae	*Nereis* sp.	1	
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Eteone platycephala*		1
Annelida	Polychaeta	Phyllodocida	Phyllodocidae		2	3
Annelida	Polychaeta	Phyllodocida	Polynoidae		2	1
Annelida	Polychaeta	Phyllodocida	Syllidae		3	1
Annelida	Polychaeta	Sabellida	Sabellidae	*Euchone* sp.		1
Annelida	Polychaeta	Sabellida	Sabellidae		1	
Annelida	Polychaeta	Sabellida	Serpulidae		1	
Annelida	Polychaeta	Spionida	Spionidae	*Laonice* sp.	1	
Annelida	Polychaeta	Spionida	Spionidae	*Spiophanes* sp.	1	
Annelida	Polychaeta	Spionida	Spionidae		1	1
Annelida	Polychaeta	Terebellida	Cirratulidae		2	
Annelida	Polychaeta	Terebellida	Terebellidae		3	
Annelida	Polychaeta	Terebellida	Pectinariidae			1
Annelida	Polychaeta	Terebellida	Terebellidae			1
Annelida	Polychaeta	Terebellida	Trichobranchidae			1
Arthropoda	Pycnogonida	Pantopoda	Colossendeidae	*Rhopalorhynchus* sp.		1
Arthropoda	Pycnogonida	Pantopoda	Pallenopsidae	*Pallenopsis cidaribatus*		2
Bryozoa	Gymnolaemata	Cheilostomata	Phidoloporidae	*Reteporella graeffei*		1
Bryozoa	Gymnolaemata	Cheilostomata	Phidoloporidae	*Triphyllozoon arcuatum*		1
Echinodermata	Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria (Theelothuria) spinifera*	1	
Echinodermata	Holothuroidea	Dendrochirotida	Cucumariidae	*Cercodemas anceps*	1	1
Echinodermata	Holothuroidea	Dendrochirotida	Cucumariidae	*Colochirus quadrangularis*	1	
Echinodermata	Holothuroidea	Dendrochirotida	Cucumariidae	*Plesiocolochirus australis*	1	
Echinodermata	Holothuroidea	Dendrochirotida	Cucumariidae	*Plesiocolochirus challengeri*	1	
Echinodermata	Holothuroidea	Dendrochirotida	Phyllophoridae		2	1
Echinodermata	Holothuroidea	Dendrochirotida	Thyonidae	*Stolus canescens*	1	
Echinodermata	Holothuroidea	Dendrochirotida	Thyonidiidae	*Actinocucumis typica*	1	
Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Astropecten monacanthus*	1	
Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Astropecten velitaris*	1	
Echinodermata	Asteroidea	Paxillosida	Luidiidae	*Luidia hardwicki*		1
Echinodermata	Asteroidea	Paxillosida	Luidiidae	*Luidia maculata*	2	2
Echinodermata	Asteroidea	Spinulosida	Echinasteridae	*Metrodira subulata*	1	**3**
Echinodermata	Asteroidea	Valvatida	Acanthasteridae	*Acanthaster planci*		1
Echinodermata	Asteroidea	Valvatida	Asterinidae	*Anseropoda rosacea*		1
Echinodermata	Asteroidea	Valvatida	Asterinidae	*Nepanthia belcheri*	2	
Echinodermata	Asteroidea	Valvatida	Asterodiscididae	*Asterodiscides macroplax*		1
Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Iconaster longimanus*		1
Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Stellaster childreni*		2

Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Stellaster inspinosus*	1	
Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Stellaster princeps*	3	**3**
Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Stellaster squamulosus*		1
Echinodermata	Asteroidea	Valvatida	Mithrodiidae	*Mithrodia clavigera*		1
Echinodermata	Asteroidea	Valvatida	Mithrodiidae	*Thromidia brycei*		3
Echinodermata	Asteroidea	Valvatida	Ophidiasteridae	*Tamaria hirsuta*	1	
Echinodermata	Asteroidea	Valvatida	Ophidiasteridae	*Fromia pacifica*		3
Echinodermata	Asteroidea	Valvatida	Ophidiasteridae	*Heteronardoa carinata*		1
Echinodermata	Asteroidea	Valvatida	Ophidiasteridae	*Leiaster coriaceus*		2
Echinodermata	Asteroidea	Valvatida	Oreasteridae	*Goniodiscaster australiae*	2	
Echinodermata	Asteroidea	Valvatida	Oreasteridae	*Pentaceraster gracilis*	2	3
Echinodermata	Asteroidea	Valvatida	Oreasteridae	*Pentaceraster regulus*		2
Echinodermata	Asteroidea	Valvatida	Pterasteridae	*Euretaster insignis*		2
Echinodermata	Echinoidea	Camarodonta	Toxopneustidae	*Toxopneustes pileolus*		1
Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Eucidaris metularia*		1
Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Prionocidaris bispinosa*	3	
Echinodermata	Echinoidea	Echinothurioida	Echinothuriidae	*Asthenosoma varium*		1
Echinodermata	Echinoidea	Clypeasteroida	Clypeasteridae	*Clypeaster latissimus*	2	
Echinodermata	Echinoidea	Clypeasteroida	Clypeasteridae	*Clypeaster telurus*	1	
Echinodermata	Echinoidea	Clypeasteroida	Laganidae	*Peronella macroproctes*	1	
Echinodermata	Echinoidea	Clypeasteroida	Laganidae	*Peronella minuta*	1	
Echinodermata	Echinoidea	Clypeasteroida	Laganidae	*Peronella orbicularis*	1	
Echinodermata	Echinoidea	Spatangoida	Loveniidae	*Lovenia elongata*	1	

5 Comparison of Montebello MP with the adjacent Pilbara Fish Trawl Fishery Area 1

5.1 Introduction

Montebello MP is situated adjacent to, and to the west of, the Pilbara Fish Trawl Fishery (PFTF, Figure 96) which targets demersal fish species. In 2016, the catch in this fishery was 1,529 tonnes with a further 621 tonnes captured by trap and line fishing. Trawl catches between 1995 and 2004 averaged about 2,500 tonnes. Effort reductions in this fishery in 2008 reduced average catches to 1,159 tonnes from 2008-2015, and are believed to have resulted in increased fish abundance as reflected in the current harvest level (Gaughan and Santoro 2018).

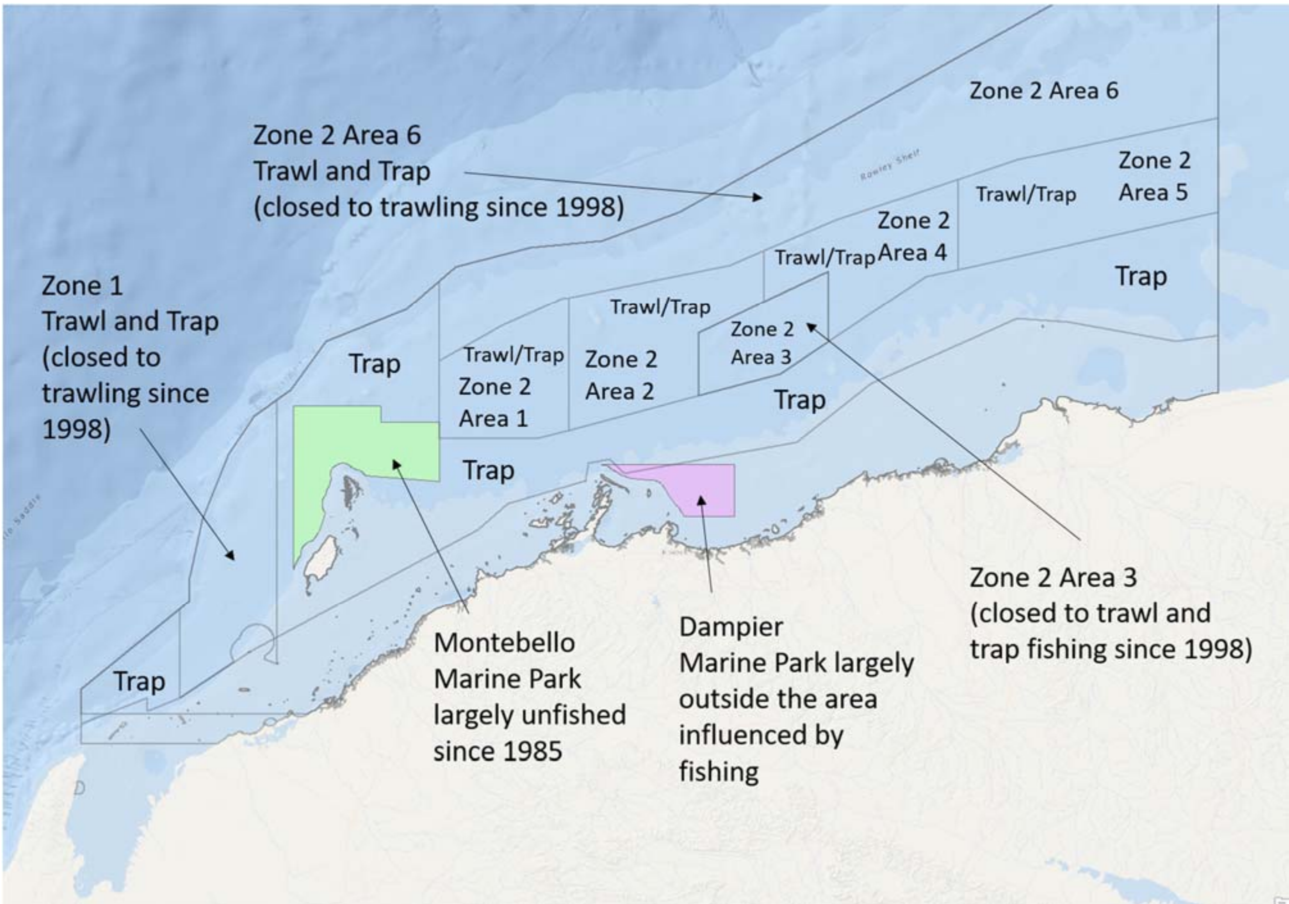


Figure 96. Pilbara Fish Trap and Trawl Fishery zoning and location of the Dampier and Montebello MPs on the Pilbara NWS

The broader area of the Pilbara NWS has been subject to trawling since the 1960s and up to 1990 a range of foreign vessels, mainly Taiwanese, Japanese and Russian vessels undertook exploratory or active fishing in the area (Sainsbury 1987, 1988, 1991). Foreign fishing was greatly reduced by 1985 and ceased in 1990 and the Fishery has been managed under its current arrangements (Figure 96) since 1998 under the *Fish Resources Management Act* 1994 (Pilbara Fish Trawl Interim Managed Fishery Management Plan 1997).

Contrasting fishing effort across the region permits some useful comparisons and in this chapter of the report we compared the results of the 2017 surveys undertaken at nine sites in and around the Montebello MP with twelve sites of similar depth in the adjacent Pilbara Fish Trawl Fishery Zone 2 Area 1 (PFTF Area 1, Figure 98). All sites were subjected to high or very high fishing effort (mostly >50% of area swept annually) between 1979 and 1985. Sites within the Montebello MP and just to its north have had zero or very low fishing effort between 2005 and 2016 (<1%) while those in the PFTF Area 1 have been subject to high or very high fishing effort over the same period (mostly >50%) (Figure 97, Table 29). Full details on how fishing effort was calculated is given in Appendix A.

Comparisons of the areas include dominant categories of habitat, bottom topography and benthic biota, biomass, morphology and size composition of habitat forming sponges and soft corals and fish diversity, biomass and assemblage types.

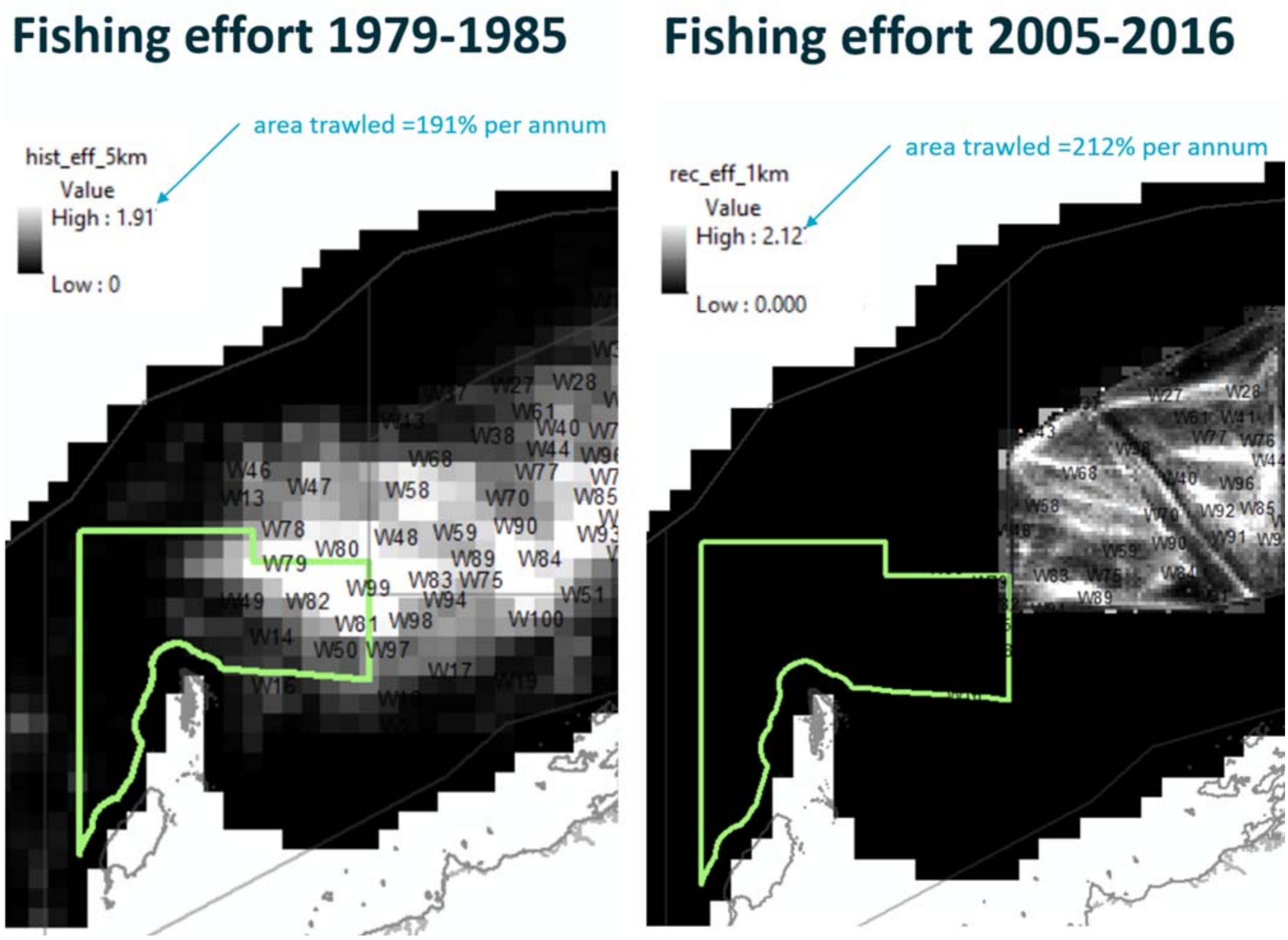


Figure 97. Comparative fishing effort in historical (left panel) and recent (right panel) periods

Table 29. Historical (1979–1990) and recent (2005–2016) trawl fishing effort history of survey sites in and around the Montebello MP and the Pilbara Fish Trawl Fishery Area 1 (see Figure 98)

Site	Depth	Fishing Area or Conservation Zone	Historical effort (%) swept area per year	Recent effort (%) swept area per year
W14	49	west of commercial trawl fishery (Montebello MP)	1-50%	0-1 %
W49	60.9	west of commercial trawl fishery (Montebello MP)	50-100%	0-1%
W50	53.7	west of commercial trawl fishery (Montebello MP)	50-100%	0-1%
W78	73.4	west of commercial trawl fishery	100-192%	0-1%
W79	68.7	west of commercial trawl fishery (Montebello MP)	100-192%	0-1%
W80	66.8	west of commercial trawl fishery (Montebello MP)	100-192%	0-1%
W81	63.2	west of commercial trawl fishery (Montebello MP)	100-192%	0-1%
W82	60.1	west of commercial trawl fishery (Montebello MP)	100-192%	0-1%
W97	55	west of commercial trawl fishery (Montebello MP)	100-192%	0-1%
W59	59.8	PFTF Area 1	50-100%	1-50%
W70	59.7	PFTF Area 1	50-100%	50-100%
W75	60.5	PFTF Area 1	50-100%	100-213%
W83	63	PFTF Area 1	100-192%	1-50%
W84	57.9	PFTF Area 1	100-192%	1-50%
W89	62.2	PFTF Area 1	100-192%	50-100%
W90	58.3	PFTF Area 1	100-192%	50-100%
W91	63.9	PFTF Area 1	100-192%	50-100%
W92	64.3	PFTF Area 1	100-192%	50-100%
W93	66.5	PFTF Area 1	100-192%	50-100%
W94	62.7	PFTF Area 1	100-192%	100-213%
W95	62.7	PFTF Area 1	100-192%	100-213%

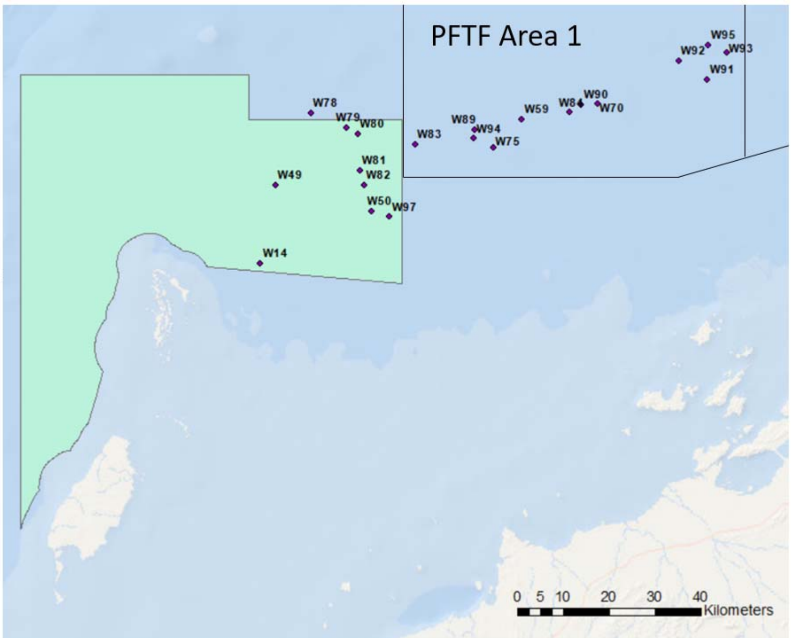


Figure 98. Location of 2017 survey sites in and around the Montebello MP and the Pilbara Fish Trawl Fishery Area 1

5.2 Habitat and benthic biota comparisons

5.2.1 Substrate type, topography and biota

To compare the substrate, topography and biota types at different sites and between the Montebello MP and the PFTF Area 1, at least 120 trawl headline camera still images from each site were scored for different biophysical attributes (see detailed methods in Appendix A). The number of each attribute scored across all images was converted to a proportion of the total and are presented as histograms (Figure 99, Figure 100, and Figure 101).

Substrate and topography were similar between the two areas dominated by predominantly flat bottom with fine sand substrate (Figure 99, Figure 100). Only site W81 in the Montebello MP was predominantly hard substrate and sites W14 and W49 had patches of hard bottom as well (Figure 99).

The proportion of each biota type at each station in the Montebello MP and the PFTF Area 1 are shown in Figure 101. The main biota types scored on the images were sponges, gorgonians, whips and other soft corals (octocorals), hydroids, crinoids and sea pens.

Although the dominant biota type and the mix of assemblages varied among stations, assemblages were similar between the two areas. The exception to this was that sponge and whips were more abundant in the PFTF Area 1, making up more than 50% of biota scored in images from 6 sites (50% of sites) compared to none in the Montebello MP sites (Figure 101).

Overall the presence of habitat forming filter feeder communities was much greater in the PFTF Area 1 than in the Montebello MP.

This was obvious when the density and biomass of sponges and soft corals captured in the trawls was examined.

Average sponge density and biomass in PFTF Area 1 was 29.6 ha^{-1} and 43.4 $kg.ha^{-1}$ compared to just 3.7 ha^{-1} and 7.8 $kg.ha^{-1}$ in the Montebello MP (Table 30). In general the distribution pattern for the different morphotypes and size categories of sponges was the same with each category being 2–28 times more abundant in terms of density and 3–45 times more abundant in terms of biomass in the PFTF Area 1 compared to the Montebello MP (Figure 102, Table 30). Notably, massive form sponges >50 cm were more than 40 times more abundant in the PFTF Area 1 where trawling has been ongoing since the 1970s. However, this may be due to differences the favourability of the habitat to sponges between the two areas which we have been unable to determine. For example, we have not yet undertaken analysis of the sub-bottom profile data at sites in the PFTF Area 1 for comparison with that from the Montebello MP (see Chapter 2).

The comparison of soft corals between the two areas was not as clear, mainly due to one site in the Montebello MP (W14) having very high density and abundance of massive form *Dendronephthya* soft corals (Figure 103) with more than 85 $kg.ha^{-1}$ at that site, while the average for this category of soft corals at sites in PFTF Area 1 was just 469 $g.ha^{-1}$ (Table 31). However for the fan forming types of soft corals and the whips, these were more than 10 times and 8 times more abundant in the PFTF Area 1 respectively (Figure 103, Table 31).

