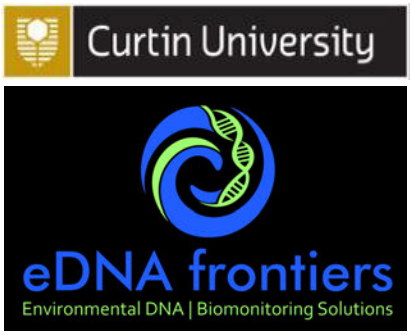

Taxonomic evaluation of biofoul eDNA samples associated with Chevron's Thevenard Island offshore platforms

Prepared for

Chevron Energy Technology Company and Chevron Australia Pty Ltd

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Executive Summary

Study Scope:

Using environmental DNA (eDNA) metabarcoding methods, eDNA frontiers laboratory was tasked with analysing a total of 49 biofoul samples from sites around Thevenard Island offshore oilfield infrastructure. Samples were collected from three tripod platform jackets (Saladin A, B and C) and from six monopod jackets (Roller A, B and C, Skate, Yammadery and Cowle). Two to three replicate samples were collected from each of the three depths (near surface, mid-water and near bottom) with the exception of Roller B, Yammadery and Cowle, where only near surface samples were collected due to adverse weather conditions. The objectives of the study were to generate a list of biodiversity present and to screen for the presence of Alien Invasive Species (AIS) as listed in Appendix 1.

Samples and Data:

Samples were collected using a tubular scraping device and mesh bag attached to either an ROV (mid-water and deep samples) or a long pole extended from the platform (shallow samples). Samples were delivered frozen to eDNA frontiers. Samples were processed to extract DNA and an 18S metabarcoding eDNA assay was used to assemble a biological inventory and to test for the presence of AIS.

Results and recommendations:

This report documents a broad suite of biodiversity recovered by an eDNA survey from around Thevenard Island offshore oilfield infrastructure. The eDNA survey detected a total of 25 eukaryotic Phyla, 48 Classes, 83 Orders and 130 Families. There were significant differences in assemblages between the tripod and monopod structure types. Individual tripods and monopods were not significantly different to each other. Depth was associated with assemblage patterns on the tripods, where the samples were collected from the surface to maximum 16 m. However, the monopods showed no significant differences associated with depth, as the maximum depth was only 10 m.

When eDNA was screened against the custom database of Western Australian regionally relevant AIS there were no ‘highly probable’, ‘probable’ or ‘possible’ detections of AIS. ‘Inconclusive’ detections were recorded for the planktonic jellyfish *Blackfordia virginica* and the seaweed *Sargassum muticum.* In most instances, ‘inconclusive’ detections represent closely-related local (native) taxa that are yet to be sequenced for the 18S barcode region - such classifications need to be conservative until the local taxa can be categorically excluded. To be more definitive about the inconclusive AIS detections, additional DNA assays that can differentiate the AIS from other (native) taxa could be conducted. If future eDNA surveys are planned it may also be appropriate to obtain local reference sequences for a select number of local taxa in the same family/genus as target AIS.

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1.0 INTRODUCTION

1.1 eDNA Background

Environmental DNA (eDNA) refers to a complex mixture of genomic DNA present in biological samples as a by-product of metabolic processes – it can be derived from multiple sources such as: faeces, urine, skin, hair, saliva and whole microorganisms (e.g. bulk samples), which can be extracted and analysed from the environment non-invasively (Taberlet *et al.* 2012a, Taberlet *et al.* 2018).

Traditionally, genetic approaches to characterise organisms used DNA barcoding; a technique where genetic markers (barcodes) consisting of higher interspecific than intraspecific variation were analysed, resulting in species identification (Hebert *et al.* 2003). However, this method was not feasible when a biological sample contained many species. With the development of Next Generation Sequencing technologies, it is now more favourable to utilise DNA "metabarcoding", which utilises the amplification of multiple taxonomic groups simultaneously, allowing for the ability to generate complete biotic surveys from complex (multi species) samples. The method is a powerful tool that can used to identify taxa from bacteria to mammals, importantly in most instances it decreases the cost and laboratory time associated with species identification (Thomsen *et al.* 2012; Bohmann *et al.* 2014; Gardner *et al.* 2016; Stat *et al.* 2017). In recent years there has been a growing amount of literature reporting the use of these methods for biodiversity analyses (Thomsen & Willerslev, 2015) due to the wide applicability of metabarcoding and eDNA methods (Figure 1-1).