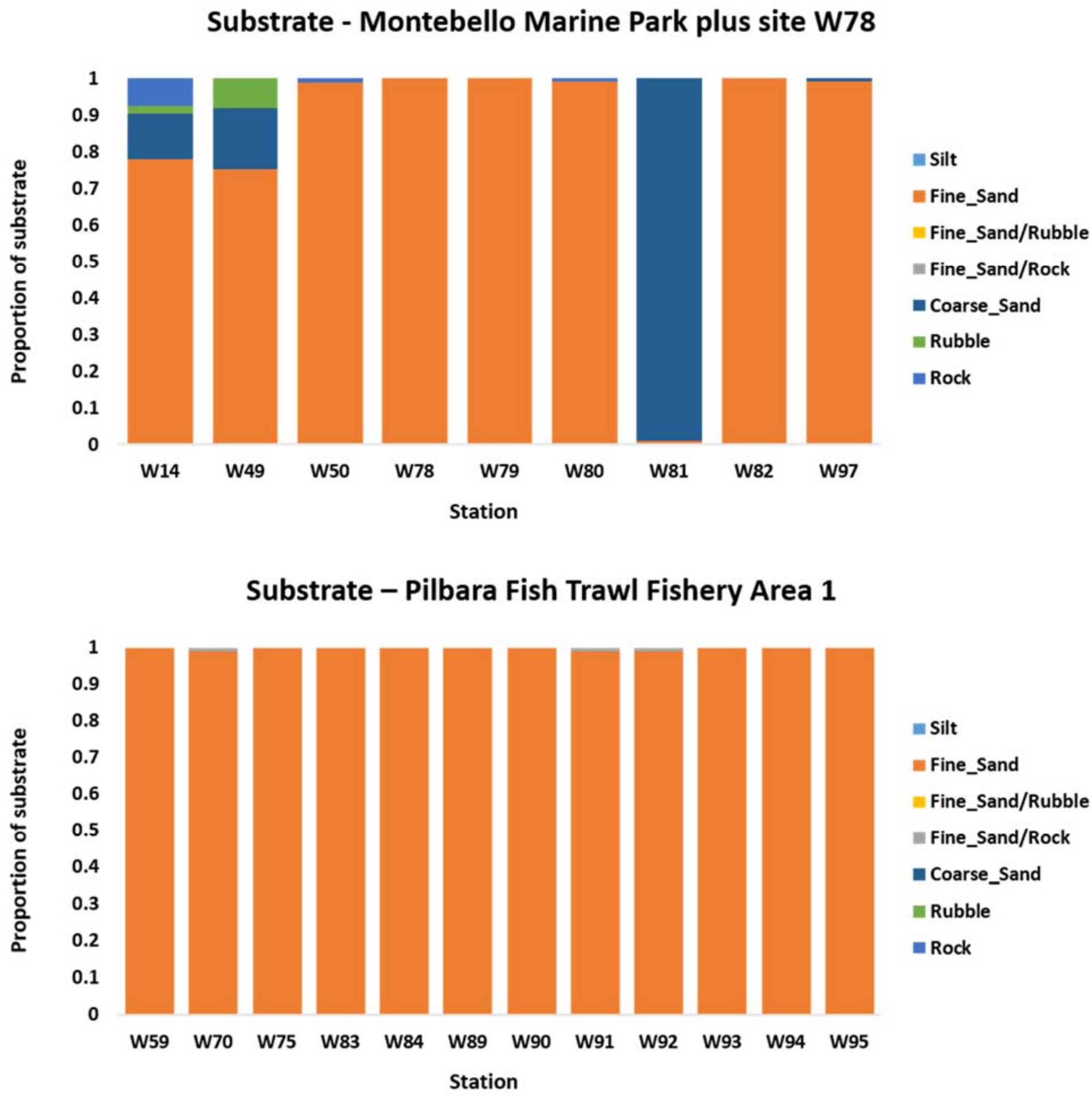
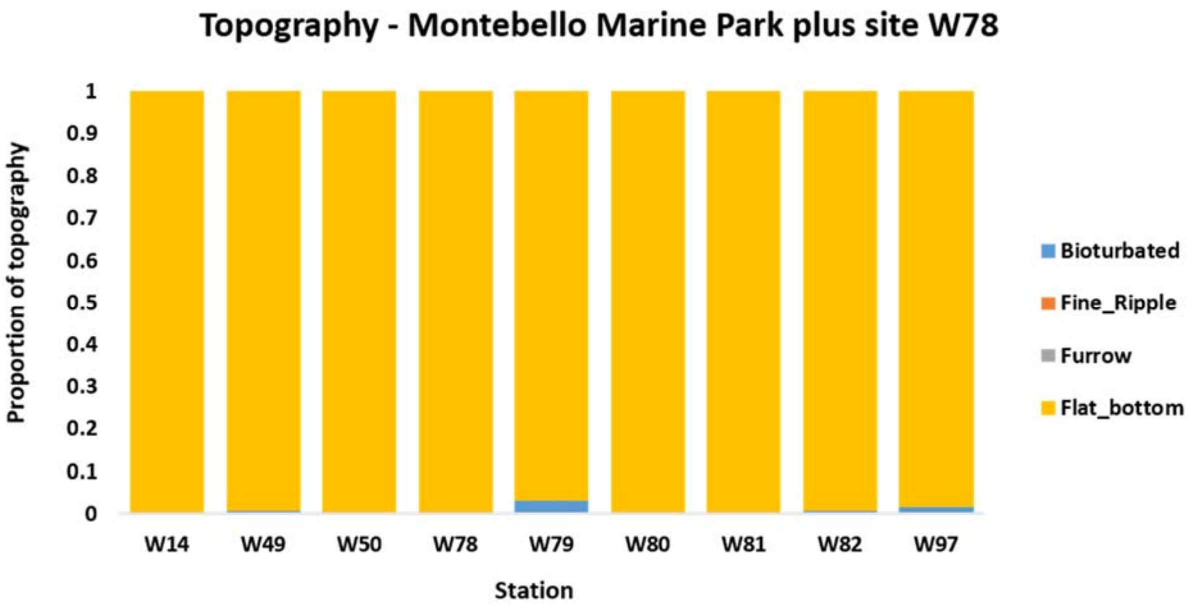


Figure 99. Proportion of substrate types in seabed images along trawl lines for INV2017_05 survey sites. Lower panel within the PFTF Area 1 immediately to the east Montebello MP. Upper panel within Montebello MP and one (site W78) just north of the MP



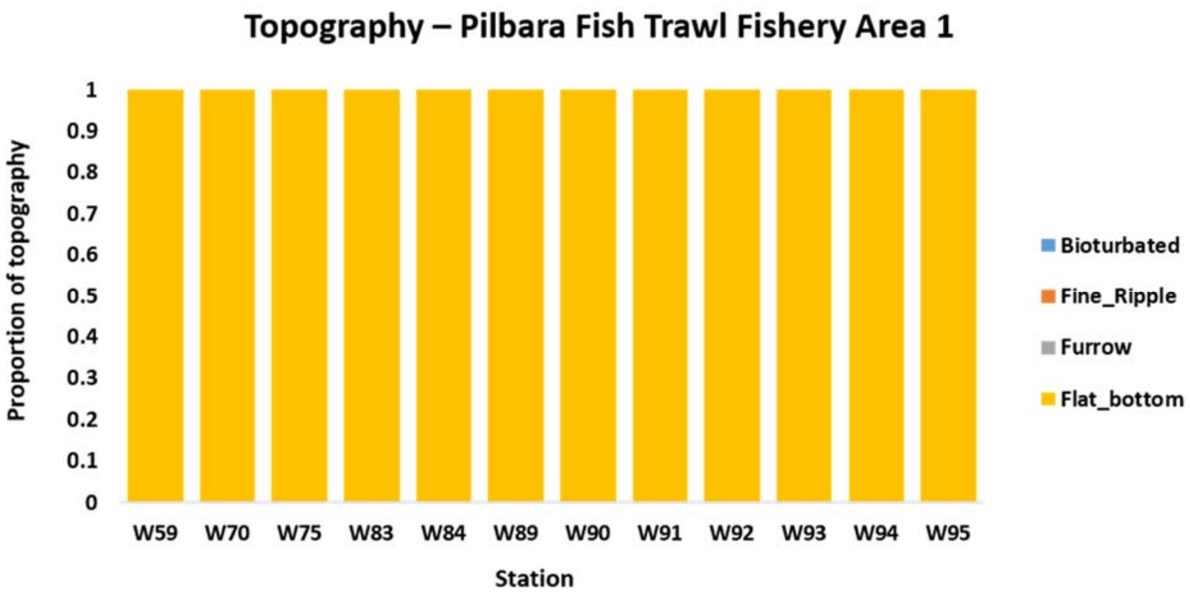


Figure 100. Proportion of topography types in seabed images along trawl lines for INV2017_05 survey sites. Lower panel within the PFTF Area 1 immediately to the east Montebello MP. Upper panel within Montebello MP and one (site W78) just north of the MP

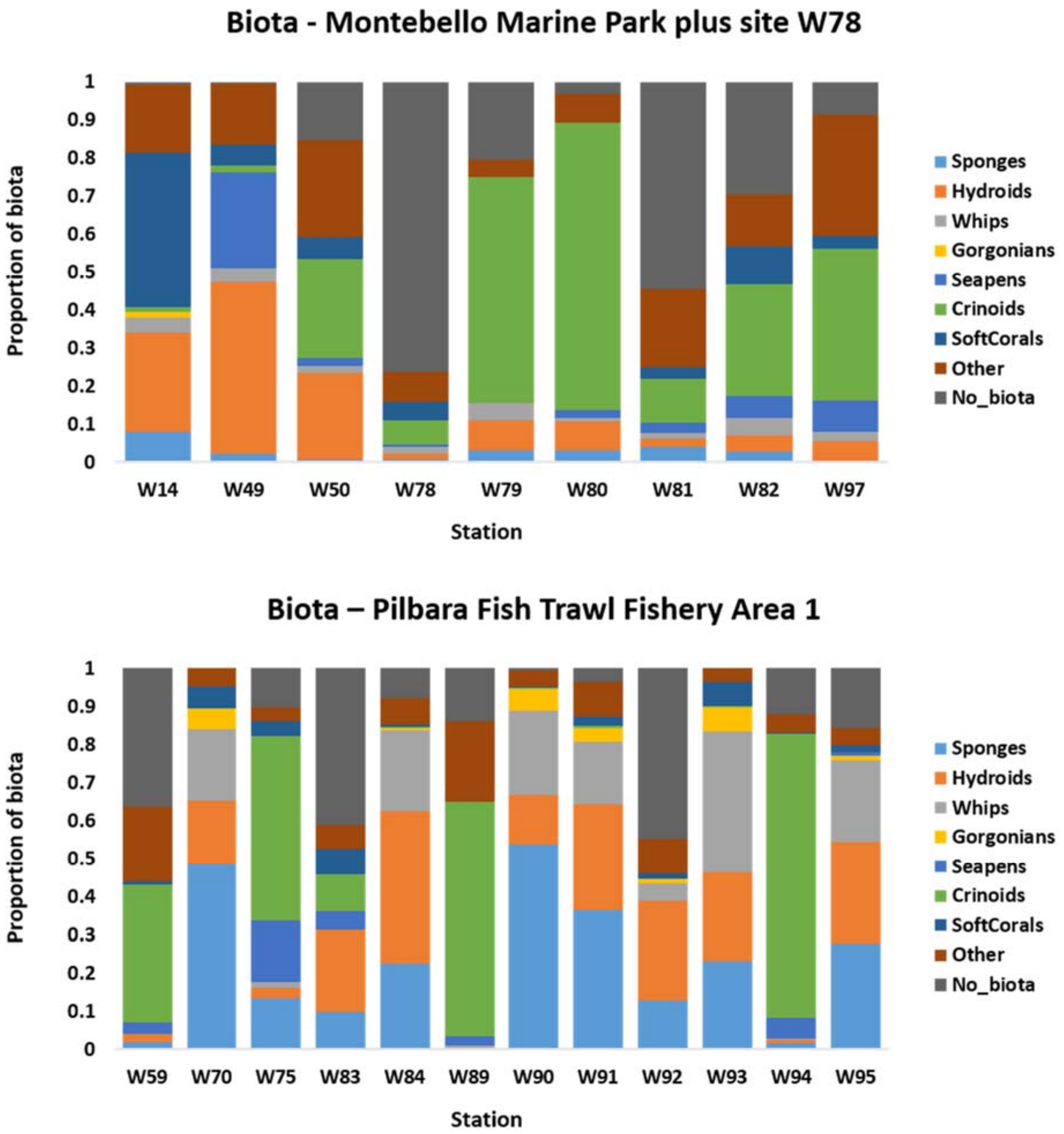


Figure 101. **Proportion of biota types in seabed images along trawl lines for INV2017_05 survey sites. Lower panel within the PFTF Area 1 immediately to the east Montebello MP. Upper panel within Montebello MP and one (site W78) just north of the MP. The category "other" includes taxa such as ascidians but also includes cases where the animal could not be identified due to poor image quality.**

Table 30. Mean biomass and density of sponge morphotype and size categories for trawl stations in the Montebello MP (plus station W78) and the PFTF Area 1. Number in brackets is the coefficient of variation (sample standard deviation/sample mean)

Sponge morphotypes and sizes	Montebello MP (plus site W78) (n=9)	Pilbara Fish Trawl Fishing Area (PFTF) Area 1 (n=12)	Montebello MP (plus site W78) (n=9)	Pilbara Fish Trawl Fishing Area (PFTF) Area 1 (n=12)
	Average biomass (g. ha^{-1})		Average density (no. ha^{-1})	
sponges cup <25 cm	348 (1.7)	1012 (0.9)	0.2 (1.8)	1.0 (1.0)
sponges cup 25 cm – 50 cm	1246 (2.1)	5585 (0.8)	0.2 (2.4)	1.8 (1.2)
sponges cup 50 cm – 100 cm	1644 (1.6)	4538 (0.8)	0.1 (2.0)	0.6 (1.0)
sponges cup>100 cm	1463 (3.0)	2703 (1.7)	0.0 (3.0)	0.1 (1.2)
sponges erect <25 cm	351 (2.8)	1385 (1.2)	1.0 (2.6)	3.7 (1.2)
sponges erect 25 cm – 50 cm	0	596 (2.4)	0.0	0.1 (1.7)
sponges erect 50 cm – 100 cm	320 (2.9)	3685 (1.1)	0.5 (2.9)	3.7 (1.4)
sponges erect >100 cm	843 (3.0)	2434 (1.5)	0.5 (3.0)	1.4 (1.5)
sponges massive <25 cm	993 (1.6)	4451 (0.7)	1.0 (2.0)	5.2 (1.0)
sponges massive 25 cm – 50 cm	0	0	0.0	0.0
sponges massive 50 cm – 100 cm	516 (1.5)	13585 (1.3)	0.2 (1.6)	10.4 (1.5)
sponges massive >100 cm	123 (3.0)	3477 (1.3)	0.0 (3.0)	1.6 (2.1)
Total all sponges	7846 (1.4)	43452 (0.8)	3.7 (2.3)	29.6 (1.0)

Table 31. Mean biomass and density of soft coral morphotype and size categories for trawl stations in the Montebello MP (plus station W78) and the PFTF Area 1. Number in brackets is the coefficient of variation (sample standard deviation/sample mean)

Soft coral morphotypes and sizes	Montebello MP (plus site W78) (n=9)	Pilbara Fish Trawl Fishing Area (PFTF) Area 1 (n=12)	Montebello MP (plus site W78) (n=9)	Pilbara Fish Trawl Fishing Area (PFTF) Area 1 (n=12)
	Average biomass (g. ha^{-1})		Average density (no. ha^{-1})	
soft corals fan <25 cm	2.8 (2.9)	49.2 (1.3)	0.0 (2.8)	0.7 (1.2)
soft corals fan 25 cm – 50 cm	7.3 (2.2)	82.1 (2.3)	0.1 (1.6)	0.5 (2.4)
soft corals fan 50 cm – 100 cm	4.7 (3.0)	82.0 (1.5)	0.0 (3.0)	0.2 (1.6)
soft corals fan >100 cm	3.6 (3.0)	0.0	0.0 (3.0)	0.0
soft corals massive <25 cm	40.0 (1.1)	246.1 (1.1)	0.2 (1.1)	0.9 (1.0)
soft corals massive 25 cm – 50 cm	9794.5 (2.9)	193.2 (1.4)	22.0 (2.9)	0.2 (1.2)
soft corals massive 50 cm – 100 cm	47.7 (3.0)	28.4 (3.5)	0.0 (3.0)	0.0 (3.5)
soft corals massive >100 cm	0.0	1.4 (3.5)	0.0	0.0 (3.5)
soft corals whip <25 cm	0.7 (3.0)	0.0	0.0	0.0
soft corals whip 25 cm – 50 cm	0.0	0.0	0.0	0.0
soft corals whip 50 cm – 100 cm	2.1 (3.0)	4.2 (3.5)	0.0 (3.0)	0.1 (3.5)
soft corals whip >100 cm	0.0	49.8 (2.8)	0.0	0.2 (1.3)
Total all soft corals	9903.5 (2.9)	736.4 (1.1)	22.3 (2.9)	2.9 (1.1)

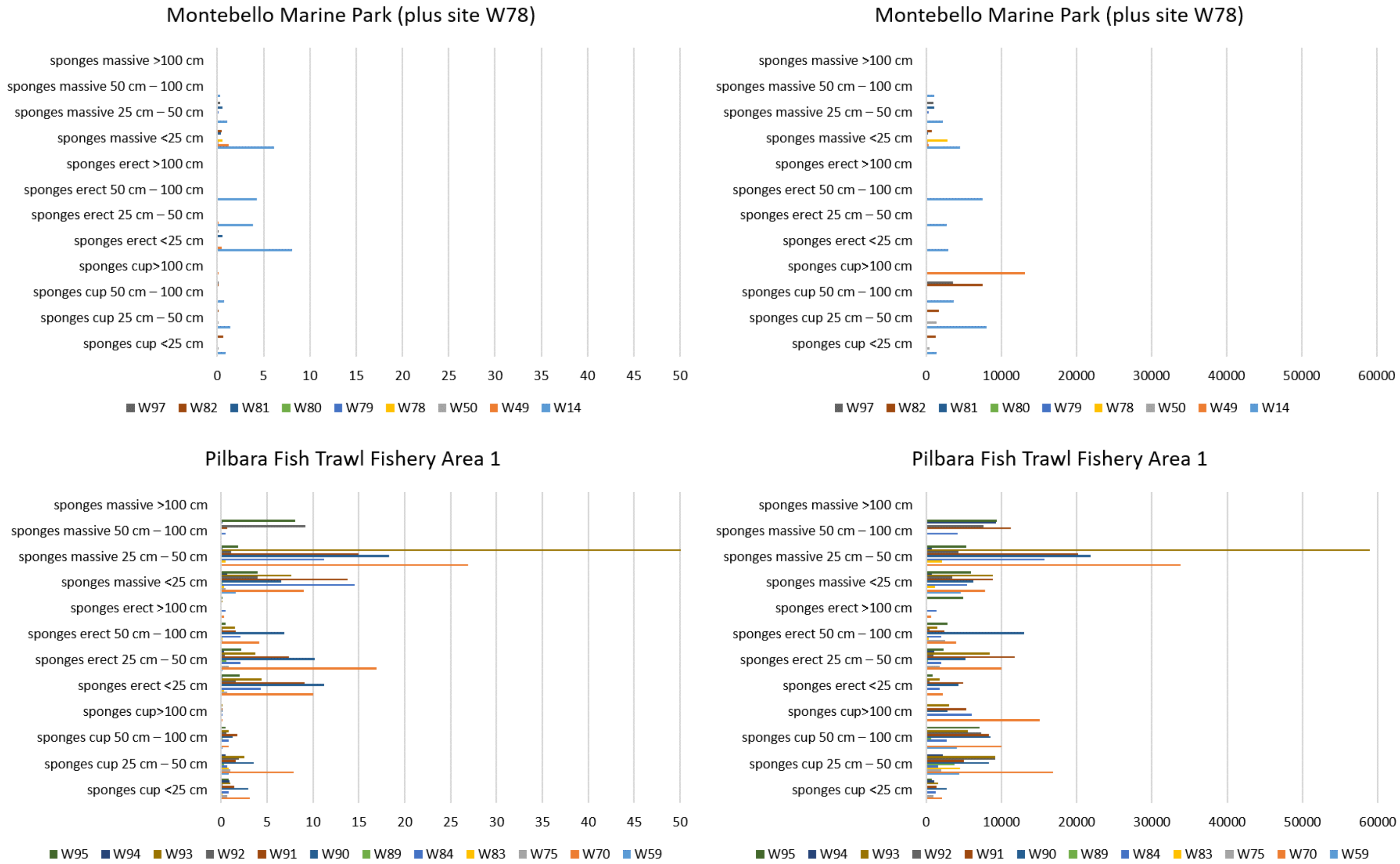


Figure 102. Density (individuals.ha^{-1}) (left panels) and biomass (g.ha^{-1}) (right panels) of size and morphology categories of sponges in trawls for sites in and around the Montebello MP and PFTF Area 1.

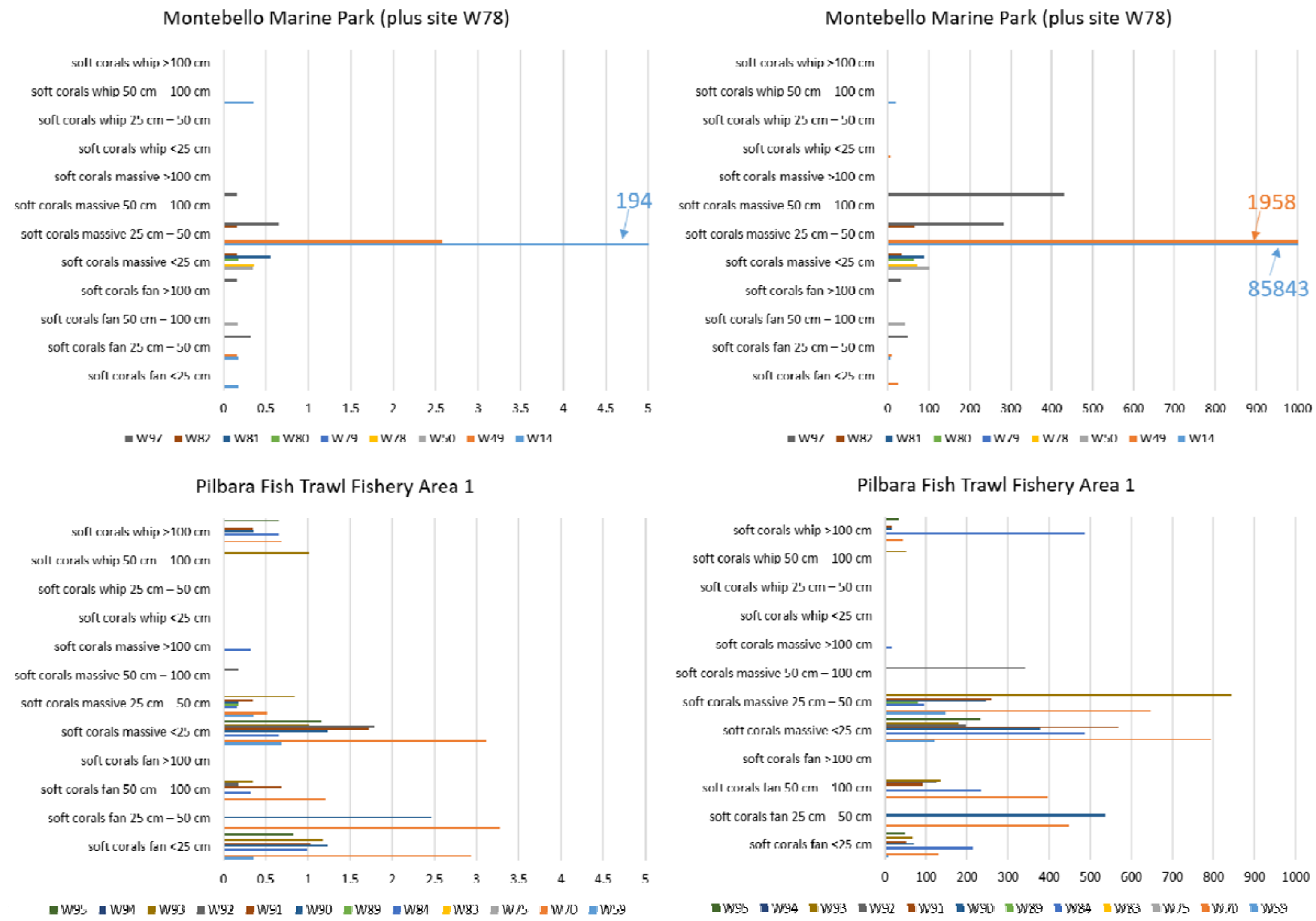


Figure 103. Density (individuals.ha^{-1}) (left panels) and biomass (g.ha^{-1}) (right panels) of size and morphology categories of soft corals (octocorals) in trawls for sites in and around the Montebello MP and PFTF Area 1.

5.3 Comparison of fish communities: species assemblages and diversity

5.3.1 Pilbara Fish Trawl Fishery (PFTF) Area 1

In the PFTF Area 1, a total of 168 fish taxa were collected from the 12 key sites (W59, W70, W83, W84, W89, W90, W91, W92, W93, W94, W95 and W75) (Table 32), which represented approximately half of the total number of fish taxa collected during the survey. Sites 70 (66 spp., 39% of total species recorded from the 12 PFTF Area 1 sites noted above) and sites W84 and W90 (both 61 spp., 36%) were the most diverse in terms of species numbers, whereas sites W89 (17 spp., 10%) and W59 (27 spp., 16%) had the fewest taxa.

The differences in species diversity between individual PFTF Area 1 sites cannot be explained by substrate (Figure 99 – all dominated by fine sand), topography (Figure 100 - consistently flat bottom at all sites) or bathymetry (Table 29, depth range within 58–66 m for all sites). However, two of the three highest diversity PFTF Area 1 sites (W70 and W90) had the highest proportions of sponges in seabed images (Figure 101), which may provide more opportunities for shelter and prey species. The lowest diversity PFTF Area 1 sites (W89 and W59) had high proportions of crinoids and very low proportions of sponges and soft corals in seabed images (Figure 101), suggesting lower habitat complexity which may reduce shelter and feeding opportunities.