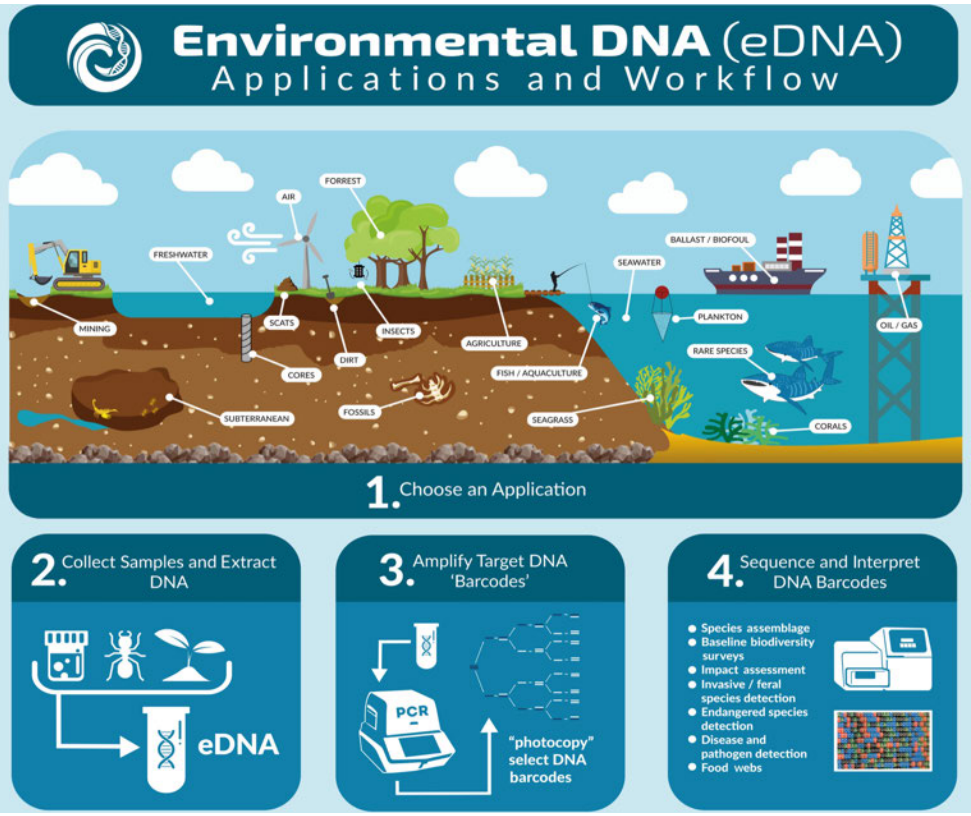

Figure 1-1 - Environmental DNA (eDNA) Applications and Workflow

eDNA based methods have been used as a novel technique for both total biodiversity assessment (Stat *et al.* 2017), detection of fish (Miya *et al*. 2015, Stat *et al.* 2018) and alien invasive species (AIS) (Pochon *et al.* 2013). eDNA can be detected in a range of substrates such as water, sediment and biofoul (Koziol *et al.* 2018). Collection of samples is rapid and a wide range of taxa can be detected in a single sample, without observing the individual organisms (Ficetola *et al.* 2008).

Studies comparing the efficacy of eDNA metabarcoding with traditional techniques for detection of AIS have demonstrated that molecular based techniques can outperform the detection efficacy of traditional methods, while also reducing detection time (Valentini *et al.* 2016). This is paramount for biosecurity purposes, as the early detection of first colonisers, which may be initially low in abundance, is critical in the successful eradication of AIS before they become established and are difficult or logistically unfeasible to eradicate (Simberloff, 2003).