5.3.2 Montebello MP (plus site W78, west of Commercial Fishery)

In the Montebello MP area, a total of 124 fish taxa were collected from the nine sites (W14, W49, W50, W78, W79, W80, W81, W82, W97) (Table 32), representing approximately one-third of the total number of fish taxa collected during the survey. Sites W14 (50 spp., 40% of total species recorded from all Montebello MP sites) and W81 (45 spp., 36% of total Montebello MP species) had the highest diversity, whereas site W79 (14 spp., 11%) and W80 (16 spp., 13%) had the fewest taxa.

The differences in species diversity between individual Montebello MP sites cannot be explained by topography (Figure 100- consistently flat bottom at all sites) or bathymetry (Table 29- depth range within 49–73 m for all sites and all but two sites were 54–69 m). However, substrate type (Figure 99) appears to have an influence with two of the highest diversity sites being predominantly (W81) or significantly (W14) rock in seabed images, whereas all other sites are sand-dominated. In addition, the highest diversity site (W14) had the highest proportion of soft corals (*Dendronephthya*) in seabed images resulting in high diversity of reef-associated species (e.g. five Labridae, four Serranidae and three Chaetodontidae spp. and a total of 19 spp. not recorded at any other Montebello MP sites). Sites with the lowest diversity (W79 and W80) had the highest proportions of crinoids in Montebello MP site seabed images.

5.3.3 Comparison of PFTF Area 1 with Montebello MP (plus site W78, west of Commercial Fishery)

The differences in species diversity between PFTF Area 1 sites (168 total taxa, range 17–66 species per site, mean 48 species per site) and Montebello MP sites (124 total taxa, 14–50 species per site, mean 31 species per site) cannot be explained by topography (Figure 100 - consistently dominated by flat bottom at all sites) or depth (Montebello MP range 49–73 m, mean 61.2 m (and all but two sites were 54–69 m) versus PFTF Area 1 range 58–66 m, mean 61.8 m).

However, there is more dominance by sponges in seabed images at most PFTF Area 1 sites than Montebello MP sites and greater array of habitat diversity present in seabed images at most PFTF Area 1 sites than

Montebello MP sites (Figure 101). The average biomass and density of sponge morphotypes was clearly higher at all PFTF Area 1 sites in comparison to Montebello MP sites (Table 30), which is likely responsible for the higher fish diversity than Montebello MP sites. This is likely due to favourable habitat complexity for a diverse size range of fishes that shelter within, on or around sponges, and often use the sponges as protection from strong currents.

Although the combined PFTF Area 1 sites had fewer elasmobranchs than Montebello MP (6 versus 8 species), most fish orders had much greater diversity at PFTF Area 1 than Montebello MP (e.g. Perciformes 94 versus 66, Tetraodontiformes 24 versus 16, Scorpaeniformes 15 versus 7 and Aulopiformes 8 versus 5).

5.3.4 Most common taxa

Species present at all PFTF Area 1 and all Montebello MP sites included the largescale saury *Saurida undosquamis* and starry triggerfish *Abalistes stellatus*. Rosy threadfin bream *Nemipterus furcosus* was present at all 12 PFTF sites and eight of nine Montebello MP sites (absent at site W80). Gulf damsel *Pristotis obtusirostris* was recorded at 11 of 12 PFTF Area 1 sites (absent from W93) and five of nine Montebello MP sites. Lunartail bigeye *Priacanthus hamrur* was present at 10 of 12 PFTF Area 1 sites and six of nine Montebello MP sites, and spotted dottyback *Pseudochromis quinquedentatus* was present at 10 of 12 PFTF Area 1 sites and five of nine Montebello MP sites.

5.3.5 Commercial species

The most commonly recorded commercial species were red emperor *Lutjanus sebae* (recorded at nine of 12 PFTF Area 1 sites, one Montebello MP site and one Dampier MP site), blue spotted emperor *Lethrinus punctulatus* (recorded at 10 PFTF Area 1 sites, 5 Montebello MP sites and 2 Dampier MP sites) and barcheek coral trout *Plectropomus maculatus* (recorded at seven, one and two sites, respectively).

Table 32. Fish species sampled in 2017 from comparable stations from within the Montebello MP plus station W78 not subject to trawling since 1985 and those within PFTF Area 1. 1 means the species was collected from that station

CLASS/ FAMILY	SPECIES	Montebello MP plus site W78									Pilbara Fish Trawl Fishery Area 1											
		W14	W49	W50	W79	W80	W81	W82	W97	W78	W59	W70	W83	W84	W89	W90	W91	W92	W93	W94	W95	W75
ELASMOBRANCHII																						
Stegostomatidae	*Stegostoma fasciatum*					1																
Scyliorhinidae	*Atelomycterus fasciatus*		1														1					
Carcharhinidae	*Carcharhinus plumbeus*																1					
Carcharhinidae	*Rhizoprionodon acutus*							1						1		1						
Hemigaleidae	*Hemigaleus australiensis*								1													
Rhinidae	*Rhynchobatus australiae*						1												1			
Dasyatidae	*Megatrygon microps*						1															
Dasyatidae	*Neotrygon australiae*																					1
Dasyatidae	*Pateobatis fai*						1															
Dasyatidae	*Taeniurops meyeni*															1						
Dasyatidae	*Urogymnus asperrimus*				1																	
ACTINOPTERYGII																						
Unknown	Unidentified Anguilliform larvae						1	1	1						1					1		
Muraenidae	*Gymnothorax cribroris* cf.		1					1			1	1		1		1	1	1			1	
Muraenidae	*Gymnothorax pseudothyrsoideus*											1										
Congridae	*Ariosoma meeki* cf.					1																
Congridae	*Ariosoma* sp.			1				1														
Ophichthidae	*Scolecenchelys gymnota*								1													
Synodontidae	*Saurida* sp.						1	1												1		1
Synodontidae	*Saurida undosquamis*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Synodontidae	*Synodus dermatogenys*											1				1						
Synodontidae	*Synodus hoshinonis*							1				1										
Synodontidae	*Synodus indicus*					1	1		1			1		1						1		1
Synodontidae	*Synodus jaculum*											1	1									1

Synodontidae	*Synodus sageneus*													1								
Synodontidae	*Trachinocephalus trachinus*				1	1			1						1					1		1
Batrachoididae	*Halophryne ocellatus*	1	1											1		1		1			1	
Antennariidae	*Antennarius commerson*																				1	
Antennariidae	*Antennarius striatus*					1																
Ogcocephalidae	*Halieutaea indica*	1									1			1								
Bregmacerotidae	*Bregmaceros* sp.						1	1						1								
Ophidiidae	*Ophidion* sp.								1													
Carapidae	*Carapus mourlani*																					1
Carapidae	*Encheliophis gracilis*													1						1		
Holocentridae	*Myripristis botche*																		1			
Holocentridae	*Sargocentron rubrum*															1	1		1			
Fistulariidae	*Fistularia commersonii*	1										1				1						1
Fistulariidae	*Fistularia petimba*				1	1		1		1	1			1				1				
Solenostomidae	*Solenostomus cyanopterus*				1																	
Syngnathidae	*Hippocampus angustus*																1				1	
Syngnathidae	*Hippocampus spinosissimus*		1																			
Pegasidae	*Eurypegasus draconis*		1																			
Scorpaenidae	*Dendrochirus brachypterus*																		1		1	
Scorpaenidae	*Pterois* sp.															1			1			1
Scorpaenidae	*Pteroidichthys amboinensis*										1											
Scorpaenidae	*Pteroidichthys noronhai*																	1				
Scorpaenidae	*Scorpaenodes smithi*	1	1					1	1		1	1	1	1		1		1		1		
Scorpaenidae	*Scorpaenopsis venosa*																				1	
Synanceiidae	*Minous roseus*			1			1								1							
Tetrarogidae	*Liocranium pleurostigma*	1																				
Tetrarogidae	*Richardsonichthys leucogaster*	1				1		1	1					1				1				
Triglidae	*Lepidotrigla japonica* cf.		1					1	1									1		1		
Platycephalidae	*Cymbacephalus bosschei*																		1			
Platycephalidae	*Onigocia grandisquama*		1								1											
Platycephalidae	*Platycephalus endrachtensis*																					1

Platycephalidae	*Rogadius patriciae*													1								
Platycephalidae	*Rogadius tuberculatus*					1	1															
Platycephalidae	*Thysanophrys* sp.																					1
Dactylopteridae	*Dactyloptena papilio*												1				1		1		1	
Serranidae	*Cephalopholis boenak*	1										1							1	1		
Serranidae	*Diploprion bifasciatum*															1	1					1
Serranidae	*Epinephelus amblycephalus*																	1				
Serranidae	*Epinephelus areolatus*	1					1	1			1	1	1	1		1	1	1	1		1	
Serranidae	*Epinephelus bilobatus*											1		1		1	1		1		1	
Serranidae	*Epinephelus multinotatus*	1										1	1					1	1		1	
Serranidae	*Plectropomus maculatus*	1										1	1	1		1	1		1		1	
Serranidae	*Pseudanthias rubrizonatus*							1					1							1		
Serranidae	*Tosana* sp.																		1			
Pseudochromidae	*Congrogadus spinifer*			1																		
Pseudochromidae	*Pseudochromis howsoni*	1					1			1		1									1	1
Pseudochromidae	*Pseudochromis quinquedentatus*		1	1			1	1	1		1		1	1	1	1	1	1	1	1	1	
Priacanthidae	*Priacanthus hamrur*	1	1	1			1		1	1	1	1	1			1	1	1	1	1	1	1
Priacanthidae	*Priacanthus tayenus*											1										
Apogonidae	*Apogonichthyoides atripes*								1		1	1	1				1					
Apogonidae	*Apogonichthyoides brevicaudatus*													1		1						
Apogonidae	*Gymnapogon* n. sp. 1																	1				
Apogonidae	*Gymnapogon* n. sp. 2							1	1										1			
Apogonidae	*Ostorhinchus fasciatus*											1		1								
Apogonidae	*Ostorhinchus monospilus* cf.																1		1	1		
Apogonidae	*Ostorhinchus semilineatus*														1					1		1
Apogonidae	*Ostorhinchus septemstriatus*						1	1			1											1
Apogonidae	*Ostorhinchus* sp.		1	1																		1
Apogonidae	*Pristiapogon fraenatus*																1					1
Apogonidae	*Rhabdamia gracilis*																			1		1
Rachycentridae	*Rachycentron canadum*						1	1								1						

Echeneidae	*Echeneis naucrates*					1	1	1	1			1							1		1	1
Carangidae	*Carangoides caeruleopinnatus*		1		1		1			1			1				1		1			1
Carangidae	*Carangoides chrysophrys*		1		1		1			1												1
Carangidae	*Carangoides gymnostethus*	1	1	1			1	1	1		1		1		1			1	1	1	1	
Carangidae	*Carangoides* sp. (juveniles)							1														
Carangidae	*Decapterus macrosoma*							1														
Carangidae	*Gnathanodon speciosus*							1														
Carangidae	*Parastromateus niger*																			1		
Carangidae	*Selar crumenophthalmus*																	1				
Carangidae	*Seriolina nigrofasciata*								1													
Leiognathidae	*Equulites elongatus*																	1				
Caesionidae	*Dipterygonotus balteatus*											1								1		1
Caesionidae	*Pterocaesio chrysozona*									1		1	1			1	1	1	1	1	1	1
Lutjanidae	*Lutjanus erythropterus*											1										
Lutjanidae	*Lutjanus lutjanus*												1									
Lutjanidae	*Lutjanus malabaricus*									1									1			
Lutjanidae	*Lutjanus russellii*									1			1				1		1	1	1	
Lutjanidae	*Lutjanus sebae*									1		1	1	1		1	1	1	1	1	1	
Lutjanidae	*Lutjanus vitta*						1					1	1	1		1	1	1	1	1	1	1
Lutjanidae	*Pristipomoides multidens*						1															
Lutjanidae	*Symphorus nematophorus*																		1			
Nemipteridae	*Nemipterus celebicus*				1	1				1			1								1	
Nemipteridae	*Nemipterus furcosus*	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nemipteridae	*Pentapodus nagasakiensis*	1					1					1	1	1			1		1	1		1
Nemipteridae	*Pentapodus porosus*	1	1									1		1		1			1			
Nemipteridae	*Scolopsis monogramma*	1					1					1	1	1		1	1	1	1		1	
Haemulidae	*Diagramma pictum*											1				1	1		1		1	1
Lethrinidae	*Gymnocranius elongatus*		1						1	1		1		1		1	1	1	1		1	
Lethrinidae	*Lethrinus genivittatus*													1								
Lethrinidae	*Lethrinus lentjan*									1						1						
Lethrinidae	*Lethrinus nebulosus*	1								1						1						

Lethrinidae	*Lethrinus punctulatus*	1	1	1			1			1		1	1	1		1	1	1	1	1	1	1
Lethrinidae	*Lethrinus ravus*											1				1						
Sparidae	*Argyrops bleekeri*	1	1		1				1	1		1				1	1	1	1		1	
Mullidae	*Parupeneus chrysopleuron*											1										
Mullidae	*Parupeneus heptacanthus*	1					1			1		1	1	1		1	1	1	1	1	1	
Mullidae	*Parupeneus indicus*						1					1		1		1	1				1	
Mullidae	*Upeneus guttatus*						1					1	1							1		1
Mullidae	*Upeneus margarethae*											1					1					
Pempherididae	*Parapriacanthus ransonneti* cf.																			1		1
Ephippidae	*Platax batavianus*	1											1	1		1						
Chaetodontidae	*Chaetodon assarius*	1					1									1						
Chaetodontidae	*Chelmon marginalis*															1						
Chaetodontidae	*Coradion altivelis*												1	1								
Chaetodontidae	*Coradion chrysozonus*	1	1				1					1	1	1		1	1	1	1	1	1	
Chaetodontidae	*Heniochus diphreutes*	1									1											
Chaetodontidae	*Parachaetodon ocellatus*		1					1	1	1	1	1	1	1	1	1	1	1	1		1	1
Pomacanthidae	*Chaetodontoplus duboulayi*	1					1					1	1	1		1	1		1	1	1	
Pomacanthidae	*Chaetodontoplus personifer*	1	1				1		1			1	1	1		1	1	1	1	1	1	1
Pomacanthidae	*Pomacanthus sexstriatus*	1										1		1		1						
Pomacentridae	*Amblypomacentrus breviceps*																		1			
Pomacentridae	*Chromis fumea*	1										1		1		1		1		1	1	1
Pomacentridae	*Pristotis obtusirostris*	1		1			1	1	1		1	1	1	1	1	1	1	1		1	1	1
Cirrhitidae	*Cirrhitichthys aprinus* cf.	1						1				1						1				
Sphyraenidae	*Sphyraena forsteri*																				1	
Labridae	*Anampses lennardi*	1												1								
Labridae	*Bodianus solatus*												1						1			1
Labridae	*Choerodon cauteroma*	1					1					1	1	1		1	1	1	1	1	1	1
Labridae	*Choerodon cephalotes*	1																				
Labridae	*Choerodon schoenleinii*	1																				
Labridae	*Iniistius* n. sp. (damaged)										1											
Labridae	*Leptojulis cyanopleura*																1			1		

Labridae	*Oxycheilinus orientalis*	1										1		1		1					1	
Labridae	*Suezichthys soelae*	1						1	1			1							1			
Scaridae	*Scarus ghobban*	1					1					1	1	1		1	1	1	1		1	1
Uranoscopidae	*Ichthyscopus insperatus*														1							
Champsodontidae	*Champsodon vorax* cf.								1						1					1		
Gobiidae	*Bathygobius* sp.							1			1							1		1		
Gobiidae	Gobiidae - undifferentiated									1												
Gobiidae	*Larsonella* sp.							1														
Gobiidae	*Lubricogobius ornatus*						1			1				1								
Gobiidae	*Priolepis cincta*													1								
Gobiidae	*Priolepis profunda*		1					1	1		1		1	1			1	1				
Gobiidae	*Sueviota larsonae* cf.			1			1		1		1											
Acanthuridae	*Acanthurus grammoptilus*											1	1	1		1	1		1		1	1
Acanthuridae	*Naso reticulatus*											1				1						
Acanthuridae	*Naso unicornis*											1										
Siganidae	*Siganus fuscescens*																1		1		1	
Psettodidae	*Psettodes erumei*	1		1									1				1	1			1	1
Bothidae	*Engyprosopon grandisquama*								1													
Bothidae	*Engyprosopon maldivensis*														1							
Bothidae	*Grammatobothus pennatus*	1	1		1	1	1	1	1	1	1		1	1		1	1	1			1	1
Bothidae	*Grammatobothus polyophthalmus*							1														
Paralichthyidae	*Pseudorhombus diplospilus*							1	1					1				1				
Paralichthyidae	*Pseudorhombus dupliciocellatus*		1	1	1	1	1	1	1	1	1		1							1	1	1
Paralichthyidae	*Pseudorhombus elevatus*															1						
Paralichthyidae	*Pseudorhombus spinosus*			1		1																
Pleuronectidae	*Samaris cristatus*																				1	
Balistidae	*Abalistes stellatus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Balistidae	*Pseudobalistes flavimarginatus*											1									1	1
Balistidae	*Sufflamen fraenatum*											1	1	1		1	1	1	1		1	
Monacanthidae	*Aluterus monoceros*										1											

Monacanthidae	*Anacanthus barbatus*			1										1								
Monacanthidae	*Cantherhines fronticinctus*															1						
Monacanthidae	*Chaetodermis penicilligerus*	1														1						
Monacanthidae	*Eubalichthys caeruleoguttatus*	1										1		1								
Monacanthidae	*Paramonacanthus oblongus*																	1				
Monacanthidae	*Paramonacanthus* sp.							1							1				1			1
Monacanthidae	*Pseudomonacanthus peroni*	1	1	1					1					1			1	1	1			
Ostraciidae	*Lactoria cornuta*		1	1	1	1	1	1		1	1				1					1		1
Ostraciidae	*Lactoria diaphana*			1								1		1								
Ostraciidae	*Lactoria fornasini*															1						
Ostraciidae	*Ostracion cubicus*											1		1		1	1				1	1
Ostraciidae	*Ostracion nasus*	1		1								1	1			1	1	1	1			
Ostraciidae	*Ostracion rhinorhynchos*																		1			
Ostraciidae	*Tetrosomus gibbosus*	1	1				1					1		1			1	1	1		1	
Tetraodontidae	*Canthigaster cyanospilota*											1		1	1	1	1		1		1	
Tetraodontidae	*Canthigaster rivulata*	1									1	1		1				1	1		1	
Tetraodontidae	*Feroxodon multistriatus*							1														
Tetraodontidae	*Lagocephalus sceleratus*						1		1			1		1		1		1	1			
Tetraodontidae	*Torquigener pallimaculatus*	1	1	1																		
Diodontidae	*Cyclichthys orbicularis*						1									1						
Diodontidae	*Diodon holocanthus*											1				1		1	1			
Diodontidae	*Tragulichthys jaculiferus*	1												1					1			
	Number of taxa	**50**	**31**	**22**	**14**	**16**	**45**	**39**	**34**	**25**	**27**	**66**	**43**	**61**	**17**	**61**	**51**	**48**	**59**	**40**	**53**	**47**

5.4 Comparison of fish communities: biomass

To enable comparisons in fish biomass between the areas of contrasting historical and recent fishing effort, fish catches in the trawl stations surveyed on the 2017 voyage were standardised to grams per hectare taking into account (usually small) variation in trawl length (about 3 km) and the spread of the net doors (about 90 m).

In general fish biomass was much greater at stations within the PFTF Area 1 than in the Montebello MP. The commercially important emperor (Lethrinidae) and snapper (Lutjanidae) families occurred at six and 11 stations in PFTF Area 1 (Figure 104) with an average biomass of 435 g. ha^{-1} and 734.2 g.ha^{-1} respectively (Table 33). By comparison these families only occurred at four and two stations in the Montebello MP (Figure 104) with an order of magnitude less average biomass of 40 g. ha^{-1} and 52 g.ha^{-1} respectively (Table 33). The other families that had more than ten-times the average biomass in the PFTF Area 1 were groupers (Serranidae), goatfishes (Mullidae), sweetlips (Haemulidae), squirrelfishes (Holocentridae) and parrotfishes (Scaridae) (Figure 104, Figure 106, Table 33). The families that were more abundant in the Montebello MP were those generally associated with poor fishing grounds or degraded habitats. These include lizardfishes (Synodontidae), threadfin breams (Nemipteridae), trevallies (Carangidae) (Figure 105, Table 33) (Sainsbury 1991). The density of sharks and rays was similar in the two areas (Table 33).

In summary, fish biomass for most families of fish were highest in the PFTF Area 1 than in the Montebello MP. Both areas had a similar history of fishing up until about 1985 (Table 29, Figure 97), however there has been no trawling in the area that is now the Montebello MP since 1985. However differences in fish biomass are more likely to reflect differences in the type of benthos than differences in fishing effort. The sites in the PFTF Area 1 have much more habitat forming benthic filter feeder biota that those within the Montebello MP (Table 30, Table 31, Figure 101). There is a strong association between habitat forming benthic filter feeder biomass and fish biomass for most families of fish.

Table 33. Mean biomass per area trawled at stations in the Montebello MP (plus station W78) and the PFTF Area 1. Number in brackets is the coefficient of variation (sample standard deviation/sample mean)

Fish Family	Montebello MP (plus site W78) (n=9)	Pilbara Fish Trawl Fishing Area (PFTF) Area 1 (n=12)
Lutjanidae (g. ha^{-1})	52.2 (2.0)	734.2 (1.1)
Lethrinidae (g. ha-1)	40.5 (1.4)	435.1 (2.0)
Synodontidae (g. ha-1)	1060.9 (1.3)	509.8 (1.3)
Nemipteridae (g. ha-1)	1199.3 (1.6)	747.0 (0.8)
Serranidae (g. ha-1)	26.9 (3.0)	392.2 (1.0)
Balistidae (g. ha-1)	305.8 (0.5)	889.8 (0.6)
Carangidae (g. ha-1)	206.8 (1.2)	77.9 (1.1)
Mullidae (g. ha-1)	4.3 (3.0)	205.4 (1.1)
Pomacanthidae (g. ha-1)	57.6 (2.3)	335.5 (0.9)
Chaetodontidae (g. ha-1)	16.0 (1.6)	48.2 (0.7)
Haemulidae (g. ha-1)	0.0	211.7 (1.7)
Holocentridae (g. ha-1)	0.0	80.2 (2.5)
Sparidae (g. ha-1)	39.1 (1.3)	38.8 (1.6)
Scaridae (g. ha-1)	13.2 (2.1)	216.4 (1.4)
Elasmobranchs (no. ha-1)	0.031 (0.9)	0.030 (1.4)

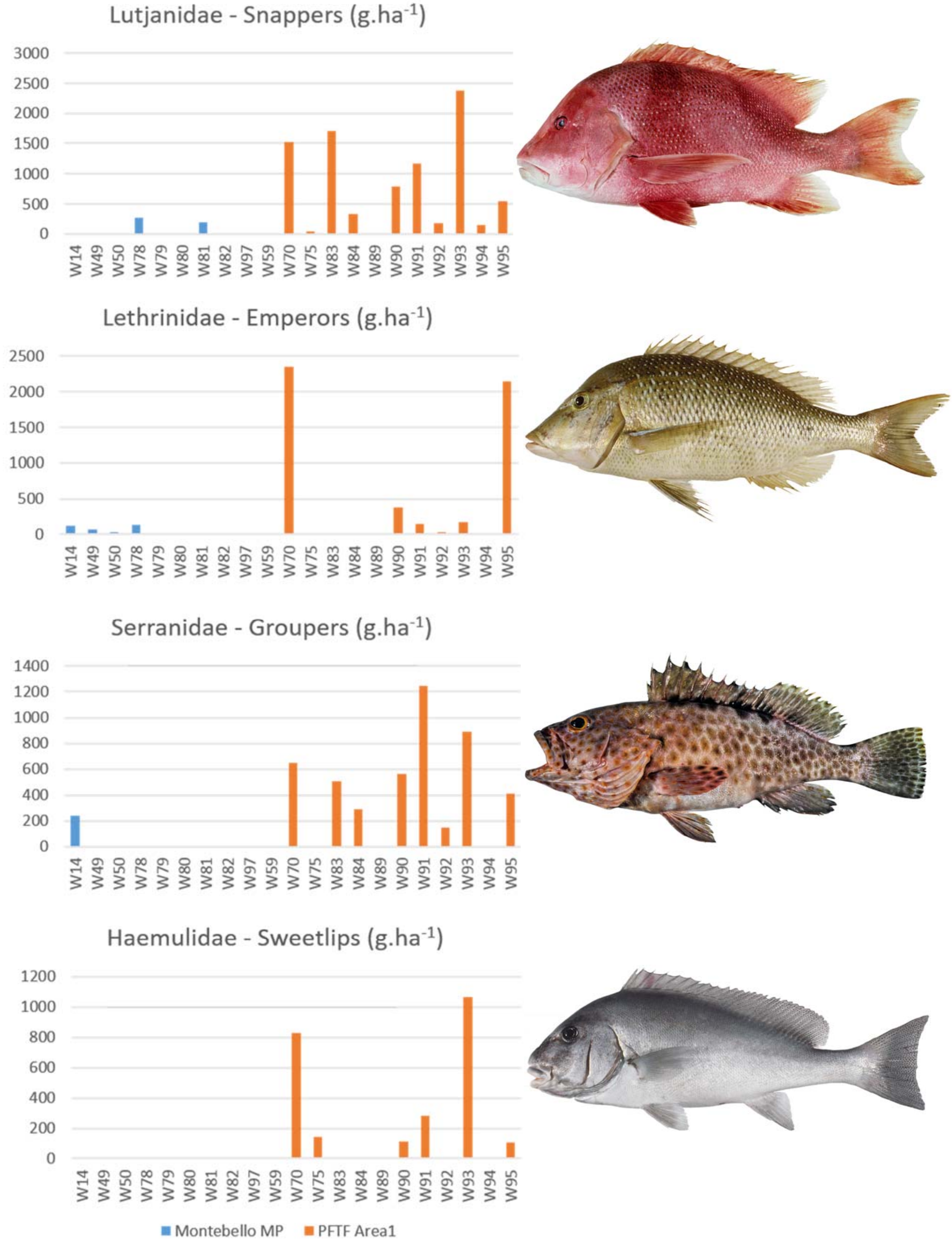


Figure 104. Comparative biomass of fish families in trawl catches (g. ha^{-1}) on the 2017 voyage in the Montebello MP (plus station W78) and the PFTF Area 1

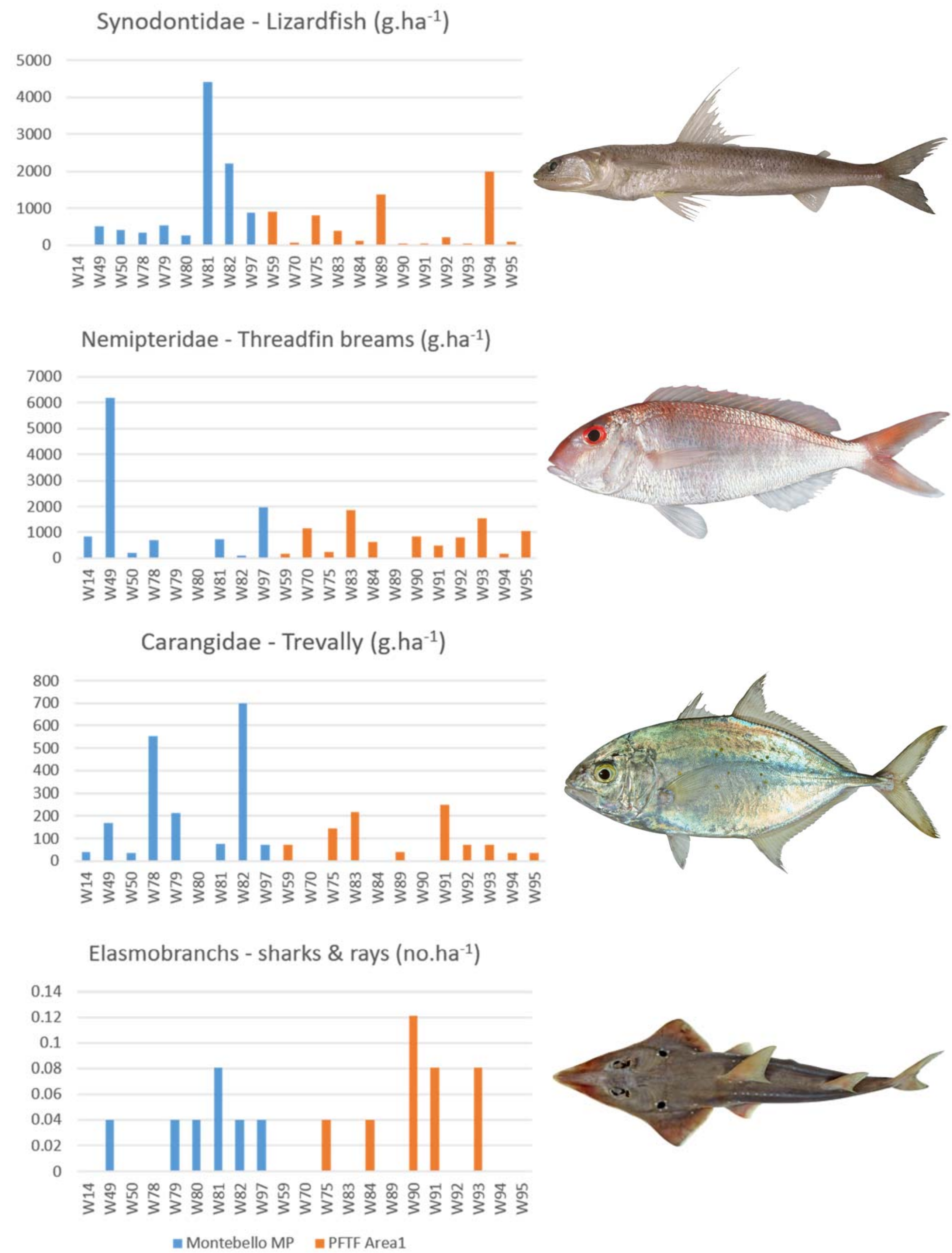


Figure 105. Comparative biomass of fish families in trawl catches (g. ha^{-1}) on the 2017 voyage in the Montebello MP (plus station W78) and the PFTF Area 1

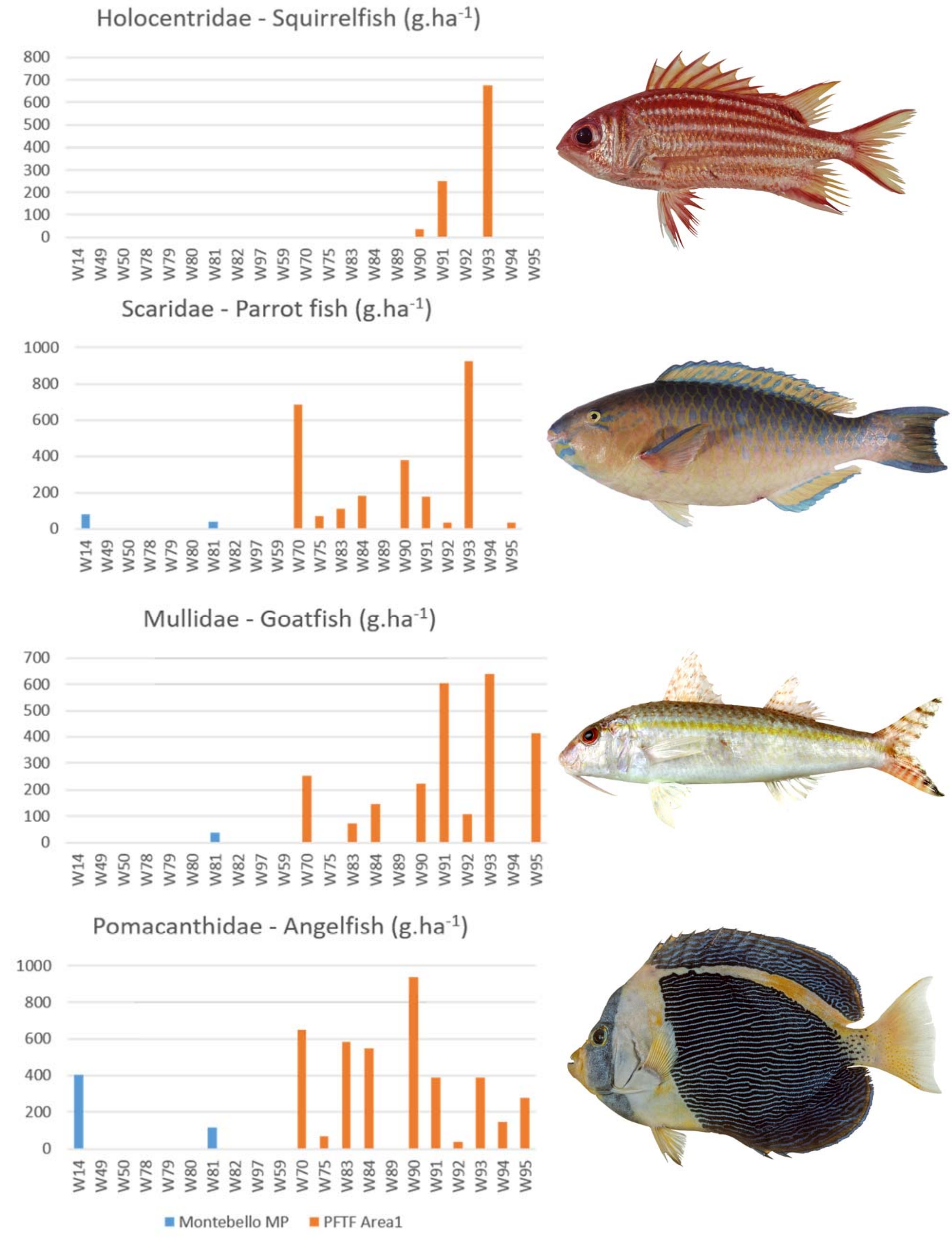


Figure 106. Comparative biomass of fish families in trawl catches (g. ha^{-1}) on the 2017 voyage in the Montebello MP (plus station W78) and the PFTF Area 1

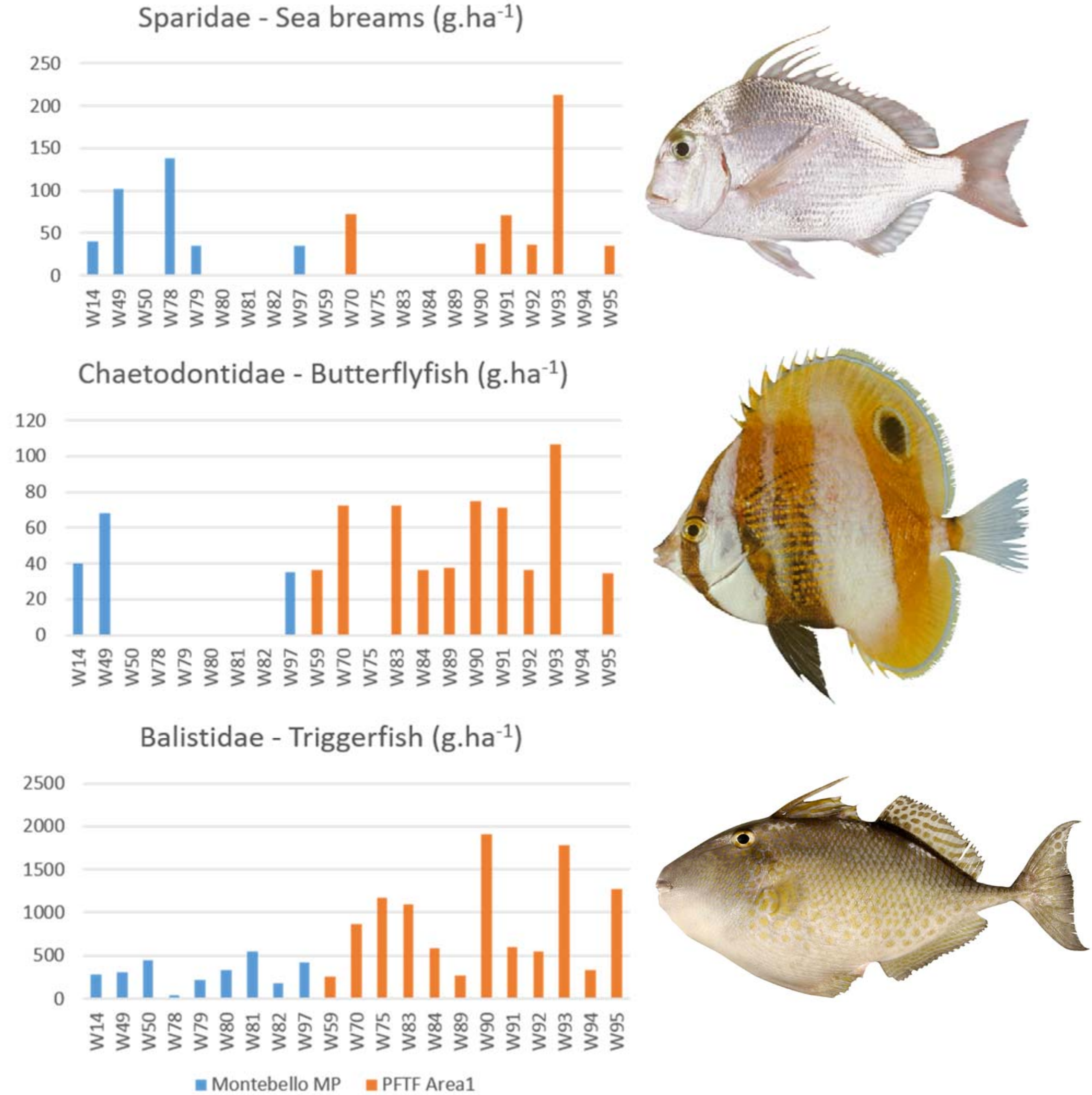


Figure 107. Comparative biomass of fish families in trawl catches (g. ha^{-1}) on the 2017 voyage in the Montebello MP (plus station W78) and the PFTF Area 1

Table 34. Catch in kg of different fish families at each station in the Montebello MP (plus station W78) and nearby comparable sites in the PFTF Area 1 which have been continuously fished since the 1970s. Data not corrected for minor differences in trawl length at each station. Historical effort = 1979–1987, Recent effort = 2005–2016

Site	Historical effort (%) swept area per year	Recent effort (%) swept area per year	Lutjanidae (kg)	Lethrinidae (kg)	Synodontidae (kg)	Nemipteridae (kg)	Serranidae (kg)	Balistidae (kg)	Carangidae (kg)	Mullidae (kg)	Monacanthidae (kg)	Fistularidae (kg)	Pomacanthidae (kg)	Chaetodontidae (kg)	Haemulidae (kg)	Holocentridae (kg)	Sparidae (kg)	Scaridae (kg)	Elasmobranchs (No.)
W14	1-50%	0-1 %	0	3	0	21	6	7	1	0	1	0	10	1	0	0	1	2	
W49	50-100%	0-1%	0	2	15	181	0	9	5	0	0	0	0	2	0	0	3	0	1
W50	50-100%	0-1%	0	1	11	6	0	12	1	0	0	0	0	0	a	0	0	0	
W78	100-192%	0-1%	8	4	10	20	0	1	16	0	0	0	0	0	0	0	4	0	
W79	100-192%	0-1%	0	0	15	1	0	6	6	0	0	0	0	0	0	0	1	0	1
W80	100-192%	0-1%	0	0	7	0	0	9	0	0	0	0	0	0	0	0	0	0	1
W81	100-192%	0-1%	5	0	114	19	0	14	2	1	0	0	3	0	0	0	0	1	2
W82	100-192%	0-1%	0	0	63	3	0	5	20	0	0	0	0	0	0	0	0	0	1
W97	100-192%	0-1%	0	0	25	56	0	12	2	0	0	0	0	1	0	0	1	0	1
W59	50-100%	1-50%	0	0	25	5	0	7	2	0	0	0	0	1	0	0	0	0	
W70	50-100%	50-100%	42	65	2	32	18	24	0	7	0	0	18	2	23	0	2	19	
W75	50-100%	100-213%	1	0	23	7	0	33	4	0	0	0	2	0	4	0	0	2	1
W83	100-192%	1-50%	47	0	11	51	14	30	6	2	0	0	16	2	0	0	0	3	
W84	100-192%	1-50%	9	0	3	17	8	16	0	4	1	0	15	1	0	0	0	5	1
W89	100-192%	50-100%	0	0	37	1	0	7	1	0	0	0	0	1	0	0	0	0	
W90	100-192%	50-100%	21	10	1	22	15	51	0	6	4	1	25	2	3	1	1	10	3
W91	100-192%	50-100%	33	4	1	14	35	17	7	17	1	0	11	2	8	7	2	5	2
W92	100-192%	50-100%	5	1	6	22	4	15	2	3	0	0	1	1	0	0	1	1	
W93	100-192%	50-100%	67	5	1	43	25	50	2	18	1	0	11	3	30	19	6	26	2
W94	100-192%	100-213%	4	0	55	5	0	9	1	0	0	0	4	0	0	0	0	0	
W95	100-192%	100-213%	16	62	3	30	12	37	1	12	0	0	8	1	3	0	1	1	

5.5 Comparison of soft coral diversity

In total 53 species were recorded from the twelve PFTF Area 1 sites (W59, W70, W83, W84, W89, W90, W91, W92, W93, W94, W95 and W75). The Montebello MP was less speciose with 32 species recorded from nine sites (W14, W49, W50, W78, W79, W80, W81, W82, W97) (Figure 108). Sixteen (16) species were present in both the Montebello MP and the PFTF Area 1, while 37 species were unique to the PFTF Area 1 and 16 species were unique to the Montebello MP.

From the twelve stations investigated in the PFTF Area 1, station W90 (17 species), W70 (14 species), W93 (14 species), and W75 (12 species) had the highest octocoral diversity, whereas all other stations were less speciose. The most abundant morphotype in the PFTF Area 1 was *Dendronephthya*, and the sea whips *Junceella juncea and Verrucella* sp.1 (family Ellisellidae). From the nine stations investigated at the Montebello MP, station W14 and W49 had the highest octocoral diversity with 23 and 12 species respectively, followed by W50, W97, W81 and W82 (with less than 10 species) and W78, W79 and W80 with one species respectively. The most abundant morphotypes in the Montebello MP were sea fans (33 %), massive octocorals (33 %) and *Dendronephthya* (23 %), while sea whips were less abundant (11 %).

In general, the species composition in both areas were similar. Within PFTF Area 1 and the Montebello MP the subordinal group Alcyoniina was strongly represented by the family Nephtheidae, and only one species within the family Viguieriotidae (*Studeriotes crasssa*). *Nephthyigorgia kükenthali* (Nidaliidae) was only found in the Montebello MP. No specimens from the families Alcyoniidae and Xeniidae were collected at any of the Montebello MP or PFTF Area 1 sites. Scleraxonian diversity in both areas was low, with some sea fans (*Melithaeidae*) and *Solenocaulon tortuosum* (Anthothelidae) being more abundant. In the PFTF Area 1 there were also some larger sea fans present (*Parisis australis, Annella reticulata and Subergorgia suberosa*), which were absent in the Montebello MP. The latter indicating areas of stronger currents in the PFTF Area 1.

The main difference between the PFTF Area 1 and the Montebello MP was the strong representation of the family *Plexauridae* (38% of the fauna) in the PFTF Area 1. Nine genera and 21 species within the family Plexauridae were found in the PFTF Area 1: *Echinogorgia* (five species), *Astrogorgia* (four species), *Menella* (three species), *Trimuricea* (two species), *Villogorgia* (two species), *Echinomuricea* (two species), *Bebryce* (one species), *Euplexaura* (one species), *Paraplexaura* (one species). Only four genera and five species were collected from the Montebello MP (15% of the fauna), which consisted of two species of *Paraplexaura*, and a single species of each of *Echinogorgi*a, *Echinomuricea* and *Menella*. The dominant families within the Montebello MP were the families Nephtheidae (28 %) and Ellisellidae (25%).

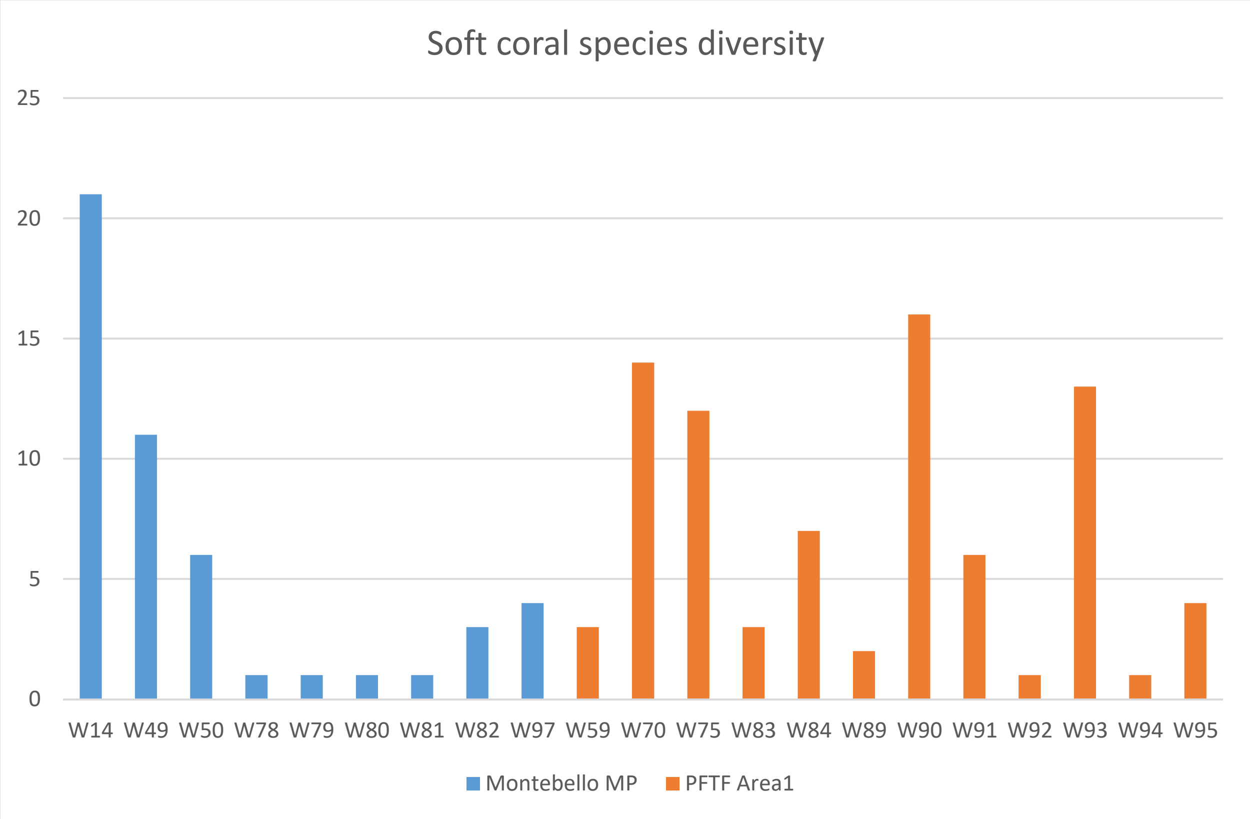


Figure 108. Comparative soft coral diversity (number of species) in the Montebello MP (plus station W78) and the PFTF Area 1

5.6 Association of demersal fish assemblages and benthic filter feeder communities

One of the overall objectives of the fisheries relevant work undertaken on the 2017 voyage relates to determining the relationships between demersal fish assemblages and benthic filter feeder communities, and how these might have recovered from the effects of trawling in the 1970s and 1980s. This information will also be of relevance to MP management.

Sponge biomass was found to be a significant predictor of fish biomass for 12 of 15 fish families and elasmobranch groupings. Of the 12 families whose biomass was significantly correlated with sponge biomass, only lizardfishes (Synodontidae) showed a negative correlation. Earlier research on the NWS (Sainsbury 1991) supported the hypothesis that declines in commercially important fish families, primarily emperors (Lethrinidae) and snappers (Lutjanidae) and associated increases in lizardfishes (Synodontidae) and threadfin breams (Nemipteridae) were due in part to trawlers modifying the seabed by removing habitat forming filter feeder biota.