Koziol *et al.* (2018) report that the biological substrate used in eDNA studies heavily influences the biotic profiles obtained, accordingly, there are often advantages to processing more than a single biological substrate when employing eDNA metabarcoding. Depending on the question being addressed it may be advisable to collect samples from a range of different substrate types. Another important consideration in experimental design is selection of appropriate eDNA assay. Stat *et al.* (2017) discussed the importance of using multiple metabarcoding assays to detect a greater diversity of taxa. Hence, assay selection will depend on the aims of the study. For this study around Thevenard Island the 18S assay was selected to target a wide diversity of eukaryotes including AIS.

1.2 Alien Invasive Species (AIS)

Marine species introduced to regions outside their native range (Alien Invasive Species – (AIS)) can pose a significant threat to coastal ecosystems through their potential to decrease endemic biodiversity and modify habitats, as well as threaten marine industries and infrastructure (Rilov & Crooks 2009). AIS are commonly transported and introduced through hull biofouling and ballast water, and represent an increasing threat as coastal infrastructure continues to proliferate. The total economic cost of an AIS incursion is very difficult to determine because it can include not only direct costs related to reductions in economic output but also indirect costs via damage to coastal infrastructure, social implications, risks to human health and environmental impacts, which can be more difficult to quantify. Once an incursion has occurred, eradication of an AIS is very costly and often ineffective (Bax *et al.* 2003, Pimentel *et al*. 2000, Pochon *et al*. 2013). Prevention and early detection are well recognised as the best strategies for minimizing the risks posed by AIS (Bax *et al.* 2001, Hulme 2006, Simberloff 2001). Central to this is the ability to rapidly and accurately identify the presence of AIS, often from complex environmental samples like biofouling, sediment and seawater (Bott *et al.* 2010).

Routine surveillance aims to detect marine pests at the early stages of the invasion process and inform managers/regulators to allow them to better manage any secondary spread or

establishment. Surveys can also help to inform the risk of translocation of invasive species for evaluating decommissioning alternatives, such as cleaning, leaving structures in place and reefing. Molecular tools which target environmental DNA (eDNA) are rapidly evolving to be able to quickly and accurately determine the presence or absence of target marine pests from complex samples even at microscopic or larval life stages.

2.0 OBJECTIVES

Using environmental DNA (eDNA) metabarcoding, eDNA frontiers was tasked with analysing the biofoul samples collected from the Thevenard Island sites for tree of life biodiversity and the presence of AIS as listed in Appendix 1.

3.0 METHODS

3.1 Sampling Location

Biofoul samples suitable for eDNA analysis were collected by Chevron staff from 9 sites in 3 depth ranges (deep, mid and shallow) around Thevenard Island oilfield infrastructure in December 2018 and January 2019 (Table 3-1).

Table 3-1 Sample collection details from eDNA metabarcoding surveys of oilfield infrastructure around Thevenard Island in Dec 2018 and Jan 2019

Curtin ID	Site	Sample Date	Depth	Number of replicates
E19-865 – 873	Saladin A	Dec 2018	Deep (16m)	3
		Dec 2018	Mid (8m)	3
		Dec 2018	Shallow (3m)	3
E19-874 - 882	Saladin B	Dec 2018	Deep (15m)	3
		Dec 2018	Mid (7m)	3
		Dec 2018	Shallow (3m)	3
E19-883 - 889	Saladin C	Dec 2018	Deep (6m)	2
		Dec 2018	Mid (3.5m)	2
		Jan 2019	Shallow (surface)	2
E19-890 - 895	Roller A	Dec 2018	Deep (10m)	2
		Dec 2018	Mid (5m)	2
		Jan 2019	Shallow (surface)	2
E19-896 - 901	Roller B	Dec 2018	Deep (10m)	2
		Dec 2018	Mid (5m)	2
		Jan 2019	Shallow (surface)	2
E19-902 -903	Roller C	Jan 2019	Shallow (surface)	2
E19-904 - 909	Skate	Dec 2018	Deep (8.5m)	2
		Dec 2018	Mid (4m)	2
		Jan 2019	Shallow (surface)	2
E19-910 -911	Yammadery	Jan 2019	Shallow (surface)	2
E19-912 - 913	Cowle	Jan 2019	Shallow (surface)	2

3.2 Sample Collection

Biofoul samples were collected from the legs of tripods and monopods using an apparatus developed by Chevron ETC, which included a stainless or aluminium tubular scraping device and nylon mesh collection bag. Deep and mid-water samples were collected using an ROV and shallow samples were collected by hand. Mesh bags were stored in 50 ml Falcon tubes, delivered frozen to eDNA frontiers and on arrival, samples were stored at -20°C.

3.3 Laboratory Methods

3.3.1 eDNA Extraction and Analysis

DNA was extracted from a small section of each mesh bag using a Qiagen DNeasy blood and tissue kit, following the eDNA frontiers lab's SOPs and detailed in Koziol *et al.* (2018), Stat *et al.* (2017), Stat *et al.* (2018). The remainder of each primary sample and corresponding DNA is stored at -20°C for 12 months and can be used for further analysis if required.

Each sample was assigned an individual barcode tag and amplified by PCR using the 18S assay. DNA sequences from the 18S gene region are present in most eukaryotic organisms and the use of this gene region is based on results from previous research (Stat *et al.* 2016). A library was generated and sequenced using the Illumina MiSeq. Laboratory extraction and PCR controls were included to test for contamination.

3.3.2 Bioinformatics and Taxonomic assignments

Bioinformatic tools were used to analyse raw sequence data from these samples. The Greenfield Hybrid Analysis Pipeline (GHAPv.2) (Greenfield 2017) was used to analyse raw sequence data. Paired-end sequences were merged, trimmed and quality filtered for sequencing errors and minimum length. Sequences were then dereplicated and unique sequences were transformed into zero radius operational taxonomic units (ZOTUs) to provide sensitive taxonomic resolution (Usearch v11) (Edgar 2018), which were queried against a curated SILVA 18S database. Taxa were identified to the Family level.

Following stringent quality control filtering as described by eDNA frontiers standard operating procedures, the final DNA sequences from the samples were screened against an *in-house* target pest database to determine presence and absence of target introduced marine pests. This custom database contains the genetic sequence reference library compiled by DPIRD, Aquatic Pest Biosecurity (as listed in Appendix B) of the target pest species identified by the Western Australian Prevention List for Introduced Marine Pests, Department of Fisheries (November 2016). The database was prepared by amplifying and sequencing all pest species individually using the same 18S assay as the NGS process.

Environmental DNA is a powerful and novel method for detection of AIS. However, like morphological analysis, one of the key steps is to differentiate the (genetic) features of an AIS

away from local taxa that might be 'mistaken' for an AIS (i.e. a false positive). Until suitable reference barcodes are obtained from local closely related taxa, conservative assignments must be made. Accordingly, the stepwise criteria used for assigning sequence to an AIS are outlined in Table 3-2.

Table 3-2 Criteria for assigning sequences to an AIS using the 18S assay on eDNA. These criteria and cut-offs were developed in conjunction with DPIRD (Western Australia) and are subject to change.

Criteria				Confidence
1	Is a sequence >97%* similar to an AIS reference sequence	Yes Go to 2	No	
2	Can the assay differentiate the AIS from other species	Yes Go to 3	No	Inconclusive
3	Does the sequence match to an AIS at 99%*	Yes Go to 4	No	Inconclusive
4	Are there available reference sequences for closely related local taxa	Yes Go to 5	No	Possible
5	Has the AIS been reported in the area before	Yes Go to 6	No	Probable
6				Highly Probable

3.3.3 Comparison of Biodiversity among Sites

Taxon assignments from DNA barcode data were transformed to presence/absence. Data were transformed using a Jaccard similarity matrix designed for the handling of community assemblage data. To visualize the effects of structure type, site and depth on biodiversity, the Jaccard transformed dataset was analysed using a Principal Coordinate Ordination (PCO) (Anderson and Willis 2013) for sites. PCO is an ordination method to visualise similarity among samples. It relates a matrix of response variables (taxa) with a predictor variable (eg. site/substrate). It groups similar samples into a cluster and then places them on a 2D image. Eigen vectors were overlayed on the ordinations to display the families that exhibited correlations of >0.4. Permutational analysis of variance (PERMANOVA; Anderson 2005) was used to assess if taxon assemblage was significantly different between structures and sites. As sampling depth was not consistent between sites, depth was treated as a covariate factor as opposed to a fixed factor.