In general the 2017 data supports the part of the hypothesis that there is a strong association between habitat forming filter feeder biota and certain families of fish, including the commercially important emperor (Lethrinidae) and snapper (Lutjanidae) families. However, we might have expected greater abundances of filter feeder habitat and associated fish families in the Montebello MP given the area has not been subject to trawling since at least 1985 (and little if any trawling since 1985). However, it is not possible to draw conclusions about rates of recovery from trawling on different parts of the NWS based on the data presented here. This will await a full analysis of the substrate and biota across the full set of 100 stations sampled on the 2017 voyage (including in areas which have never been trawled) and a comparison of those data with that collected in the 1980s and 1990s.

Table 35. Regression analyses of fish family biomass (g.ha^{-1}) or density (no. ha^{-1}) and sponge biomass (g.ha^{-1}) for the 21 sites surveyed in the Montebello MP (plus station W78) and the PFTF Area 1. Bolded values are statistically significant.

Fish Family	Correlation coefficient	P value (ANOVA)
Lutjanidae (g. ha^{-1})	0.750	**<0.0001**
Lethrinidae (g. ha^{-1})	0.523	**0.015**
Synodontidae (g. ha^{-1})	-0.440	**0.046**
Nemipteridae (g. ha^{-1})	0.066	0.776
Serranidae (g. ha^{-1})	0.859	**<0.0001**
Balistidae (g. ha^{-1})	0.624	**0.003**
Carangidae (g. ha^{-1})	-0.247	0.281
Mullidae (g. ha^{-1})	0.830	**<0.0001**
Pomacanthidae (g. ha^{-1})	0.732	**<0.0001**
Chaetodontidae (g. ha^{-1})	0.761	**<0.0001**
Haemulidae (g. ha^{-1})	0.815	**<0.0001**
Holocentridae (g. ha^{-1})	0.608	**0.003**
Sparidae (g. ha^{-1})	0.538	**0.012**
Scaridae (g. ha^{-1})	0.869	**<0.0001**
Elasmobranchs (no. ha^{-1})	0.356	0.113

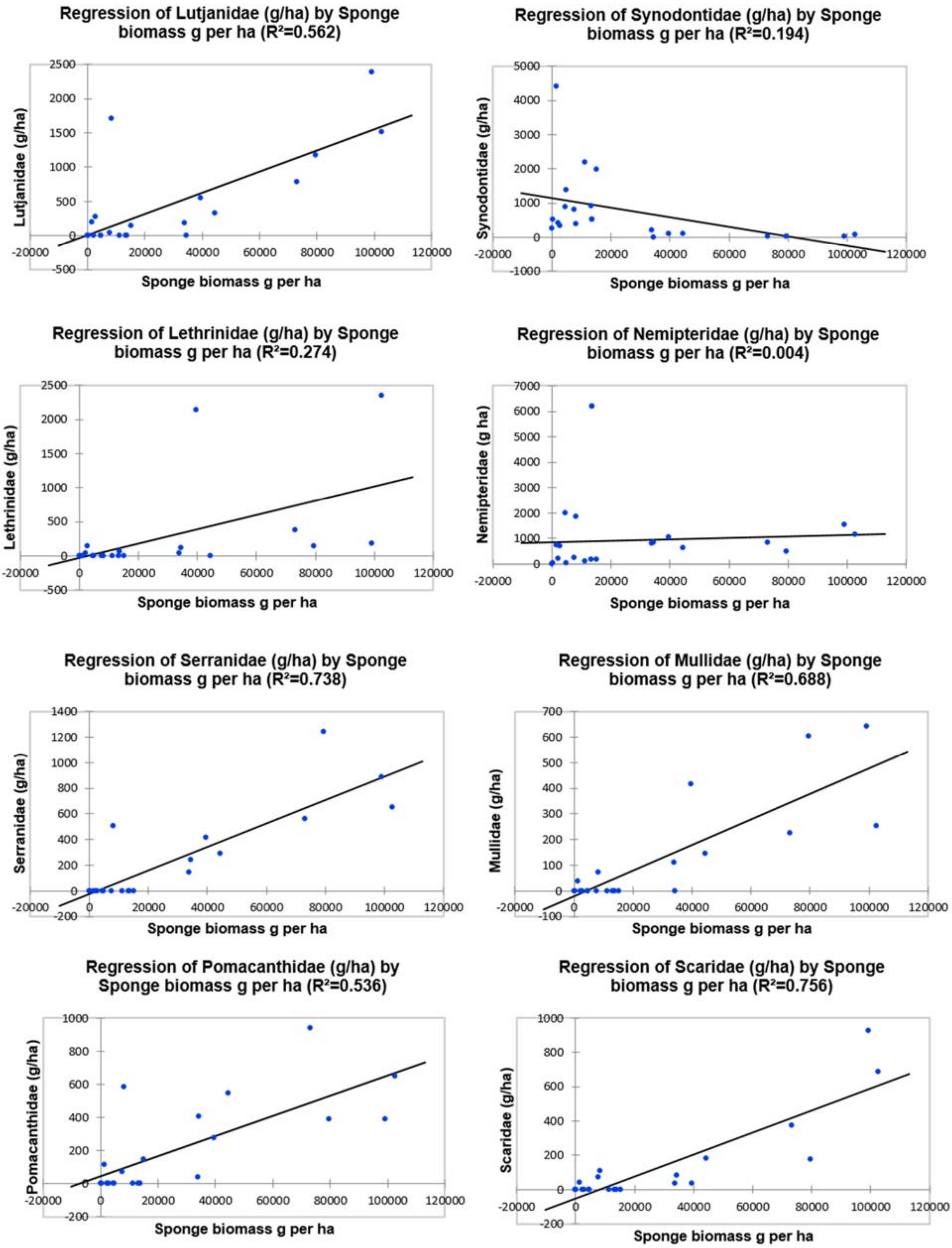


Figure 109. Regression plots for selected fish families of fish biomass and sponge biomass for the 21 sites surveyed in the Montebello MP (plus station W78) and the PFTF Area 1. Results of the regression analysis are shown in Table 35

Table 36. Biomass and abundance of sponge and soft corals at each station in the Montebello MP (plus station W78) and nearby comparable sites in the PFTF Area 1 which have been continuously fished since the 1970s. Data not corrected for minor differences in trawl length at each station. Historical effort = 1979–1987, Recent effort = 2005–2016

Site	Depth (m)	Historical effort (%) swept area per year	Recent effort (%) swept area per year	Sponge (kg)	Soft Coral (kg)	Sponge (n)	Soft Coral (n)	Sponge >50 cm (n)	Soft Coral >50 cm (n)
14	49	1-50%	0-1 %	215	491	140	1103	6	2
49	60.9	50-100%	0-1%	87	14	3	17	1	0
50	53.7	50-100%	0-1%	13	1	1	3	0	1
78	73.4	100-192%	0-1%	16	0	3	2	0	0
79	68.7	100-192%	0-1%	2	0	1	0	0	0
80	66.8	100-192%	0-1%	0	0	0	1	0	0
81	63.2	100-192%	0-1%	8	0	3	3	0	0
82	60.1	100-192%	0-1%	69	1	6	1	1	0
97	55	100-192%	0-1%	28	5	1	7	1	1
59	59.8	50-100%	1-50%	77	2	12	7	1	0
70	59.7	50-100%	50-100%	728	15	449	69	8	11
75	60.5	50-100%	100-213%	46	0	14	0	0	0
83	63	100-192%	1-50%	51	1	11	34	0	0
84	57.9	100-192%	1-50%	298	12	206	10	9	1
89	62.2	100-192%	50-100%	30	1	6	1	1	0
90	58.3	100-192%	50-100%	440	8	338	24	8	2
91	63.9	100-192%	50-100%	525	10	294	21	15	6
92	64.3	100-192%	50-100%	192	4	105	11	54	1
93	66.5	100-192%	50-100%	633	14	423	21	6	8
94	62.7	100-192%	100-213%	89	0	15	1	1	0
95	62.7	100-192%	100-213%	257	4	112	17	53	4

Appendix A Detailed description of survey design and methodology

A.1 Study design and site selection methodology

A.1.1 Data sources

A series of existing data sources were compiled in order to carry out a comprehensive spatial stratification of the study area:

Historical trawl fishing effort

Trawl effort data for the Taiwanese pair-trawl fleet was originally sourced from AFMA logbook data compilation which contains trawl records from foreign trawlers that had been collated in the "AFZIS" data base between 1974 and 1987 and in the "radio-reporting" database (1979–1990). Prior to 1979, trawl effort had been reported on 30 minute grid cells, whereas from 1979 onwards trawl effort was reported as trawl start and end positions with trawl durations although the resolution and quality of these positions was variable (noting also that these were prior to GPS). The start–end positions and duration data from 1979 to 1987 were linear-interpolated then gridded and aggregated at 0.01 degree by Franzis Althaus (CSIRO O&A Hobart). However, while this resolution was satisfactory for other AFMA fisheries following implementation of GPS, it was too fine for the historical Taiwanese pair-trawl effort data. Hence, these data were aggregated further to 0.05 degrees and averaged for the period 1979–1985 inclusive.

Recent trawl fishing effort (Pilbara Fish Trawl Fishery)

Trawl effort data for the domestic Pilbara Fish Trawl fleet (otter trawls) were provided by DPIRD and originally compiled from vessel logbook data, for the period from 2005 when shot-by-shot effort data became available and2016. The start–end positions and tow-durations of the individual trawls were linear-interpolated then gridded and aggregated at 0.01 degree. For the purposes of the survey design, these data were averaged to give the mean annual effort in hours per grid cell. The hours of effort were re-scaled to swept-area by multiplying by average trawl-speed and swept-width between the doors, then divided by grid-cell area to give swept-area ratio.

Environmental data

A range of mapped environmental data layers had been collated by a previous project (originally the CERF Marine Biodiversity Hub) and progressively updated by a series of subsequent projects, most recently FRDC 2016-039. These environmental layers include: bathymetry DEM (depth, slope, aspect, terrain topography membership); sediments (%mud, sand, gravel, carbonate); seabed shear-stress; bottom-water attributes (temperature, salinity, O_2, NO_3, PO_4, Si); ocean colour derived variables (e.g. SST, Chl k490, PAR, NPP, epoc & b_irr); with seasonal ranges where applicable — a total of 40 variables. The layers were all gridded at 0.01d and mapped for the entire EEZ; subsequently subsetted to the Pilbara NWS study area.

Biological survey data

Biological data from historical NWS Effects of Trawling (EoT) Project surveys from 1982 to 1997 were used in analyses to quantify relationships between biological composition and environmental gradients, as well as both historical and recent trawl effort. These surveys conducted trawl sampling, using a McKenna trawl on two RV *Southern Surveyor* voyages (SS199508: 108 stations; SS199707: 106 stations) and Frank & Bryce trawls on 11 FRV *Soela* voyages (SO198205 to SO198805: 1096 stations) and two RV *Southern Surveyor* voyages (SS199002: 133 stations; SS199104: 101 stations). Identification and quantification of these trawl samples focussed primarily on the fishes, with some identification of discrete invertebrates at high taxonomic levels. Sponges were quantified at the phylum level only on the two McKenna trawl voyages.

On most voyages (10 of 15), a 35 mm still film camera was fitted to the headline of many trawls and provided images of sessile benthos on the seabed ahead of the trawl net. Photos were available for 583 stations (of a total of 1544 trawls) and typically about 80 photos were available for each although this ranged widely. The photos had previously been analysed by Franzis Althaus (CSIRO O&A Hobart) to provide counts of large (>25 cm), small (5–25 cm) and mini (<5 cm) benthos for up to about a dozen morpho-types, including: sponges (lump, cup, branching, flat), gorgonians (sea fans, whips), soft coral and sea pens among others.

Determination of sampling strata

The biological, environmental and trawl effort data were analysed using R package gradientForest (Ellis et al. 2012) to quantify the magnitude and shape of relationships between biological composition and gradients in the environment. These compositional turnover curves were used to transform the multi-dimensional environmental space of the study area (i.e. the mapped environmental variables) to a multi-dimensional biological space where increasing distance between points in this space reflects increasing differences in biological composition as associated with the environmental gradients. The biological space provides the basis of the stratification of the study. For example, if a representative sampling of the regions biodiversity was desired, then simply clustering the biological space into a number of groups equal to the expected number of stations would provide a suitable stratification.

However, in this study, the primary objective was to quantify the extent of recovery in sessile benthos and of fish populations. Hence, a key contrast (or strata) was in areas that had been trawled heavily by the Taiwanese but later were untrawled after the foreign trawlers ceased fishing. Other important contrasts were between such areas and those areas that continued to be trawled by the domestic fishery; as well as those areas that were not fished by either fleets. Thus the first step was to establish the effort contrasts and then determine the number of stations to be sampled in each. This process included excluding areas which could not be sampled due to obstacles in the form of the intensive array of undersea communications cables, oil and gas pipes and well heads.

The trawl effort intensity (average annual grid swept ratio: F-ratio) of both the historical and recent fishing was divided into categories representing zero, low, medium and high potential impact on benthos (i.e. F-ratio = [0, 0.01] [0.01, 0.5] [0.5, 1.0] [1.0, 2.0]) and the entire study grid of 24,371 cells was assigned into one of the 16 possible categories. Three categories did not exist (i.e. historical= zero with recent=low, medium or high) and some categories were rare (i.e. recent=medium or high; historical=high). The total number of stations planned in the survey was 100 and these initially were distributed in proportion to the number of grid cells in each categories to the power of ⅓, with some subsequent adjustment of allocation to ensure a minimum of 3 and to up-weight the key contrast of high historical and zero recent effort.

The second step was to cluster each effort category into a number of groups corresponding to the number of stations to be allocated, where the clustering was based on the transformed biological space described above. These cluster groups within effort categories provided the strata for the survey. Within each strata, the medoid grid cell was identified as a candidate most typical station, where the medoid is defined as the cell having the minimum sum of distances (in biological space) to all other cells in the same strata.

A.1.2 Site selection

Site selection principles and rules

Having established the 0.01 degree (1111 m) grid extent for the study and determined which grid cells comprised each of the 100 strata — and the position of the medoid in each strata (as described above) — a series of rules were applied to select the actual stations to be sampled. These rules were established to enable, where possible, comparison with historical scientific trawl data collected in 1963 and 1964 (Masuda et al. 1964; Suzuki et al. 1964) and between 1982 and 1997 by CSIRO (Sainsbury 1987 [which also includes a summary of Japanese and other surveys on the NWS]; Althaus et al. 2006; Fulton et al. 2006). Firstly, if the start position for an Oshoru Maru trawl fell within the strata, it was selected as the station. If there was no corresponding Oshoru Maru station then the midpoint of the closest to medoid RV *Southern Surveyor* 1995 or 1997 trawl that fell within the strata was chosen. Priority was given to these three voyages because they had collected quantitative biomass data on sponge catches in trawls. If no SS1995 or SS1997 voyage trawl fell within the strata, then we selected the midpoint of the closest to medoid other CSIRO 1982-1997 voyage trawl for which headline camera photos of benthos were collected at the station (subject to a minimum of 40 photos). If there were no historic research trawls in the strata then the medoid cell was selected as the station.

By this process 100 stations were selected for the study. Following this and immediately prior to the voyage a feasibility/risk assessment was undertaken by Bridge Officers from the RV *Investigator* and this resulted in 6 of the original 100 sites being ruled invalid. These were moved sufficient to avoid the obstacle by 1 nm but always remained within the same strata. Only one other site was moved. Site 6 was moved 3.4 nm south of its original position to match a historical research trawl (SO1983_04_64) inside the Dampier MP while remaining within the same strata.

Tow transect selection

Where possible the selected stations were treated as the midpoint of the trawl transect. The primary consideration in trawl and sled transect selection was to remain within strata. The trawl and sled transects were selected blind to the substrate type and bottom topography. Once a transect was selected it was swath mapped at 70–100 kHz using a Kongsberg EM710 multibeam acoustic swath mapper so that any trawl hazards could be assessed before deploying the net. Any sharp changes in depths on hard bottom which indicated ledges greater than 1 m depth change in 10 m transect length were avoided (to minimise chance of net damage and camera loss) by changing the transect bearing. In general, tow direction was dictated by wind direction with most trawl and sled tows done with the ship heading into the wind. Some latitude around this, particularly when winds were light provided flexibility to avoid hazards (a 1 nm buffer was maintained around pipelines, abandoned well heads and drill holes) and remain in small strata or strata with complex shapes. In a few cases a curved or dog-legged trawl line had to be set to avoid oil and gas infrastructure hazards and remain within strata. All other tows were straight.

A.2 Trawl and sled operations and gear configuration

A.2.1 Trawl design, set up and operation

Trawl headline camera

The Trawl headline camera consisted of a Canon M5 mirrorless camera and a Quantum QFlash Trio QF8 flash in waterproof housings mounted on a sturdy acrylic and stainless steel frame. Two laser beams fixed at 25 cm apart were added to provide a scale to all photographs. Photograph interval was set at 4 seconds which is every 4.6 m at 3 knots. Depth activation/deactivation was programmed into the camera to avoid excessive memory or battery use during net streaming. A GoPro 5 video camera in a Nimar housing rated to 200 m was also fixed to the camera frame. Additional floats were added to the trawl headline to compensate for the mass of the camera.

Trawl set up and operation

The CSIRO Semi V Wing trawl net (McKenna trawl net) was used for all trawls. Trawl navigation lines were established which consisted of a 2 km lead in to an on-bottom position and a 4 km trawl track. On approach to the trawl line, the cod-end was paid out at 5–6 knots and when the net was off the drum the trawl headline camera frame was attached to the trawl headline with shackles along with the Marport sensors. The camera was turned on and the net was then paid out and the trawl doors attached. Depending on water depth, the net was towed with doors fixed until approximately 600 m from the on-bottom position and then with the vessel slowed to 4–5 knots, 50 m of wire was paid out. At a point calculated on the basis of vessel speed and depth, wire was then paid out at a wire:depth ratio of 3.5:1.

The net did not have its own USBL system so the following provides an estimate of the position of the doors and the net relative to the vessel position. The length of the back chains from boards (15 m), sweep length (90 m) and bridles (45 m) gives a total of 150 m, which when the doors are fully spread equates to approximately 140 m from the centre of the footrope to an imaginary line between the two boards. The position of the doors relative to the ships position was calculated using Pythagorean Theorem with the depth and amount of wire out as two sides of a right angle triangle and taking into account the distance from the stern to the ships GPS (60 m). No attempt was made to compensate for the spread of the two winch wires which are 9 m apart at the stern and maybe as much as 100 m apart at the doors. For example in 80 m depth with 270 m of wire out, this was a distance of 318 m. When added to the distance between the boards and the net of 140 m (see above), this total distance (458 m in the above example) was recorded in the ships event logger as the layback distance from the ships position (ships GPS) to the centre of the net headline with the boards fully spread. The ships position was recorded in the ship's event logger at three times on each trawl: the time when the doors touched the bottom, the time the boards were fully spread and at the time the boards lifted from the bottom. The timing of each of these events was provided using a Marport net monitoring system (see below). The above records make it possible to estimate the position of the boards and the net relative to the ships position at each important phase of the fishing operation.

With the boards fully spread at approximately 90 m (range is between 80 m and 100 m) and the net width at fishing about 19 m wide (as it bows back from its full length of 26 m), the effective fishing swept width for fish will be about 90 m and for benthic invertebrates about 19 m. Of the 100 sites trawled major net tearing occurred at only one site (Site W3) but the catch was regarded as representative and quantitatively valid. There were compromised trawls (net tangle) at three sites, but two of these were repeated on an adjacent line offset by 200 m leaving only the catch at site W29 regarded as invalid.

Trawl net monitoring system

A Marport net monitoring system with acoustic sensors on both doors and the centre of the net headline provided a measure of board spread and net headline height above the seabed.

A.2.2 Sled design, set up and operation

The epibenthic sled was the same as used on previous surveys on other vessels in the Kimberley and the Pilbara (e.g. Fry et al. 2008; Pitcher et al. 2016) consisting of a galvanised steel frame with an opening measuring 1.5 m wide by 0.5 m high and 20 mm steel mesh base, top and sides with a depth of 1.0 m. A heavy nylon codend (18 mm square mesh, 30 mm stretched) was attached to the back of the sled to collect the sample. The length of the chain bridle on each side was 1.0 m. A GoPro 5 video camera in a Nimar housing rated to 200 m and lighted by a Keldan video light was mounted inside the sled to check that the sled was fishing effectively.

A sled line was plotted central and parallel to the planned trawl line offset by 100 to ensure the trawl and sled did not overlap each other. The vessel approached the start of the sled line at 2 knots the sled was lowered at 60 m per minute during which time the vessel slowed to 1 knot for the duration of the tow.

Trawl and sled distance and duration

Trawl transects were 30 minutes duration at 3 knots speed over ground (usually about 2,800–3,000 m depending on average speed of tow). Sleds were initially run for 200 m at 1 knot, but after only light catches were obtained in the first few stations this was increased to 400 m at 1 knot.

A.3 Handling of trawl and sled catches, sorting and vouchering

A.3.1 Trawl catch handling and invertebrate sorting and vouchering

The cod-end was emptied into between one and four 600–800 L “mega bins” containing AQUI-S fish anaesthetic at a concentration of 100–150 mg/L in sea water, on the after deck near the stern ramp and then wheeled under cover of either the sheltered science area or a canvas gazebo on the starboard side of the after deck. Sponges and large fans were separated from fish which were allowed time to anaesthetise (usually about 20 minutes). During this time sponges and octocoral soft corals were sorted into morphotypes (massive, cup, erect for sponges and whips, fans, dendronephthid) and size categories (<25 cm, 25–50 cm, 50–100 cm, >100 cm). Counts and weights of each combination of morphotype and size category were recorded. Weights and counts of some soft coral and sponge species that were particularly abundant in some sites, were estimated by averaging numbers and weights of the individuals contained in 3 of the sorting baskets or bins and multiplying by the total number of full baskets. In other cases where individuals of particular species (e.g. sponge species of *Callyspongia, Amphimedon, Chondropsis*) were extremely fragmented, but still recognisable the number of individuals was estimated by dividing the total weight by the individual weight of complete individuals founded among the catch. Any fragments broken from the main colonies of sponges and soft corals were weighed as one lot (not separated into morphotypes). Other invertebrates were sorted from the catch and sorted into groups with bulk weights and counts recorded. Cephalopods were anaesthetised in a solution of Magnesium Chloride mixed at the rate of 58.5 g/L $MgCl_2$ in sea water. The taxonomic level of these groups varied according to abundance and the amount of material to be sorted, but as a minimum, the following groups were separated: anthozoans, bryozoa, hydroids, colonial ascidians, solitary ascidians, asteroids, ophiuroids, echinoids, crinoids, holothuroids, bivalves, gastropods, squid, cuttlefish, octopus, crabs and shrimps. Vouchers of all crustaceans, echinoderms, molluscs were retained and vouchers of the most abundant sponges and octocorals were retained. In the case of sites which fell within the Dampier and Montebello Marine Parks, an attempt was made to voucher all sponge and octocoral species collected. At other sites, vouchers of selected specimens from unknown species and those selected for chemistry studies were also kept. All counts and weights were entered into the catch database. During the sorting process photographs were taken of the catch. Some of the individual voucher specimens were photographed separately. Most sponges and soft corals separated for vouchering were assigned a unique barcode and photographed individually. A representative fragment of the specimen was preserved in alcohol; but in few cases the whole specimen was preserved frozen. Some specimens or fragments of specimens were retained frozen for biological analyses (e.g. stable isotopes) and linked to the preserved voucher (if any) in the database. Some specimens were retained frozen for biological analyses (e.g. stable isotopes).