4.0 RESULTS AND DISCUSSION

18S Metabarcoding data was recovered from all samples. The following analyses focus on (i) the AIS results (see 4.1) and (ii) a description of the overall taxonomic diversity (4.2).

4.1 AIS Results

This report documents the taxa recovered by an eDNA survey from offshore assets associated with Chevron's Thevenard Island field, including 3 tripods and 6 monopods. Screening against the in-house AIS database indicated that taxa were detected within some of the same families and genera as target species. However, there were no 'highly probable' or 'probable' or 'possible' detections in any of the samples. According to the criteria detailed in Table 3-2, *Blackfordia virginica* and *Sargassum muticum* were considered 'inconclusive' (Table 4-1). All taxa listed on the WA Prevention List that are not listed in Table 4-1 have not been detected in the samples around Thevenard Island.

Sequences matching the jellyfish *Blackfordia virginica* were detected in 1 replicate from the deep point (16m) at Saladin A. However, there are no reference sequences available for closely related species to determine the accurate identity of the sequences detected in the samples. As a planktonic species rather than a sessile biofoul species, this detection is not likely to be associated with the offshore infrastructure.

Similarly, sequences matching *Sargassum muticum* were detected in Saladin A at the mid water (8m) collection point as well as both the mid (3.5m) and shallow (surface) collection points at Saladin C. Sequences in the *Sargassum* genus are not able to be resolved to species level using only the 18S gene region. According to the Atlas of Living Australia, at least 9 species of Sargassum have been recorded in waters surrounding Thevenard Island. Only 4 of the 9 species have 18S reference sequences available on NCBI and none of those sequences have been generated from vouchered specimens.

Table 4-1 Results of comparing the 18S eDNA metabarcoding survey of Thevenard Island to the custom sequence database for detection of Western Australian target AIS. This table indicates when sequences were found within the same family or genus as a target species and lists the samples in which target AIS are detected. ND indicates not detected. Confidence is the level of certainty of the species assignment according to the criteria in Table 3-2.

Common name	Family	Genus	Target Species	Confidence/ Comments
Fan Worms	Sabellidae	*Sabella*	*Sabella spallanzanii*	Most closely identified as *Sabella crassicornis*
	Saladin B (mid), Saladin B (shallow)	Saladin B (mid), Saladin B (shallow)	ND	
Bay barnacle	Balanidae	*Amphibalanus, Balanus*		Taxa were detected in the family Balanidae but were more closely matched to a non-target genus.
	Saladin A (shallow), Saladin B (shallow), Saladin C (mid), Roller A (deep)	ND	ND	
Comb jelly	Blackfordiidae	*Blackfordia*	*Blackfordia virginica*	Inconclusive - Sequences were a 99% match to *B. virginica* but cannot be differentiated from other closely related jellyfish and are not targeted by biofoul in relation to offshore structures.
	Saladin A (deep)	Saladin A (deep)	Saladin A (deep)	
Mussels	Mytilidae	*Arcuatula, Geukensia, Limnoperna, Mytella, Perna*	ND	Taxa were detected in the family Mytilidae but were more closely matched to a non-target genus.
	Saladin A (mid), Saladin B (mid)	ND	ND	
Oyster	Ostereidae	*Crassostrea*	*Crassostrea sp.*	Taxa were detected in the family Ostereidae but were more closely matched to a non-target genus.
	Saladin C (mid)	ND	ND	
Asian seaweed	Sargassaceae	*Sargassum*	*Sargassum muticum*	Inconclusive - Sequences match multiple *Sargassum sp.*
	Saladin A (mid), Saladin C (mid), Saladin C (shallow)	Saladin A (mid), Saladin C (mid), Saladin C (shallow)	Saladin A (mid), Saladin C (mid), Saladin C (shallow)	

4.2 Taxonomic Diversity (18S metabarcoding)

A diverse range of taxa were detected using the 18S metabarcoding surveys from each site. A list of marine taxa (assigned to family level) are detailed in Appendix 3 and visualised in a pie chart in Figure 4-1 displaying the number of families detected within each phylum. Note- this is only displaying diversity, it is not an indication of abundance. Analysis of pooled samples from the four sites combined detected 25 Phyla, 48 Classes, 83 Orders and 130 Families.

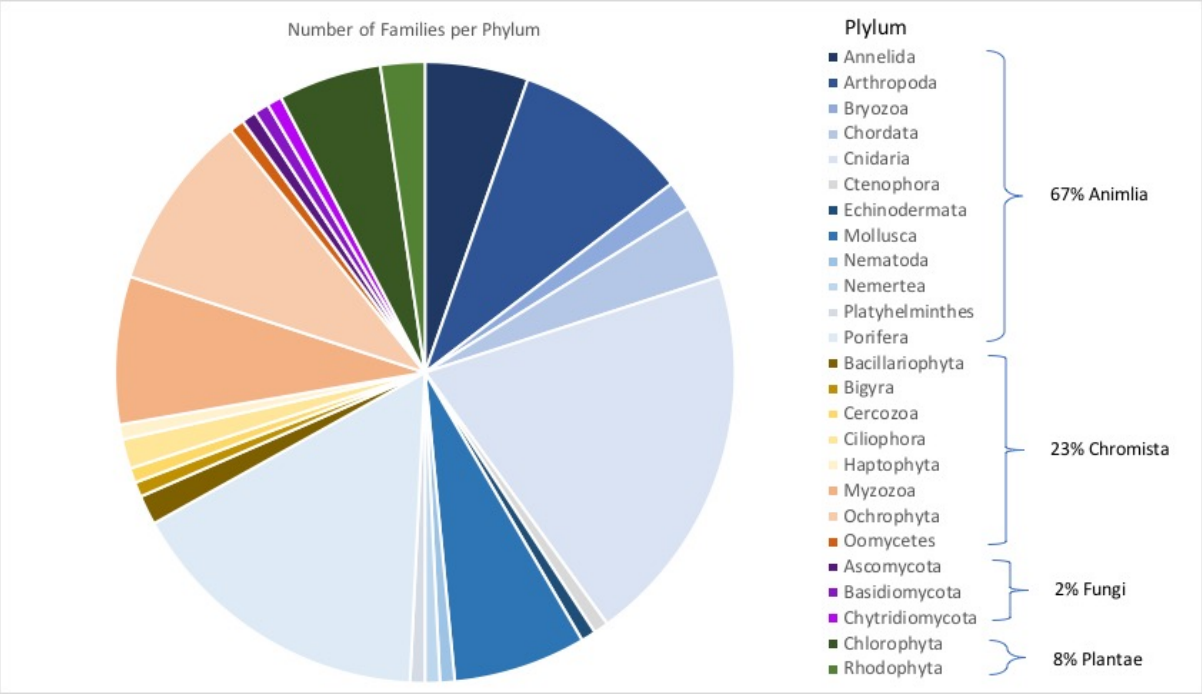

Figure 4-1 Pie chart displaying taxa identified by 18S eDNA metabarcoding of biofoul samples collected from 9 sites around Thevenard Island oilfield infrastructure. The sections indicate the number of families represented within each phylum.

To visualise how distinctly the taxa detected in the samples were spatially structured, the Jaccard transformed dataset was analysed using a PCO (Anderson and Willis 2013) for all sites (Figure 4-2). The PCO ordinations exhibited clustering suggesting significant differences between the tripod and monopod structures (Figure 4-2). Eigen values indicated that the monopods were highly correlated with multiple families of green, brown and red algae, barnacles and copepods. Whereas the deeper tripod structures were more closely related to families of jellyfish and sessile organisms including hydroids, bryozoans and worms.