A.3.2 Sled catch handling, sorting and vouchering

Sled catches were much smaller and the cod-end was emptied into 60 L tubs and baskets on the back deck and then invertebrates were sorted, counted, weighed, photographed and vouchered as described above for trawls. Large sponges and baskets of sponges and other biota were weighed on a motion compensating POLS P-15/S-210 electronic balance (±20 g accuracy) or a Mettler spring balance. Small and individual invertebrates were weighed on a motion compensating Marel M1100 balance (0.5 g accuracy). Fish were only captured by sleds incidentally and these were counted and weighed as a bulk lot and frozen for later identification and individual vouchering. Some specimens were retained frozen for biological analyses (e.g. stable isotopes). Where captured alive, fish were anaesthetised in concentrations of AQUI-S as described above, but in smaller containers.

A.3.3 Trawl caught fish and pharaoh's cuttlefish (*Sepia pharaonis*)

All trawl caught fish were sorted to species and identified and a count and bulk weight of each species obtained using a motion compensating POLS P-15/S-185 electronic balance (±20 g accuracy). Length and weight of up to 100 fish of each species from each trawl catch were taken using motion compensating scales (Marel M1100, ±2 g accuracy) and electronic fish measuring boards which logged directly into the catch database. Once a total of 500 individual length and weight measurements had been made, only the length of up to 100 fish from each species in each trawl catch were taken. Large elasmobranchs (> 1m) were released alive after measuring and tissue samples were taken from either the disc margin, the dorsal or caudal fin. Individual lengths and weights of pharaoh's cuttlefish (*Sepia pharaonis*) were also made. Batches of very small fish species were individually reweighed on the more accurate Marel balance to improve precision of length-weight relationships. For some commercially significant species, additional data from a subset of the total catch on reproductive state (macroscopic scale) was recorded and histological samples were also taken from pearl perch (*Glaucosoma* spp.), coral trout (*Plectropomus maculatus*) and yellow spot rock cod (*Epinephelus areolatus*).. Otoliths (approx. 2500) were retained from over 20 species and guts were also retained from a subset of these fish. Some specimens (or tissue) were retained frozen for molecular analyses and/or other biological analyses (e.g. stable isotopes).

Representatives of the vast majority of fish species were retained as taxonomic voucher specimens for the CSIRO Australian National Fish Collection (ANFC, Hobart). However, almost all large (>1 m) sharks and rays landed alive were fin-clipped and released. One large specimen of an unidentified stingray (*Urogymnus* sp) was retained as a voucher specimen due to doubt about its identity. It was later identified as *U. asperrimus*.

A.3.4 Trawl caught reptiles

The trawl captured 4 turtles and 59 sea snakes. Turtles were photographed to enable identification and returned quickly to the water alive. Sea snakes were photographed, measured (total length) and weighed (±20 g accuracy) and a tissue sample was taken from the tail for molecular analysis and frozen. Those captured alive were then released (55), those that were dead (4) were retained and frozen.

A.3.5 Collecting and animal ethics permits

Sampling and methods of handling fish and other animals was carried out inaccordance with CSIRO Wildlife and Large Animal - Animal Ethics Committee approval 2017_17, the Australian Fisheries Management Authority scientific permit 1003509, Australian Department of National Parks permits E2017-0134 and AU-COM2017-378 and the Western Australian Department of Biodiversity, Conservation and Attractions permit number 08-0011252-1.

A.4 Other sampling and equipment used

A.4.1 Tow video camera

In order to characterise the seabed before and after trawling a live wire real time view tow video camera was deployed along the trawl line at some stations. The tow video system consists of a large tow body with Canon 1DX digital still camera and a Canon C300 video camera in housings rated to 3000 m depth. Lighting for both video and stills was provided by four Deep Sea Power and Light 3150 Sealite video lights. A forward looking Hitachi video camera and long range altimeter (Kongsberg Mesotech 1007D) and Druck PMP 5074 pressure sensor assist the on-board winch operator keep the camera above the seabed and avoid obstacles ahead of the camera as the vessel moves at 2.5 knots.

A.4.2 Zooplankton sampling

Zooplankton was collected at each station with oblique bongo net tows (50 cm diameter) with 100 μm mesh nets. Net was towed from 5–10 m off the bottom to the surface. All tows were done at night. Samples for biomass and species composition were preserved in 5% formalin. Samples for stable isotopes were size fractionated onboard (100–150, 150–250, 250–355, 355–1,000, 1,000–3,000 and 3,000 micron) and stored in -20°C.

A.4.3 Grab Sampling

A Smith McIntyre Grab was deployed at each station on the sled line to sample for chlorophyll, stable isotopes and sediment grain size. Three syringe core subsamples 0–2 cm depth and 2–5 cm depth were taken for chlorophyll- *a* analyses and stored in -80 C. One syringe core 0–5 cm depth sample was taken for stable isotopes and stored in -20°C. One L scoop sample was taken for sediment grain size and stored in -20°C.

A.4.4 CTD and water column sampling

Water samples at 70 sites were collected using a 36 x 12 L Niskin bottle rosette with profiles of conductivity and temperature (Seabird SBE 9/11 dual-sensor unit) photosynthetically active radiation (PAR 400–700 nm; Biospherical Instruments QCP-2300), fluorescence (Chelsea Instruments Aquatracka™ fluorometer), transmission (Wetlabs C–Star™), dissolved oxygen (DO; Seabird 43 series optode) and nitrate (Satlanic ISUS sensor) determined concurrently. Water samples at each station were collected from between 3 and 6 nominal depths (surface [~ 3 m], 10 m, 25 m, 50 m, the chlorophyll maximum, where present, and 5 m from bottom) and analysed for dissolved oxygen, salinity, nutrients, chlorophyll a (size fractionated), phytoplankton community structure, particulate organic carbon and particulate nitrogen, and environmental DNA.

Replicate 10 mL water samples of unfiltered seawater from each depth was analysed for dissolved inorganic nutrients (nitrate + nitrite [hereafter nitrate], ammonia, phosphate and silicate) by segmented flow injection analysis (Seal AA3HR auto-analyser) with detection by absorbance at specific wavelengths for silicate [CSIRO Method 1 V01 - Molybdate], nitrate [CSIRO Method 3 V01] and phosphate [CSIRO Method 2 V01], and by Fluorescence for ammonia (Watson et al., 2005). Detection limits were 0.02 μM for all inorganic nutrient species, with a standard error of < 0.7%.

One L of seawater from each depth was vacuum-filtered onto a Whatman 25 mm diameter GF/F (nominal pore size of 0.7 μm) and analysed for chlorophyll-*a* (chl-*a*) and phaeopigment (represents the total chl-*a* fraction). A further 2 L of sample was filtered onto a 25 mm diameter, 5 μm Nitex mesh and analysed for chl- *a* and phaeopigment (the > 5 μm fraction). The filters and screens were stored in liquid nitrogen until analysis. Pigments were extracted in 90% acetone overnight and analysed using a calibrated Turner Designs model 10AU fluorometer and the acidification technique of Parsons et al. (1989). The < 5 μm fraction was calculated as the difference between the total and > 5 μm fractions.

Suspended particulate matter ([SPM]) samples were collected from surface and chlorophyll maximum or the bottom (if no chlorophyll maximum was present) from each of the CTD casts. Four L of sample water was vacuum-filtered onto a pre-weighed glass fibre filter (47 mm, 0.7 μm, Whatman GF/F) and stored in the cool and dark until analysis.

Four L of the surface water sample and chlorophyll maximum or the bottom (if no chlorophyll maximum was present) were filtered onto a 25 mm, 0.7 μm, Whatman GF/F and stored in liquid nitrogen until analysis. Phytoplankton pigments will be extracted and analysed by High Performance Liquid Chromatography (HPLC) with a Waters-Alliance system following the protocol detailed in Hooker et al., (2009).

At each CTD cast site 3 x 1 L replicates of sample water collected 5 m from the bottom was filtered onto a 47 mm, 0.22 or 0.45 μm, Pall membrane filter using a peristaltic pump to collect samples for environmental

DNA of fishes. When analysed, this will be compared directly with the fish catch species diversity from the demersal trawls.

A.4.5 Turbulence profiles

In order to measure the micro-scale turbulence, the Vertical Micro-structure Profiles (VMP-250) was deployed at 73 stations. Two shear probes and one FP07 thermistor are installed on VMP-250. They record data internally on a Flash card. The instrument is powered by an internal polymer lithium-ion battery of nominally 14.8 V and 2.2 Ah capacity. Brushes required to achieve the desired fall rate between 0.4–0.9 m/s. The instrument is turned on by attaching the magnet to the front bulkhead and waiting for confirmation that the LED 'ON'. The instrument is then lowered to below the sea surface, ensuring enough slack in the deployment rope to allow a free-fall, but ensuring the total rope length is less than the actual depth. The instrument is then released and when the rope is taut, the instrument is recovered to the sea surface. This was repeated to obtain three profiles at each station. When the instrument was back on deck the power was turned off and returned to the workroom, connect the cable to the computer, and data was downloaded to the computer.

A.5 Analyses of trawl headline camera images

Images of the seabed were selected between the on-bottom and off-bottom times of the trawl. For most trawls this was a distance of about 2 km covered in 30 minutes. Every fifth image was then selected for the analysis (1 image/~22 m), and the benthic composition and abundance were obtained by scoring points overlaid on each benthic invertebrate visible on the image using TransectMeasure software (www.seagis.com.au). For each image the type of substrate was recorded and for each superimposed point the underlying taxon was identified as per the classification in the table below, by a trained analyst with access to a range of appropriate reference resources. These classification and scoring criteria are the same as those used for previous research carried out on the NWS (Sainsbury 1988; 1991). Benthic invertebrates present in the corners of the images and/or not entirely showing on the images were not scored. The output containing all the scored points per image was then exported as a text file for each site and then all the text files were combined into an Excel spreadsheet for comparison. For the analyses presented in this report no attempt was made to correct for variation in frame (image) area caused by variation in the distance of the camera from the bottom and angle of camera view. In the absence of correcting for these factors the data scored from the images can be used for qualitative comparisons of habitat type as is done in this report rather than quantitative comparisons of biota density. Fish are also shown in the table below but were not scored in images.

Apx Table A.1 North West Shelf benthic image classification categories

Category	Description
Boundary	Marked change in either topography or sediment type within the frame
Ridge	A hill in the frame
Furrow	Ditch present
Pothole	Holes present (e.g. large feeding marks of fish)
Flat	Bottom is either flat or only irregularly pockmarked by fish feeding
Rock	Large individual rock(s) , different to rubble
Fine_Ripple	Regular ripples: >4 ripples per 1 m
Large_Ripple	Large ripples: 1–4 ripples per 1 m
V_LG_Ripple	Very large ripples: < 1 ripple per 1 m
Silt	Clouds of sediment kicked up by the gear can be seen in the photo
Fine_Sand	Grains can be distinguished up to the 1 m mark (second row of grid)

Coarse_Sand	Grains can be distinguished up to the 1.5 m mark (third row of grid)
Rubble	Sediment coarser than gravel
LG_Lump	Number of large lump shaped objects; mostly sponge (>25 cm)
LG_Cup	Number of large cup shaped sponges (>25 cm)
LG_Branch	Number of large branched/erected sponges (in 3D) not interlacing (>25 cm)
LG_Flat	Number of large fan shaped or convoluted objects (in 2D); mostly sponge (>25 cm)
LG_Alcyon	Number of large cauliflower-shaped, fleshy looking organisms (alcyonarians >25 cm)
LG_Gorgon	Number of large fan shaped or convoluted objects; lacy, brittle looking organisms (gorgonians >25 cm)
LG_Seapen	Number of large whitish/yellow, often ghostly objects; sometimes shaped like a quill, or a stalk with a ball at the base (>25 cm)
LG_Whip	Number of large whitish or reddish long 'sticks'; may spiral at the end (>25 cm)
LG_Hydro	Number of large stringy objects, ghostly greenish/brown long stemmed objects resembling feathers; often circular scouring at the base (mostly hydroids >25 cm)
LG_Crino	Number of large crinoids; several stick-like arms coming from a central base (>25 cm)
LG_Others	Number of large objects not fitting in the rest of the large categories (>25 cm)
Mini_Abund (<5 cm)	Abundance of small organisms <5 cm (Grouping categories ranked 1:1–4 items; 2: 5–7 items; 3: 8 or more items)
SM_Lump	Number of small lump shaped objects; mostly sponge (5–25 cm)
SM_Cup	Number of small cup shaped sponges (5–25 cm)
SM_Branch	Number of small branched/erected sponges (in 3D) not interlacing (5–25 cm)
SM_Flat	Number of small fan shaped or convoluted objects (in 2D); mostly sponge (5–25 cm)
SM_Alcyon	Number of small cauliflower-shaped, fleshy looking organisms (alcyonarians: 5–25 cm)
SM_Gorgon	Number of small fan shaped or convoluted objects; lacy, brittle looking organisms (gorgonians: 5–25 cm)
SM_Seapen	Number of small whitish/yellow, often ghostly objects; sometimes shaped like a quill, or a stalk with a ball at the base (5–25 cm)
SM_Whip	Number of small whitish or reddish long 'sticks'; may spiral at the end (5–25 cm)
SM_Hydro	Number of small stringy objects, ghostly greenish/brown long stemmed objects resembling feathers; often circular scouring at the base (mostly hydroids: 5–25 cm)
SM_Crino	Number of small crinoids; several stick-like arms coming from a central base (5–25 cm)
SM_Others	Number of small objects not fitting in the rest of the large categories (5–25 cm)
Coral trout	Presence of Coral trout
Lizard	Presence of Lizardfish
Lethrinid	Presence of Lethrinidae species
Lutjanid	Presence of Lutjanidae species
Big red fish	Presence of Big red fish (*Lutjanus sebae*)
Nemipterid	Presence of Nemipteridae species
Trigg	Presence of Triggerfish
Shark and Ray	Presence of Shark(s) and Ray(s)
Squirrel fish	Presence of Squirrelfish
Cuttle	Presence of Cuttlefish
Squid	Presence of Squid

Appendix B Detailed list of operations by date, site and gear type taken in the Dampier and Montebello Marine Parks

B.1 List of operations

There were three stations occupied in the Dampier MP (W4, W6, W8) and eight in the Montebello MP (W14, W49, W50, W79, W80, W81, W82, W97). At each station priority was given to obtaining a successful McKenna fish demersal trawl (with headline camera) and an epi-benthic sled for the purposes of examining biodiversity within the MPs. Other operations undertaken include epibenthic sled, CTD profile and water sampling, bongo net plankton tow, turbulence probe and tow video. The details of each operation at each site are given in the table below.

Apx Table B.1 Details sampling gear and instrument deployments undertaken within the Dampier MP (sites W4, W6, W8) and the Montebello MP (sites W14, W49, W50, W79, W80, W81, W82, W97)

Operation	Station name	Date	Time (UTC)	Type	Depth (m)	Equipment
162	W4	19-Oct-17	13:23	Plankton	34	Bongo Nets
163	W4	19-Oct-17	13:41	Benthos	32	WHOI epibenthic Biological sled
164	W4	19-Oct-17	14:43	Sediment Grab	34	Smith McIntyre grab
165	W6	19-Oct-17	16:49	Benthos	30	WHOI epibenthic Biological sled
166	W6	19-Oct-17	17:13	Sediment Grab	30	Smith McIntyre grab
167	W6	19-Oct-17	17:32	Plankton	30	Bongo Nets
172	W6	20-Oct-17	0:46	CTD Cast	31	CTD - Seabird 911 with 36 Bottle Rosette
173	W6	20-Oct-17	1:02	Turbulence probe	31	VMP Microstructure profiler
174	W6	20-Oct-17	1:40	Catch	31	McKenna demersal fish trawl nets
175	W4	20-Oct-17	4:19	CTD Cast	33	CTD - Seabird 911 with 36 Bottle Rosette
176	W4	20-Oct-17	4:35	Turbulence probe	33	VMP Microstructure profiler
177	W4	20-Oct-17	5:24	Catch	57	McKenna demersal fish trawl nets
178	W8	20-Oct-17	8:14	CTD Cast	35	CTD - Seabird 911 with 36 Bottle Rosette
179	W8	20-Oct-17	8:27	Turbulence probe	35	VMP Microstructure profiler
267	W8	23-Oct-17	18:51	Turbulence probe	37	VMP Microstructure profiler
268	W8	23-Oct-17	19:01	Plankton	37	Bongo Nets
269	W8	23-Oct-17	19:19	Benthos	37	WHOI epibenthic Biological sled
270	W8	23-Oct-17	19:42	Sediment Grab	36	Smith McIntyre grab
271	W8	23-Oct-17	21:27	Catch	37	McKenna demersal fish trawl nets
473	W79	1-Nov-17	10:49	Benthos	70	WHOI epibenthic Biological sled
474	W79	1-Nov-17	11:15	Benthos	67	Smith McIntyre grab
475	W79	1-Nov-17	11:25	Turbulence probe	67	VMP Microstructure profiler
476	W79	1-Nov-17	11:46	Plankton	69	Bongo Nets
477	W80	1-Nov-17	12:28	Plankton	67	Bongo Nets
478	W80	1-Nov-17	12:40	Catch	67	WHOI epibenthic Biological sled
479	W80	1-Nov-17	13:17	Benthos	68	Smith McIntyre grab
480	W80	1-Nov-17	13:26	Turbulence probe	68	VMP Microstructure profiler
485	W81	1-Nov-17	17:48	Catch	60	Bongo Nets
486	W81	1-Nov-17	18:05	Benthos	61	WHOI epibenthic Biological sled
487	W81	1-Nov-17	18:30	Catch	61	Smith McIntyre grab
488	W81	1-Nov-17	18:34	Catch	61	VMP Microstructure profiler
489	W82	1-Nov-17	19:50	Catch	59	WHOI epibenthic Biological sled
490	W82	1-Nov-17	20:13	Benthos	59	Smith McIntyre grab

491	W82	1-Nov-17	20:27	Plankton	59	Bongo Nets
492	W82	1-Nov-17	21:01	Turbulence probe	60	VMP Microstructure profiler
493	W82	1-Nov-17	21:46	Catch	60	McKenna demersal fish trawl nets
494	W81	1-Nov-17	23:31	CTD Cast	66	CTD - Seabird 911 with 36 Bottle Rosette
495	W81	1-Nov-17	23:49	Turbulence probe	66	VMP Microstructure profiler
496	W81	2-Nov-17	0:26	Catch Failed	60	McKenna demersal fish trawl nets
497	W81	2-Nov-17	2:19	Catch	63	McKenna demersal fish trawl nets
498	W80	2-Nov-17	4:40	Catch	65	McKenna demersal fish trawl nets
499	W80	2-Nov-17	5:47	Catch	65	VMP Microstructure profiler
500	W79	2-Nov-17	6:33	Catch	66	McKenna demersal fish trawl nets
501	W79	2-Nov-17	7:49	Catch	68	CTD - Seabird 911 with 36 Bottle Rosette
502	W79	2-Nov-17	8:10	Catch	68	VMP Microstructure profiler
503	W50	2-Nov-17	11:41	Photo	55	Deep Towed Camera System
504	W50	2-Nov-17	12:48	Benthos	55	WHOI epibenthic Biological sled
505	W50	2-Nov-17	13:15	Benthos	55	Smith McIntyre grab
506	W50	2-Nov-17	13:28	Plankton	55	Bongo Nets
507	W97	2-Nov-17	14:27	Catch	56	Bongo Nets
508	W97	2-Nov-17	14:44	Benthos	56	WHOI epibenthic Biological sled
509	W97	2-Nov-17	15:09	Benthos	55	Smith McIntyre grab
544	W97	4-Nov-17	6:23	Catch	52	McKenna demersal fish trawl nets
545	W50	4-Nov-17	8:07	Catch	54	McKenna demersal fish trawl nets
569	W14	5-Nov-17	15:23	Catch	51	Deep Towed Camera System
570	W14	5-Nov-17	16:30	Catch	50	Bongo Nets
571	W14	5-Nov-17	17:07	Benthos	50	WHOI epibenthic Biological sled
572	W14	5-Nov-17	17:44	Catch	50	Smith McIntyre grab
573	W49	5-Nov-17	19:10	Benthos	61	WHOI epibenthic Biological sled
574	W49	5-Nov-17	19:35	Catch	61	Smith McIntyre grab
575	W49	5-Nov-17	19:42	Catch	61	Bongo Nets
576	W49	5-Nov-17	20:09	CTD Cast	59	CTD - Seabird 911 with 36 Bottle Rosette
577	W49	5-Nov-17	20:40	Catch	61	VMP Microstructure profiler
578	W49	5-Nov-17	21:56	Catch	57	McKenna demersal fish trawl nets
579	W14	5-Nov-17	23:32	Catch	45	McKenna demersal fish trawl nets
584	W14	6-Nov-17	12:41	Catch	49	Deep Towed Camera System

Appendix C Full Species list of fish caught on the NWS on the RV *Investigator* voyage in 2017 (INV2017_05)

C.1 Fish species listing

This report focusses on reporting on fish species caught in sampling of the Dampier (3 sites) and Montebello (8 sites) Marine Parks and 13 sites in the adjacent areas including 12 sites in Area 1 of the Pilbara Fish Trawl Fishery. However for completeness the full list of species collected in all 103 sites (see Figure 1) during the 2017 RV *Investigator* voyage (INV2017_05) is presented in the table below.

Apx Table C.1 Full Species list of fish caught on the NWS on the RV *Investigator* voyage in 2017 (INV2017-05)

CLASS	ORDER	FAMILY	SCIENTIFIC NAME	AUTHORITY
ELASMOBRANCHII	Orectolobiformes	Hemiscylliidae	*Chiloscyllium punctatum*	Müller & Henle, 1838
ELASMOBRANCHII	Orectolobiformes	Stegostomatidae	*Stegostoma fasciatum*	(Hermann, 1783)
ELASMOBRANCHII	Carcharhiniformes	Scyliorhinidae	*Atelomycterus fasciatus*	Compagno & Stevens, 1993
ELASMOBRANCHII	Carcharhiniformes	Carcharhinidae	*Carcharhinus coatesi*	(Whitley, 1939)
ELASMOBRANCHII	Carcharhiniformes	Carcharhinidae	*Carcharhinus plumbeus*	(Nardo, 1827)
ELASMOBRANCHII	Carcharhiniformes	Carcharhinidae	*Loxodon macrorhinus*	Müller & Henle, 1839
ELASMOBRANCHII	Carcharhiniformes	Carcharhinidae	*Rhizoprionodon acutus*	(Rüppell, 1837)
ELASMOBRANCHII	Carcharhiniformes	Hemigaleidae	*Hemigaleus australiensis*	White, Last & Compagno, 2005
ELASMOBRANCHII	Carcharhiniformes	Hemigaleidae	*Hemipristis elongata*	(Klunzinger, 1871)
ELASMOBRANCHII	Rhinopristiformes	Rhinidae	*Rhynchobatus australiae*	Whitley, 1939
ELASMOBRANCHII	Rhinopristiformes	Rhinidae	*Rhynchobatus palpebratus*	Compagno & Last, 2008
ELASMOBRANCHII	Rhinopristiformes	Trygonorrhinidae	*Aptychotrema vincentiana*	(Haacke, 1885)
ELASMOBRANCHII	Rhinopristiformes	Rhinobatidae	*Rhinobatos sainsburyi*	Last, 2004
ELASMOBRANCHII	Rhinopristiformes	Glaucostegidae	*Glaucostegus typus*	(Bennett, 1830)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Himantura australis*	Last, White & Naylor, 2016
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Himantura leoparda*	Manjaji-Matsumoto & Last, 2008
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Maculabatis astra*	(Last, Manjaji-Matsumoto & Pogonoski, 2008)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Megatrygon microps*	(Annandale, 1908)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Neotrygon australiae*	Last, White & Séret, 2016
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Neotrygon leylandi*	(Last, 1987)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Pastinachus ater*	(Macleay, 1883)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Pateobatis fai*	(Jordan & Seale, 1906)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Pateobatis jenkinsii*	(Annandale, 1909)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Taeniurops meyeni*	(Müller & Henle, 1841)
ELASMOBRANCHII	Myliobatiformes	Dasyatidae	*Urogymnus asperrimus*	(Bloch & Schneider, 1801)
ELASMOBRANCHII	Myliobatiformes	Gymnuridae	*Gymnura australis*	(Ramsay & Ogilby, 1886)
ELASMOBRANCHII	Myliobatiformes	Myliobatidae	*Aetomylaeus vespertilio*	(Bleeker, 1852)
ACTINOPTERYGII	Anguilliformes	Unknown	Unidentified Anguilliform larvae	N/A
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax cribroris* cf.	Whitley, 1932

ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax mccoskeri*	Smith & Böhlke, 1997
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax moluccensis*	(Bleeker, 1864)
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax mucifer*	Snyder, 1904
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax pseudothyrsoideus*	(Bleeker, 1852)
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax thyrsoideus*	(Richardson, 1845)
ACTINOPTERYGII	Anguilliformes	Muraenidae	*Gymnothorax undulatus*	(Lacépède, 1803)
ACTINOPTERYGII	Anguilliformes	Congridae	*Ariosoma meeki* cf.	(Jordan & Snyder 1900)
ACTINOPTERYGII	Anguilliformes	Congridae	*Ariosoma scheelei* cf.	(Strömman, 1896)
ACTINOPTERYGII	Anguilliformes	Congridae	*Ariosoma* sp.	N/A
ACTINOPTERYGII	Anguilliformes	Ophichthidae	*Apterichtus nariculus* cf.	McCosker & Hibino 2015
ACTINOPTERYGII	Anguilliformes	Ophichthidae	*Callechelys marmorata*	(Bleeker 1854)
ACTINOPTERYGII	Anguilliformes	Ophichthidae	*Scolecenchelys gymnota*	(Bleeker, 1857)
ACTINOPTERYGII	Clupeiformes	Clupeidae	*Amblygaster sirm*	(Walbaum, 1792)
ACTINOPTERYGII	Clupeiformes	Engraulidae	*Engraulis* sp.	N/A
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Saurida argentea*	Macleay 1881
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Saurida filamentosa* cf.	Ogilby, 1910
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Saurida grandisquamis*	(Günther, 1864)
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Saurida undosquamis*	(Richardson, 1848)
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Saurida* sp.	N/A
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Synodus dermatogenys*	Fowler, 1912
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Synodus hoshinonis*	Tanaka, 1917
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Synodus indicus*	(Day, 1873)
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Synodus jaculum*	Russell & Cressey, 1979
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Synodus sageneus*	Waite, 1905
ACTINOPTERYGII	Aulopiformes	Synodontidae	*Trachinocephalus trachinus*	(Temminck & Schlegel, 1846)
ACTINOPTERYGII	Siluriformes	Ariidae	*Netuma thalassina* cf.	(Rüppell, 1837)
ACTINOPTERYGII	Siluriformes	Plotosidae	*Euristhmus sandrae*	Murdy & Ferraris, 2006
ACTINOPTERYGII	Siluriformes	Plotosidae	*Paraplotosus butleri*	Allen, 1998
ACTINOPTERYGII	Batrachoidiformes	Batrachoididae	*Batrachomoeus dahli*	(Rendahl, 1922)
ACTINOPTERYGII	Batrachoidiformes	Batrachoididae	*Halophryne diemensis*	(Lesueur, 1824)
ACTINOPTERYGII	Batrachoidiformes	Batrachoididae	*Halophryne ocellatus*	Hutchins, 1974
ACTINOPTERYGII	Lophiiformes	Lophiidae	*Lophiomus setigerus*	(Vahl, 1797)
ACTINOPTERYGII	Lophiiformes	Antennariidae	*Antennarius commerson*	(Latreille, 1804)
ACTINOPTERYGII	Lophiiformes	Antennariidae	*Antennarius striatus*	(Shaw, 1794)
ACTINOPTERYGII	Lophiiformes	Antennariidae	*Tathicarpus butleri*	Ogilby, 1907
ACTINOPTERYGII	Lophiiformes	Tetrabrachiidae	*Tetrabrachium ocellatum*	Günther, 1880
ACTINOPTERYGII	Lophiiformes	Ogcocephalidae	*Halieutaea indica*	Annandale & Jenkins, 1910
ACTINOPTERYGII	Gadiformes	Bregmacerotidae	*Bregmaceros* sp.	N/A
ACTINOPTERYGII	Ophidiiformes	Ophidiidae	*Ophidion* sp.	N/A
ACTINOPTERYGII	Ophidiiformes	Carapidae	*Carapus mourlani*	(Petit, 1934)
ACTINOPTERYGII	Ophidiiformes	Carapidae	*Encheliophus gracilis*	(Bleeker, 1856)
ACTINOPTERYGII	Ophidiiformes	Carapidae	*Onuxodon* sp.	N/A
ACTINOPTERYGII	Beryciformes	Holocentridae	*Myripristis botche*	Cuvier, 1829
ACTINOPTERYGII	Beryciformes	Holocentridae	*Sargocentron rubrum*	(Forsskål, 1775)
ACTINOPTERYGII	Lampriformes	Veliferidae	*Velifer hypselopterus* cf.	Bleeker 1879
ACTINOPTERYGII	Syngnathiformes	Fistulariidae	*Fistularia commersonii*	Rüppell, 1838
ACTINOPTERYGII	Syngnathiformes	Fistulariidae	*Fistularia petimba*	Lacépède, 1803
ACTINOPTERYGII	Syngnathiformes	Centriscidae	*Centriscus cristatus*	Linnaeus, 1758

ACTINOPTERYGII	Syngnathiformes	Solenostomidae	*Solenostomus cyanopterus*	Bleeker, 1854
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	Syngnathidae (unidentified juvenile)	N/A
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	*Halicampus grayi*	Kaup, 1856
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	*Hippocampus angustus*	Günther, 1870
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	*Hippocampus spinosissimus*	Weber, 1913
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	*Hippocampus zebra*	Whitley, 1964
ACTINOPTERYGII	Syngnathiformes	Syngnathidae	*Solegnathus* sp. 2	[of Kuiter, 2000]
ACTINOPTERYGII	Syngnathiformes	Dactylopteridae	*Dactyloptena macracanthus*	(Bleeker, 1854)
ACTINOPTERYGII	Syngnathiformes	Dactylopteridae	*Dactyloptena orientalis*	(Cuvier, 1829)
ACTINOPTERYGII	Syngnathiformes	Dactylopteridae	*Dactyloptena papilio*	Ogilby, 1910
ACTINOPTERYGII	Syngnathiformes	Pegasidae	*Eurypegasus draconis*	(Linnaeus, 1766)
ACTINOPTERYGII	Scorpaeniformes	Apistidae	*Apistus carinatus*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Dendrochirus brachypterus*	(Cuvier, 1829)
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Pterois* sp.	N/A
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Pterois russelii*	Bennett, 1831
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Neomerinthe erostris*	(Alcock, 1896)
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Pteroidichthys amboinensis*	Bleeker, 1856
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Pteroidichthys noronhai*	(Fowler, 1938)
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Scorpaena* n. sp.	Motomura, in preparation.
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Scorpaenodes smithi*	Eschmeyer & Rama-Rao, 1972
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Scorpaenopsis neglecta*	Heckel, 1837
ACTINOPTERYGII	Scorpaeniformes	Scorpaenidae	*Scorpaenopsis venosa*	(Cuvier, 1829)
ACTINOPTERYGII	Scorpaeniformes	Tetrarogidae	*Cottapistus cottoides*	(Linnaeus, 1758)
ACTINOPTERYGII	Scorpaeniformes	Tetrarogidae	*Liocranium pleurostigma*	(Weber, 1913)
ACTINOPTERYGII	Scorpaeniformes	Tetrarogidae	*Richardsonicthys leucogaster*	(Richardson, 1848)
ACTINOPTERYGII	Scorpaeniformes	Synanceiidae	*Erosa erosa*	(Langsdorf, 1829)
ACTINOPTERYGII	Scorpaeniformes	Synanceiidae	*Inimicus didactylus*	(Pallas, 1769)
ACTINOPTERYGII	Scorpaeniformes	Synanceiidae	*Inimicus sinensis*	(Valenciennes, 1833)
ACTINOPTERYGII	Scorpaeniformes	Synanceiidae	*Minous roseus*	Matsunuma & Motomura 2018
ACTINOPTERYGII	Scorpaeniformes	Triglidae	*Lepidotrigla japonica* cf.	(Bleeker, 1857)
ACTINOPTERYGII	Scorpaeniformes	Aploactinidae	*Paraploactis kagoshimensis* cf.	(Ishikawa 1904)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Cymbacephalus bosschei*	(Bleeker, 1860)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Cymbacephalus nematophthalmus*	(Günther, 1860)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Inegocia japonica*	(Cuvier, 1829)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Onigocia grandisquama*	(Regan, 1908)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Platycephalus endrachtensis*	Quoy & Gaimard, 1825
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Platycephalus westraliae*	(Whitley, 1938)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Rogadius patriciae*	Knapp, 1987
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Rogadius tuberculatus*	(Cuvier, 1829)
ACTINOPTERYGII	Scorpaeniformes	Platycephalidae	*Thysanophrys* sp.	N/A
ACTINOPTERYGII	Perciformes	Serranidae	*Cephalopholis boenak*	(Bloch, 1790)
ACTINOPTERYGII	Perciformes	Serranidae	*Cephalopholis sonnerati*	(Valenciennes, 1828)
ACTINOPTERYGII	Perciformes	Serranidae	*Chromileptes altivelis* cf.	(Valenciennes, 1828)
ACTINOPTERYGII	Perciformes	Serranidae	*Diploprion bifasciatum*	Cuvier, 1828
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus amblycephalus*	(Bleeker, 1857)
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus areolatus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus bilobatus*	Randall & Allen, 1987
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus coioides*	(Hamilton, 1822)

ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus fasciatus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus multinotatus*	(Peters, 1876)
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus rivulatus*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Serranidae	*Epinephelus sexfasciatus*	(Valenciennes, 1828)
ACTINOPTERYGII	Perciformes	Serranidae	*Plectranthias* n. sp.	Gill et al. in preparation
ACTINOPTERYGII	Perciformes	Serranidae	*Plectropomus maculatus*	(Bloch, 1790)
ACTINOPTERYGII	Perciformes	Serranidae	*Pseudanthias rubrizonatus*	(Randall, 1983)
ACTINOPTERYGII	Perciformes	Serranidae	*Tosana* sp.	N/A
ACTINOPTERYGII	Perciformes	Pseudochromidae	*Congrogadus spinifer*	(Borodin, 1933)
ACTINOPTERYGII	Perciformes	Pseudochromidae	*Pseudochromis howsoni*	Allen, 1995
ACTINOPTERYGII	Perciformes	Pseudochromidae	*Pseudochromis quinquedentatus*	McCulloch, 1926
ACTINOPTERYGII	Perciformes	Glaucosomatidae	*Glaucosoma buergeri*	Richardson, 1845
ACTINOPTERYGII	Perciformes	Glaucosomatidae	*Glaucosoma magnificum*	(Ogilby, 1915)
ACTINOPTERYGII	Perciformes	Terapontidae	*Terapon jarbua*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Priacanthidae	*Priacanthus hamrur*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Priacanthidae	*Priacanthus tayenus*	Richardson, 1846
ACTINOPTERYGII	Perciformes	Apogonidae	*Apogonichthyoides atripes*	(Ogilby, 1911)
ACTINOPTERYGII	Perciformes	Apogonidae	*Apogonichthyoides brevicaudatus*	(Weber, 1909)
ACTINOPTERYGII	Perciformes	Apogonidae	*Apogonichthyoides* sp.	N/A
ACTINOPTERYGII	Perciformes	Apogonidae	*Gymnapogon* n. sp. 1	Fraser, in preparation
ACTINOPTERYGII	Perciformes	Apogonidae	*Gymnapogon* n. sp. 2	Fraser, in preparation
ACTINOPTERYGII	Perciformes	Apogonidae	*Jaydia argyrogaster*	(Weber, 1909)
ACTINOPTERYGII	Perciformes	Apogonidae	*Jaydia smithi*	(Kotthaus 1970)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus cavitensis*	(Jordan & Seale, 1907)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus fasciatus*	(White, 1790)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus monospilus* cf.	(Fraser, Randall & Allen, 2002)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus semilineatus*	(Temminck & Schlegel, 1843)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus septemstriatus*	(Günther, 1880)
ACTINOPTERYGII	Perciformes	Apogonidae	*Ostorhinchus* sp.	N/A
ACTINOPTERYGII	Perciformes	Apogonidae	*Pristiapogon fraenatus*	(Valenciennes, 1832)
ACTINOPTERYGII	Perciformes	Apogonidae	*Pseudamia gelatinosa*	Smith 1956
ACTINOPTERYGII	Perciformes	Apogonidae	*Rhabdamia gracilis*	(Bleeker, 1856)
ACTINOPTERYGII	Perciformes	Sillaginidae	*Sillago ingenuua*	McKay, 1985
ACTINOPTERYGII	Perciformes	Rachycentridae	*Rachycentron canadum*	(Linnaeus, 1766)
ACTINOPTERYGII	Perciformes	Echeneidae	*Echeneis naucrates*	Linnaeus, 1758
ACTINOPTERYGII	Perciformes	Carangidae	*Alectis ciliaris*	(Bloch, 1787)
ACTINOPTERYGII	Perciformes	Carangidae	*Alepes apercna*	Grant, 1987
ACTINOPTERYGII	Perciformes	Carangidae	*Atule mate*	(Cuvier, 1833)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides caeruleopinnatus*	(Rüppell, 1830)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides chrysophrys*	(Cuvier, 1833)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides equula*	(Temminck & Schlegel, 1844)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides fulvoguttatus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides gymnostethus*	(Cuvier, 1833)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides malabaricus*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Perciformes	Carangidae	*Carangoides* sp. (juveniles)	N/A
ACTINOPTERYGII	Perciformes	Carangidae	*Caranx ignobilis*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Carangidae	*Decapterus macrosoma*	Bleeker, 1851
ACTINOPTERYGII	Perciformes	Carangidae	*Decapterus russelli*	(Rüppell, 1830)

ACTINOPTERYGII	Perciformes	Carangidae	*Gnathanodon speciosus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Carangidae	*Parastromateus niger*	(Bloch, 1795)
ACTINOPTERYGII	Perciformes	Carangidae	*Scomberoides tol*	(Cuvier, 1832)
ACTINOPTERYGII	Perciformes	Carangidae	*Selar crumenophthalmus*	(Bloch, 1793)
ACTINOPTERYGII	Perciformes	Carangidae	*Selaroides leptolepis*	(Cuvier, 1833)
ACTINOPTERYGII	Perciformes	Carangidae	*Seriolina nigrofasciata*	(Rüppell, 1829)
ACTINOPTERYGII	Perciformes	Carangidae	*Ulua mentalis*	(Cuvier, 1833)
ACTINOPTERYGII	Perciformes	Leiognathidae	*Aurigequula longispina*	(Valenciennes, 1835)
ACTINOPTERYGII	Perciformes	Leiognathidae	*Equulites elongatus*	(Günther, 1874)
ACTINOPTERYGII	Perciformes	Leiognathidae	*Photopectoralis* sp.	N/A
ACTINOPTERYGII	Perciformes	Bramidae	*Brama pauciradiata*	Fujita & Last, 1995
ACTINOPTERYGII	Perciformes	Caesionidae	*Dipterygonotus balteatus*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Caesionidae	*Pterocaesio chrysozona*	(Cuvier, 1830)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus argentimaculatus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus carponotatus*	(Richardson, 1842)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus erythropterus*	Bloch, 1790
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus lemniscatus*	(Valenciennes, 1828)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus lutjanus*	Bloch, 1790
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus malabaricus*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus russellii*	(Bleeker, 1849)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus sebae*	(Cuvier, 1828)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Lutjanus vitta*	(Quoy & Gaimard, 1824)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Pristipomoides multidens*	(Day, 1871)
ACTINOPTERYGII	Perciformes	Lutjanidae	*Pristipomoides typus*	Bleeker, 1852
ACTINOPTERYGII	Perciformes	Lutjanidae	*Symphorus nematophorus*	(Bleeker, 1860)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus celebicus*	(Bleeker, 1854)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus furcosus*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus nematopus*	(Bleeker, 1851)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus peronii*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus virgatus*	Houttuyn, 1782)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Nemipterus zysron*	(Bleeker, 1856)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Parascolopsis tanyactis*	Russell, 1986
ACTINOPTERYGII	Perciformes	Nemipteridae	*Pentapodus nagasakiensis*	(Tanaka, 1915)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Pentapodus porosus*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Nemipteridae	*Scolopsis meridiana*	Nakamura, Russell, Moore & Motomura, 2018
ACTINOPTERYGII	Perciformes	Nemipteridae	*Scolopsis monogramma*	(Kuhl & van Hasselt, 1830)
ACTINOPTERYGII	Perciformes	Gerreidae	*Pentaprion longimanus*	(Cantor, 1850)
ACTINOPTERYGII	Perciformes	Haemulidae	*Diagramma pictum*	(Thunberg, 1792)
ACTINOPTERYGII	Perciformes	Haemulidae	*Plectorhinchus gibbosus*	(Lacépède, 1802)
ACTINOPTERYGII	Perciformes	Haemulidae	*Pomadasys kaakan*	(Cuvier, 1830)
ACTINOPTERYGII	Perciformes	Lethrinidae	*Gymnocranius elongatus*	Senta, 1973
ACTINOPTERYGII	Perciformes	Lethrinidae	*Gymnocranius grandoculis*	(Valenciennes, 1830)
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus genivittatus*	Valenciennes, 1830
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus laticaudis*	Alleyne & Macleay, 1877
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus lentjan*	(Lacépède, 1802)
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus nebulosus*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus olivaceus*	Valenciennes, 1830
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus punctulatus*	Macleay, 1878

ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus ravus*	Carpenter & Randall, 2003
ACTINOPTERYGII	Perciformes	Lethrinidae	*Lethrinus variegatus*	Valenciennes, 1830
ACTINOPTERYGII	Perciformes	Sparidae	*Argyrops bleekeri*	Oshima, 1927
ACTINOPTERYGII	Perciformes	Mullidae	*Parupeneus chrysopleuron*	(Temminck & Schlegel, 1843)
ACTINOPTERYGII	Perciformes	Mullidae	*Parupeneus heptacanthus*	(Lacépède, 1802)
ACTINOPTERYGII	Perciformes	Mullidae	*Parupeneus indicus*	(Shaw, 1803)
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus australiae*	Kim & Nakaya, 2002
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus guttatus*	(Day, 1868)
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus luzonius* cf.	(Jordan & Seale, 1907)
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus margarethae*	Uiblein & Heemstra, 2010
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus moluccensis* cf.	(Bleeker, 1855)
ACTINOPTERYGII	Perciformes	Mullidae	*Upeneus tragula* cf.	Richardson, 1846
ACTINOPTERYGII	Perciformes	Pempherididae	*Parapriacanthus ransonneti* cf.	Steindachner, 1870
ACTINOPTERYGII	Perciformes	Ephippidae	*Platax batavianus*	Cuvier, 1831
ACTINOPTERYGII	Perciformes	Ephippidae	*Platax teira*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Chaetodon assarius*	Waite, 1905
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Chaetodon aureofasciatus*	Macleay, 1878
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Chelmon marginalis*	Richardson, 1842
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Coradion altivelis*	McCulloch, 1916
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Coradion chrysozonus*	(Cuvier, 1831)
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Heniochus acuminatus*	(Linnaeus, 1758)
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Heniochus diphreutes*	Jordan, 1903
ACTINOPTERYGII	Perciformes	Chaetodontidae	*Parachaetodon ocellatus*	(Cuvier, 1831)
ACTINOPTERYGII	Perciformes	Pomacanthidae	*Chaetodontoplus duboulayi*	(Günther, 1867)
ACTINOPTERYGII	Perciformes	Pomacanthidae	*Chaetodontoplus personifer*	(McCulloch, 1914)
ACTINOPTERYGII	Perciformes	Pomacanthidae	*Pomacanthus imperator*	(Bloch, 1787)
ACTINOPTERYGII	Perciformes	Pomacanthidae	*Pomacanthus sexstriatus*	(Cuvier, 1831)
ACTINOPTERYGII	Perciformes	Pomacentridae	*Amblypomacentrus breviceps*	(Schlegel & Müller, 1839)
ACTINOPTERYGII	Perciformes	Pomacentridae	*Chromis fumea*	(Tanaka, 1917)
ACTINOPTERYGII	Perciformes	Pomacentridae	*Neopomacentrus cyanomos*	(Bleeker, 1856)
ACTINOPTERYGII	Perciformes	Pomacentridae	*Pristotis obtusirostris*	(Günther, 1862)
ACTINOPTERYGII	Perciformes	Cirrhitidae	*Cirrhitichthys aprinus* cf.	(Cuvier, 1829)
ACTINOPTERYGII	Perciformes	Cirrhitidae	*Cyprinocirrhites polyactis*	(Bleeker, 1874)
ACTINOPTERYGII	Perciformes	Sphyraenidae	*Sphyraena jello*	Cuvier, 1829
ACTINOPTERYGII	Perciformes	Sphyraenidae	*Sphyraena putnamae*	Jordan & Seale, 1905
ACTINOPTERYGII	Perciformes	Sphyraenidae	*Sphyraena forsteri*	Cuvier, 1829
ACTINOPTERYGII	Perciformes	Labridae	*Anampses lennardi*	Scott, 1959
ACTINOPTERYGII	Perciformes	Labridae	*Bodianus solatus*	Gomon, 2006
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon cauteroma*	Gomon & Allen, 1987
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon cephalotes*	(Castelnau, 1875)
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon monostigma*	Ogilby, 1910
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon schoenleinii*	(Valenciennes, 1839)
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon sugillatum*	Gomon, 1987
ACTINOPTERYGII	Perciformes	Labridae	*Choerodon vitta*	Ogilby, 1910
ACTINOPTERYGII	Perciformes	Labridae	*Coris pictoides*	Randall & Kuiter, 1982
ACTINOPTERYGII	Perciformes	Labridae	*Iniistius opalus*	Fukui, 2108
ACTINOPTERYGII	Perciformes	Labridae	*Iniistius* n. sp. (damaged)	Fukui, in preparation
ACTINOPTERYGII	Perciformes	Labridae	*Labroides dimidiatus*	(Valenciennes, 1839)