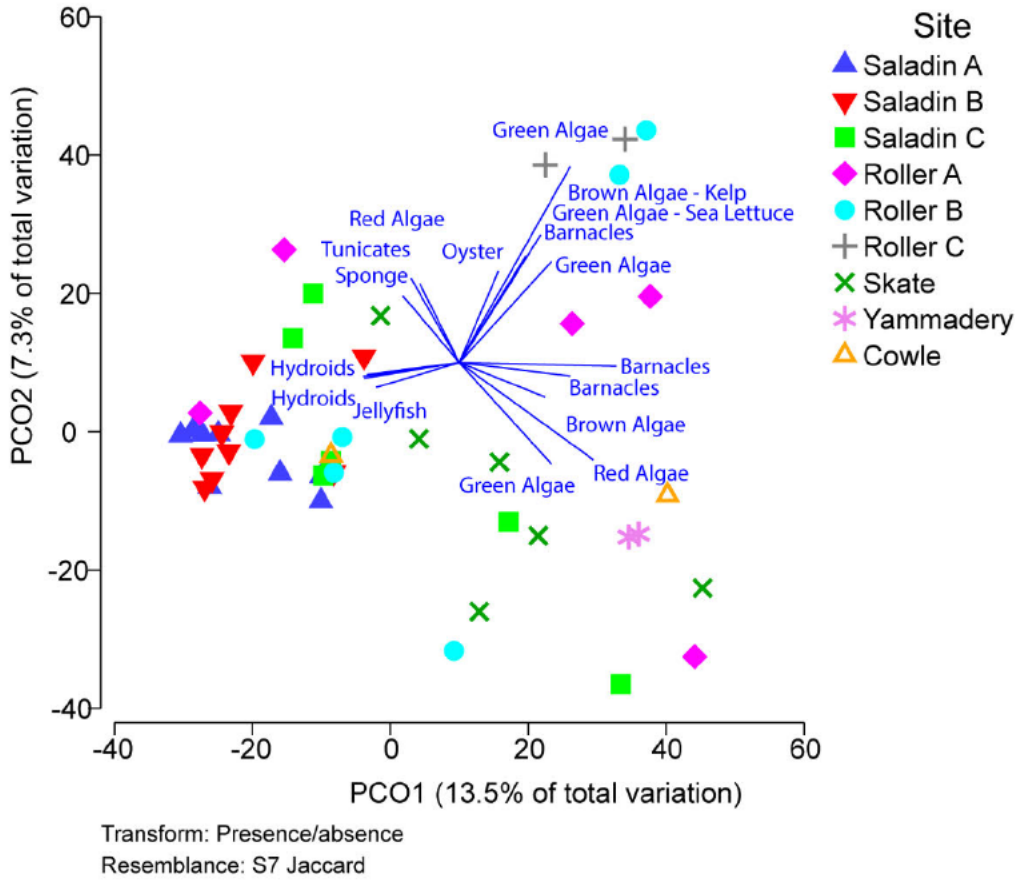

Figure 4-2 Principal coordinate ordination from the eDNA community assemblages (collapsed to family level taxonomy) detected with the 18S assay at each site around Thevenard Island oilfield infrastructure. The data set was transformed using a Jaccard similarity matrix from presence/absence transformed data for sampling location. Overlaid eigen vectors display the common names of the most highly correlated families.

PERMANOVA verified that the observed differences between tripods and monopods were significant (P=0.0001) for structure (Table 4-2). It was therefore decided to analyse the tripod and monopod datasets separately.