ACTINOPTERYGII	Perciformes	Labridae	*Leptojulis cyanopleura*	(Bleeker, 1853)
ACTINOPTERYGII	Perciformes	Labridae	*Oxycheilinus orientalis*	(Günther, 1862)
ACTINOPTERYGII	Perciformes	Labridae	*Stethojulis interrupta*	(Bleeker, 1851)
ACTINOPTERYGII	Perciformes	Labridae	*Suezichthys soelae*	Russell, 1985
ACTINOPTERYGII	Perciformes	Scaridae	*Scarus ghobban*	Forsskål, 1775
ACTINOPTERYGII	Perciformes	Pinguipedidae	*Parapercis alboguttata*	(Günther, 1872)
ACTINOPTERYGII	Perciformes	Pinguipedidae	*Parapercis nebulosa*	(Quoy & Gaimard, 1825)
ACTINOPTERYGII	Perciformes	Pinguipedidae	*Parapercis rubromaculata*	Ho, Chang & Shao, 2012
ACTINOPTERYGII	Perciformes	Pinguipedidae	*Parapercis snyderi*	Jordan & Starks, 1905
ACTINOPTERYGII	Perciformes	Pinguipedidae	*Parapercis xanthozona*	(Bleeker, 1849)
ACTINOPTERYGII	Perciformes	Uranoscopidae	*Ichthyscopus insperatus*	Mees, 1960
ACTINOPTERYGII	Perciformes	Uranoscopidae	*Uranoscopus bicinctus* cf.	Temminck & Schlegel, 1843
ACTINOPTERYGII	Perciformes	Uranoscopidae	*Uranoscopus cognatus*	Cantor, 1849
ACTINOPTERYGII	Perciformes	Champsodontidae	*Champsodon vorax* cf.	Günther, 1867
ACTINOPTERYGII	Perciformes	Blenniidae	*Xiphasia setifer*	Swainson, 1839
ACTINOPTERYGII	Perciformes	Ammodytidae	*Bleekeria* sp.	N/A
ACTINOPTERYGII	Perciformes	Callionymidae	*Callionymus australis*	Fricke, 1983
ACTINOPTERYGII	Perciformes	Callionymidae	*Dactylopus dactylopus*	(Valenciennes, 1837)
ACTINOPTERYGII	Perciformes	Gobiidae	Gobiidae - undifferentiated	N/A
ACTINOPTERYGII	Perciformes	Gobiidae	*Bathygobius* sp.	(Hoese, in preparation.)
ACTINOPTERYGII	Perciformes	Gobiidae	*Eviota* sp.	N/A
ACTINOPTERYGII	Perciformes	Gobiidae	*Larsonella* sp.	N/A
ACTINOPTERYGII	Perciformes	Gobiidae	*Lubricogiobius ornatus*	Fourmanoir, 1966
ACTINOPTERYGII	Perciformes	Gobiidae	*Pleurosicya boldinghi*	Weber, 1913
ACTINOPTERYGII	Perciformes	Gobiidae	*Priolepis cincta*	(Regan, 1908)
ACTINOPTERYGII	Perciformes	Gobiidae	*Priolepis nuchifasciata*	(Günther, 1873)
ACTINOPTERYGII	Perciformes	Gobiidae	*Priolepis profunda*	(Weber, 1909)
ACTINOPTERYGII	Perciformes	Gobiidae	*Sueviota larsonae* cf.	Winterbottom & Hoese, 1988
ACTINOPTERYGII	Perciformes	Acanthuridae	*Acanthurus grammoptilus*	Richardson, 1843
ACTINOPTERYGII	Perciformes	Acanthuridae	*Acanthurus mata*	Cuvier, 1829
ACTINOPTERYGII	Perciformes	Acanthuridae	*Naso fageni*	Morrow, 1954
ACTINOPTERYGII	Perciformes	Acanthuridae	*Naso reticulatus*	Randall, 2001
ACTINOPTERYGII	Perciformes	Acanthuridae	*Naso unicornis*	(Forsskål, 1775)
ACTINOPTERYGII	Perciformes	Siganidae	*Siganus fuscescens*	(Houttuyn, 1782)
ACTINOPTERYGII	Perciformes	Scombridae	*Cybiosarda elegans*	(Whitley, 1935)
ACTINOPTERYGII	Perciformes	Scombridae	*Rastrelliger kanagurta*	(Cuvier, 1816)
ACTINOPTERYGII	Perciformes	Scombridae	*Scomberomorus queenslandicus*	Munro, 1943
ACTINOPTERYGII	Perciformes	Trichiuridae	*Trichiurus lepturus* cf.	Linnaeus, 1758
ACTINOPTERYGII	Pleuronectiformes	Psettodidae	*Psettodes erumei*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Asterorhombus intermedius* cf.	(Bleeker, 1866)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Asterorhombus* sp.	N/A
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Crossorhombus azureus*	(Alcock, 1889)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Engyprosopon grandisquama*	(Temminck & Schlegel, 1846)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Engyprosopon* sp.	N/A
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Grammatobothus pennatus*	(Ogilby, 1913)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Grammatobothus polyophthalmus*	(Bleeker, 1866)
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Psettina* sp. (juvenile)	N/A
ACTINOPTERYGII	Pleuronectiformes	Bothidae	*Psettina variegata* cf.	(Fowler, 1933)

ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus argus*	Weber, 1913
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	(Hamilton, 1822)
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus diplospilus*	Norman, 1926
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus dupliciocellatus*	Regan, 1905
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus elevatus*	Ogilby, 1912
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus jenynsii*	(Bleeker, 1855)
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus quinquocellatus*	Weber & de Beaufort, 1929
ACTINOPTERYGII	Pleuronectiformes	Paralichthyidae	*Pseudorhombus spinosus*	McCulloch, 1914
ACTINOPTERYGII	Pleuronectiformes	Pleuronectidae	*Samaris cristatus*	Gray, 1831
ACTINOPTERYGII	Pleuronectiformes	Soleidae	*Aseraggodes melanospilus*	(Bleeker, 1854)
ACTINOPTERYGII	Tetraodontiformes	Triacanthidae	*Trixiphichthys weberi*	(Chaudhuri, 1910)
ACTINOPTERYGII	Tetraodontiformes	Balistidae	*Abalistes stellatus*	(Anonymous, 1798)
ACTINOPTERYGII	Tetraodontiformes	Balistidae	*Pseudobalistes flavimarginatus*	(Rüppell, 1829)
ACTINOPTERYGII	Tetraodontiformes	Balistidae	*Sufflamen fraenatum*	(Latreille, 1804)
ACTINOPTERYGII	Tetraodontiformes	Balistidae	*Xanthichthys lineopunctatus*	(Hollard, 1854)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	(Linnaeus, 1758)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Anacanthus barbatus*	Gray, 1831
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Brachaluteres taylori*	Woods, 1966
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Cantherhines fronticinctus*	(Günther, 1866)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Chaetodermis penicilligerus*	(Cuvier, 1817)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Eubalichthys caeruleoguttatus*	Hutchins, 1977
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Monacanthus chinensis*	(Osbeck, 1765)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Paramonacanthus choirocephalus*	(Bleeker, 1852)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Paramonacanthus oblongus*	(Schlegel, 1850)
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Paramonacanthus* spp.	N/A
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Pseudomonacanthus elongatus*	Fraser-Brunner, 1940
ACTINOPTERYGII	Tetraodontiformes	Monacanthidae	*Pseudomonacanthus peroni*	(Hollard, 1854)
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Lactoria cornuta*	(Linnaeus, 1758)
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Lactoria diaphana*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Lactoria fornasini*	(Bianconi, 1846)
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Ostracion cubicus*	Linnaeus, 1758
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Ostracion nasus*	Bloch, 1785
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Ostracion rhinorhynchus*	Bleeker, 1852
ACTINOPTERYGII	Tetraodontiformes	Ostraciidae	*Tetrosomus gibbosus*	(Linnaeus, 1758)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Arothron hispidus*	(Linnaeus, 1758)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Canthigaster cyanospilota*	Randall, Williams & Rocha 2008
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Canthigaster rivulata*	(Temminck & Schlegel, 1850)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Feroxodon multistriatus*	(Richardson, 1854)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Lagocephalus lunaris*	(Bloch & Schneider, 1801)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Lagocephalus sceleratus*	(Gmelin, 1789)
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Lagocephalus suezensis*	Clark & Gohar, 1953
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Torquigener pallimaculatus*	Hardy, 1983
ACTINOPTERYGII	Tetraodontiformes	Tetraodontidae	*Torquigener parcuspinus*	Hardy, 1983
ACTINOPTERYGII	Tetraodontiformes	Diodontidae	*Cyclichthys orbicularis*	(Bloch, 1785)
ACTINOPTERYGII	Tetraodontiformes	Diodontidae	*Diodon holocanthus*	Linnaeus, 1758
ACTINOPTERYGII	Tetraodontiformes	Diodontidae	*Lophodiodon calori*	(Bianconi, 1854)
ACTINOPTERYGII	Tetraodontiformes	Diodontidae	*Tragulichthys jaculiferus*	(Cuvier, 1818)

Appendix D Data tables giving site locations referred to in this report

D.1 Data tables giving site locations referred to in this report

In various parts of the report maps and graphs refer to sample stations. The tables below provide the GPS coordinates for each site.

Apx Table D.1 Stations sampled during the 2017 RV *Investigator* voyage (INV2017_05). Net on-bottom refers to when the net being trailed behind the vessel contacted the seabed. Net opening refers to when the doors spread and the towed net began fishing effectively. Net off bottom refers to when the net left the seabed as it was being winched back to the vessel, this is the time the net stops fishing effectively. Net spread is the average width of the doors when the net is fishing. Net layback is the distance between the stern of the vessel and the net. See Appendix A for full details on trawl methods.

Site	Oper-ation number	Start depth (m)	Net on-bottom lat (deg)	Net on-bottom long (deg)	Net open lat (deg)	Net open long (deg)	Net off bottom lat (deg)	Net off bottom long (deg)	Bottom distance towed (m)	Net spread (m)	Net layback from vessel (m)
W4	177	23.0	-20.352	117.218	-20.376	117.193	-20.372	117.197	3129.9	77.8	366.7
W6	174	24.5	-20.334	117.365	-20.357	117.341	-20.354	117.344	3127.8	74.4	350.1
W8	271	27.7	-20.310	116.990	-20.310	116.951	-20.310	116.956	3566.1	78.1	367.2
W14	579	41.5	-20.346	115.757	-20.348	115.723	-20.348	115.729	2984.7	83.2	390.2
W49	578	53.0	-20.199	115.789	-20.205	115.752	-20.204	115.758	3283.2	89.2	418.2
W50	545	46.2	-20.253	115.976	-20.253	115.941	-20.253	115.947	3106.8	87.2	409.7
W59	418	52.2	-20.059	116.261	-20.083	116.236	-20.079	116.241	3042.9	90.1	423.4
W70	421	50.7	-20.025	116.400	-20.055	116.385	-20.049	116.387	3039.4	91.1	428.9
W75	518	52.8	-20.104	116.196	-20.135	116.180	-20.130	116.182	3147.4	89.1	418.2
W78	463	65.5	-20.048	115.797	-20.072	115.822	-20.067	115.817	2949.5	98.1	461.2
W79	500	60.1	-20.101	115.928	-20.099	115.893	-20.099	115.899	3046.3	92.2	431.7
W80	498	59.0	-20.110	115.949	-20.110	115.914	-20.110	115.921	2884.0	94.1	442.2
W81	497	55.4	-20.178	115.952	-20.178	115.918	-20.178	115.925	2808.6	92.1	432.9
W82	493	52.5	-20.194	115.961	-20.204	115.926	-20.202	115.932	3208.7	89.2	418.1
W83	522	55.3	-20.130	116.063	-20.130	116.027	-20.130	116.034	3052.3	90.2	422.8
W84	301	50.0	-20.056	116.363	-20.071	116.330	-20.069	116.336	3192.4	86.1	403.4
W89	417	54.1	-20.092	116.176	-20.102	116.143	-20.100	116.149	3000.6	89.1	417.6
W90	414	50.5	-20.034	116.378	-20.056	116.353	-20.052	116.357	2987.3	89.2	418.7
W91	323	55.8	-19.984	116.624	-20.010	116.601	-20.005	116.606	3053.4	92.1	432.6
W92	278	56.5	-19.945	116.554	-19.976	116.545	-19.970	116.547	2923.9	94.2	443.0
W93	325	58.5	-19.936	116.665	-19.960	116.639	-19.956	116.644	3113.0	90.3	429.9
W94	519	54.8	-20.106	116.174	-20.119	116.142	-20.117	116.148	3032.1	91.1	427.9
W95	319	54.3	-19.922	116.628	-19.947	116.603	-19.942	116.608	3173.5	91.2	428.2
W97	544	46.4	-20.238	116.003	-20.263	115.976	-20.259	115.980	3243.5	87.1	409.5

Apx Table D.2 GPS co-ordinates for historical survey stations from 1987 to 1997 in the Montebello MP. Both start and end points of the trawls are given

Station	Start Long (deg)	Start Lat (deg)	End Long (deg)	End Lat (deg)
8707107	115.498	-20.190	115.527	-20.203
8707113	115.852	-20.290	115.848	-20.258
8707114	115.883	-20.108	115.885	-20.090
8707117	115.690	-20.113	115.725	-20.108
880561	115.908	-20.328	115.932	-20.357
8805159	115.663	-20.258	115.632	-20.220
890485	115.267	-20.765	115.273	-20.728
890487	115.315	-20.150	115.273	-20.165
890489	115.458	-20.017	115.490	-20.032
890497	115.522	-20.020	115.533	-19.975
900241	115.753	-20.352	115.750	-20.327
900242	115.597	-20.052	115.603	-20.072
900243	115.552	-20.082	115.555	-20.098
9002119	115.967	-20.267	115.970	-20.232
910410	115.253	-20.342	115.245	-20.312
910426	115.758	-20.270	115.778	-20.287
950819	115.767	-20.162	115.790	-20.158
970731	115.953	-20.167	115.937	-20.192
970733	115.270	-20.713	115.257	-20.740
970749	115.310	-20.247	115.285	-20.232
970750	115.305	-20.157	115.312	-20.132

Apx Table D.3 GPS co-ordinates for historical survey stations from 1982 to 1997 in the Dampier MP. Both start and end points of the trawls are given.

Station	Start Long (deg)	Start Lat (deg)	End Long (deg)	End Lat (deg)
830362	117.370	-20.338	117.392	-20.327
830436	117.353	-20.358	117.352	-20.335
830437	117.217	-20.320	117.232	-20.333
830438	117.172	-20.313	117.180	-20.337
880514	116.892	-20.300	116.900	-20.278
910469	117.302	-20.338	117.317	-20.313
970758	117.217	-20.370	117.195	-20.353

Apx Table D.4 GPS co-ordinates for 2013 Pilbara Marine Conservation Partnership (PMCP) survey stations in the Montebello MP. Both start and end points of the tow video are given

Station	Start Long (deg)	Start Lat (deg)	End Long (deg)	End Lat (deg)
PMCP 50	115.399	-20.579	115.403	-20.579
PMCP62	115.641	-20.349	115.635	-20.349
PMCP 96	115.298	-20.592	115.301	-20.588
PMCP 100	115.358	-20.430	115.362	-20.430
PMCP 101	115.368	-20.359	115.372	-20.361
PMCP 102	115.328	-20.320	115.332	-20.320

Appendix E Tables giving sponge and soft coral abundance and biomass data referred to in Chapter 5

E.1 Data tables on sponge and soft coral biomass and abundance

These data tables provide the measurements of sponge and soft coral abundance and biomass shown in graphs in chapters 3 and 5. Abundance is in average number per hectare and biomass is in average grams per hectare at each station surveyed by trawl net. It needs to be remembered that the CSIRO McKenna demersal trawl net, which is the same type used in the Pilbara Fish Trawl Fishery is not efficient at removing all sponges and soft corals from the seabed (Wassenberg et al. 2002), so these are not the totals of all present ,only all captured in the net. However, the consisten methodology means that abundances and biomass are comparable between sites.

Apx Table E.1 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of sponges classified by morphotypes and sizes collected in the Dampier Marine Park

Sponges morphotypes and sizes	Dampier Marine Park sites		
	W4	W6	W8
sponges cup <25 cm	2.52 1721.09	0.00 0.00	0.00 0.00
sponges cup 25 cm – 50 cm	1.85 7394.79	0.00 0.00	0.15 413.87
sponges cup 50 cm – 100 cm	0.67 2014.93	0.00 0.00	0.00 0.00
sponges cup>100 cm	0.00 0.00	0.00 0.00	0.00 0.00
sponges erect <25 cm	16.12 2591.70	3.36 627.25	0.15 138.20
sponges erect 25 cm – 50 cm	20.49 6432.16	3.70 1745.48	0.44 582.52
sponges erect 50 cm – 100 cm	5.21 3861.95	0.34 165.84	0.00 0.00
sponges erect >100 cm	0.00 0.00	0.00 0.00	0.00 0.00
sponges massive <25 cm	8.06 3567.94	1.85 801.50	0.00 0.00
sponges massive 25 cm – 50 cm	1.18 5505.80	0.50 675.81	0.00 0.00
sponges massive 50 cm – 100 cm	0.00 0.00	0.17 3306.80	0.00 0.00
sponges massive >100 cm	0.84 59746.03	0.00 0.00	0.00 0.00

Apx Table E.2 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of sponges classified by morphotypes and sizes collected in the Montebello Marine Park

Sponges morphotypes and sizes	Montebello Marine Park sites (plus site W78)								
	W14	W49	W50	W78	W79	W80	W81	W82	W97
sponges cup <25 cm	0.88 1395.11	0.00 0.00	0.17 483.55	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.66 1251.16	0.00 0.00
sponges cup 25 cm – 50 cm	1.41 8096.91	0.00 0.00	0.17 1416.71	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.16 1699.41	0.00 0.00
sponges cup 50 cm – 100 cm	0.71 3717.34	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.16 7511.89	0.16 3564.77
sponges cup >100 cm	0.00 0.00	0.16 13162.83	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
sponges erect <25 cm	8.12 2969.81	0.48 94.71	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.56 46.92	0.00 0.00	0.16 48.61
sponges erect 25 cm – 50 cm	3.89 2763.72	0.16 112.04	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
sponges erect 50 cm – 100 cm	4.24 7584.79	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
sponges erect >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
sponges massive <25 cm	6.18 4488.18	1.28 308.52	0.17 271.47	0.53 2841.64	0.00 0.00	0.00 0.00	0.38 234.60	0.49 797.00	0.00 0.00
sponges massive 25 cm – 50 cm	1.06 2269.25	0.00 0.00	0.00 0.00	0.00 0.00	0.17 310.99	0.00 0.00	0.56 1126.06	0.00 0.00	0.32 939.80
sponges massive 50 cm – 100 cm	0.35 1103.72	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
sponges massive >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

Apx Table E.3 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of sponges classified by morphotypes and sizes collected in Pilbara Fish Trawl Fishery Area 1

Sponges morphotypes and sizes	Pilbara Fish Trawl Fishery Area 1 sites											
	W59	W70	W75	W83	W84	W89	W90	W91	W92	W93	W94	W95
sponges cup <25 cm	0.00 0.00	3.11 2148.76	0.67 1020.04	0.17 17.61	0.82 1294.55	0.00 0.00	2.99 2718.72	1.38 1439.75	0.18 53.78	1.01 1595.37	0.87 1059.44	0.83 794.79
sponges cup 25 cm – 50 cm	0.86 4421.57	7.94 16844.93	1.00 2006.65	0.86 4472.66	0.66 1616.13	0.35 3757.20	3.52 8314.53	1.55 4979.77	1.97 9197.11	2.53 9200.79	0.52 2214.40	0.00 0.00
sponges cup 50 cm – 100 cm	0.17 4076.14	0.86 9993.04	0.00 0.00	0.00 0.00	0.82 2770.51	0.18 711.06	1.23 8534.49	1.72 8308.22	0.54 7350.52	0.84 5571.12	0.00 0.00	0.50 7136.56
sponges cup >100 cm	0.00 0.00	0.17 15093.12	0.00 0.00	0.00 0.00	0.16 6052.24	0.00 0.00	0.18 2868.29	0.17 5332.40	0.00 0.00	0.17 3089.44	0.00 0.00	0.00 0.00
sponges erect <25 cm	0.00 0.00	10.01 2235.23	0.67 91.97	0.35 75.98	4.29 1852.12	0.00 0.00	11.26 4337.11	9.12 4902.37	1.61 484.06	4.39 1777.69	0.17 21.71	1.99 836.19
sponges erect 25 cm – 50 cm	0.17 155.45	16.91 10008.58	0.84 1847.79	0.00 0.00	2.14 2061.39	0.53 263.35	10.21 5250.74	7.40 11822.45	0.36 932.26	3.71 8500.68	0.35 1085.49	2.15 2293.30
sponges erect 50 cm – 100 cm	0.00 0.00	4.14 4038.64	0.17 2499.95	0.17 388.55	2.14 2036.65	0.00 0.00	6.86 13012.90	1.55 2399.58	0.18 448.20	1.52 1527.84	0.00 0.00	0.50 2856.28
sponges erect >100 cm	0.00 0.00	0.35 681.74	0.00 0.00	0.00 0.00	0.49 1377.01	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.17 126.62	0.00 0.00	0.17 4967.44
sponges massive <25 cm	1.55 4594.29	8.97 7792.50	0.50 158.86	0.35 1148.38	14.51 5458.56	0.18 30.55	6.51 6259.22	13.76 8879.99	3.94 3478.05	7.60 8831.07	0.69 781.55	3.97 6003.98
sponges massive 25 cm – 50 cm	0.00 0.00	26.92 33788.23	0.00 0.00	0.52 2158.62	11.21 15691.30	0.00 0.00	18.30 21899.33	14.97 20168.51	1.08 4302.74	50.31 58944.13	0.17 764.19	1.82 5306.88
sponges massive 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.49 4205.24	0.00 0.00	0.00 0.00	0.69 11266.84	9.14 7619.44	0.00 0.00	0.17 9239.70	8.11 9396.74
sponges massive >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

Apx Table E.4 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of soft corals classified by morphotypes and sizes collected in the Dampier Marine Park

Soft coral morphotypes and sizes	Dampier Marine Park sites		
	W4	W6	W8
soft corals massive <25 cm	0.00 0.00	0.00 0.00	1.63 546.89
soft corals massive 25 cm – 50 cm	0.17 50.37	0.17 15.63	0.00 0.00
soft corals massive 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00
soft corals massive >100 cm	0.17 5.04	0.00 0.00	0.00 0.00
soft corals fan <25 cm	0.84 45.34	0.17 3.70	0.15 0.74
soft corals fan 25 cm – 50 cm	0.84 110.82	0.67 69.90	0.59 88.69
soft corals fan 50 cm – 100 cm	0.17 50.37	0.84 173.74	0.44 206.93
soft corals fan >100 cm	0.00 0.00	0.34 425.45	0.59 147.81
soft corals whip <25 cm	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 25 cm – 50 cm	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip >100 cm	0.17 50.37	0.00 0.00	0.00 0.00

Apx Table E.5 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of soft corals classified by morphotypes and sizes collected in the Montebello Marine Park

Soft coral morphotypes and sizes	Montebello Marine Park sites (plus site W78)								
	W14	W49	W50	W78	W79	W80	W81	W82	W97
soft corals massive <25 cm	0.00 0.00	0.00 0.00	0.34 101.80	0.36 71.26	0.00 0.00	0.18 63.97	0.56 90.08	0.16 32.84	0.00 0.00
soft corals massive 25 cm – 50 cm	194.43 85843.17	2.57 1958.37	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.16 65.68	0.65 283.56
soft corals massive 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.16 429.39
soft corals massive >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals fan <25 cm	0.18 0.88	24.56	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals fan 25 cm – 50 cm	0.18 7.06	0.16 10.27	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.32 48.61
soft corals fan 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.17 42.42	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals fan >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.16 32.41
soft corals whip <25 cm	0.00 0.00	6.42	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 25 cm – 50 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 50 cm – 100 cm	0.35 18.90	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00

Apx Table E.6 Abundance in numbers per hectare (upper value in each cell) and biomass in grams of wet weight per hectare (bottom value in each cell) of soft corals classified by morphotypes and sizes collected in Pilbara Fish Trawl Fishery Area 1

Soft coral morphotypes and sizes	Pilbara Fish Trawl Fishery Area 1 sites											
	W59	W70	W75	W83	W84	W89	W90	W91	W92	W93	W94	W95
soft corals massive <25 cm	0.69 120.90	3.11 793.92	0.00 0.00	0.00 0.00	0.66 486.49	0.00 0.00	1.23 378.33	1.72 567.64	1.79 197.21	1.01 177.26	0.00 0.00	1.16 231.81
soft corals massive 25 cm – 50 cm	0.35 146.81	0.52 647.22	0.00 0.00	0.00 0.00	0.16 96.47	0.18 79.01	0.18 246.36	0.34 258.02	0.00 0.00	0.84 844.11	0.00 0.00	0.00 0.00
soft corals massive 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.18 340.63	0.00 0.00	0.00 0.00	0.00 0.00
soft corals massive >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.33 16.49	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals fan <25 cm	0.35 8.64	2.93 129.44	0.00 0.00	0.00 0.00	0.99 213.23	0.00 0.00	1.23 70.39	1.03 51.60	0.00 0.00	1.18 67.53	0.00 0.00	0.83 49.67
soft corals fan 25 cm – 50 cm	0.00 0.00	3.28 448.74	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	2.46 536.71	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals fan 50 cm – 100 cm	0.00 0.00	1.21 396.96	0.00 0.00	0.00 0.00	0.33 233.35	0.00 0.00	0.00 0.00	0.69 92.89	0.18 125.50	0.34 135.06	0.00 0.00	0.00 0.00
soft corals fan >100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip <25 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 25 cm – 50 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00
soft corals whip 50 cm – 100 cm	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	1.01 50.65	0.00 0.00	0.00 0.00
soft corals whip >100 cm	0.00 0.00	0.69 43.15	0.00 0.00	0.00 0.00	0.66 486.49	0.00 0.00	0.35 17.60	0.34 17.20	0.00 0.00	0.00 0.00	0.00 0.00	0.66 33.12

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