Table 4-2 Main PERMANOVA on structures

Source	df	Pseudo-F	P(perm)	Unique permutations
Structure	1	2.5107	0.0001	9871

Tripod structure assemblages were displayed in a PCO (Figure 4-3). The numbers indicate the depth (m) from which the samples were collected. PERMANOVA indicated that there was no significant difference between the sites. However, depth, as a co-variate was significant (Table 4-3). Eigen vectors again indicated that families of brown and green algae and barnacles were highly correlated with the shallow samples and hydroids and sponges were correlated with the deep samples.

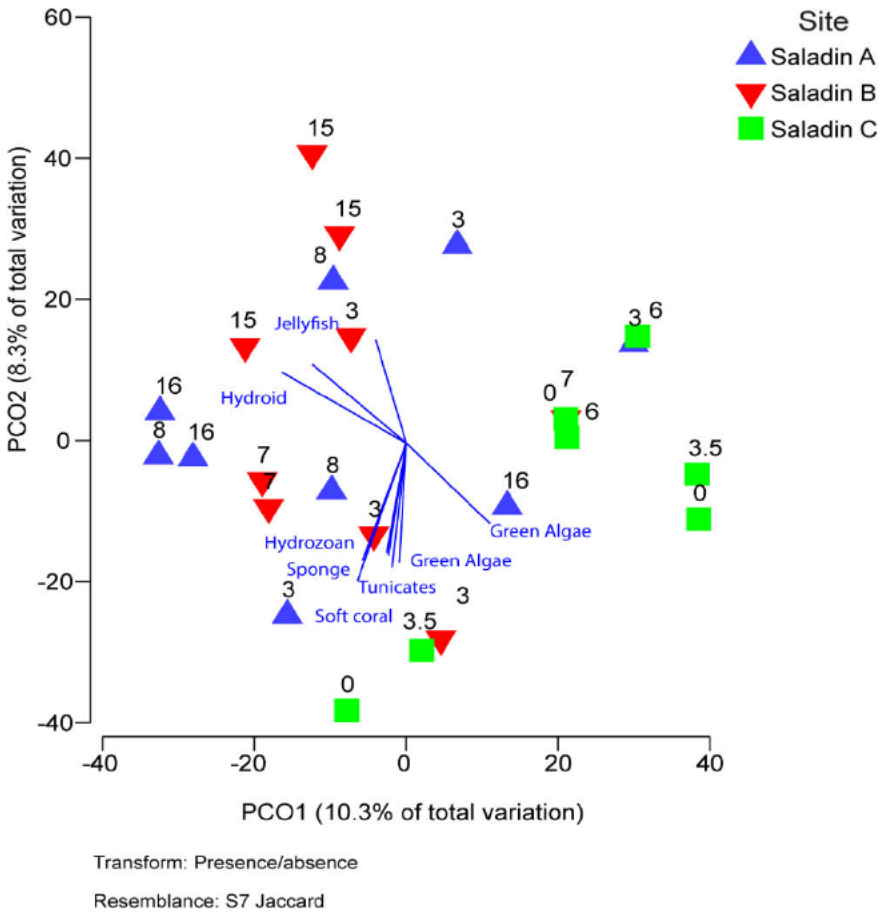

Figure 4-3 Principal coordinate ordination from the eDNA community assemblages (collapsed to family level taxonomy) detected with the 18S assay at each tripod structure around Thevenard Island oilfield infrastructure. The data set was transformed using a Jaccard similarity matrix from presence/absence transformed data for sampling location. Numbers indicate the depth (m) from where biofoul samples were collected. Overlaid eigen vectors display the common names of the most highly correlated families.

Table 4-3 Main PERMANOVA on tripod structures. Depth is treated as a co-variate.

Source	df	Pseudo-F	P(perm)	Unique permutations
Site	2	1.1924	0.0968	9796
Depth	1	1.9556	0.0003	9863

Monopod structure assemblages were displayed in a PCO (Figure 4-4). The numbers indicate the depth (m) from which the samples were collected. PERMANOVA showed that sites were not significantly different to each other. Additionally, the differences in depth from the shallow sites (surface) to the deep sites (max. 10m) was not enough to be significant (Table 4-4). For these structures, eigen vectors indicated that families of brown, green and red algae and barnacles were highly correlated with the most samples.

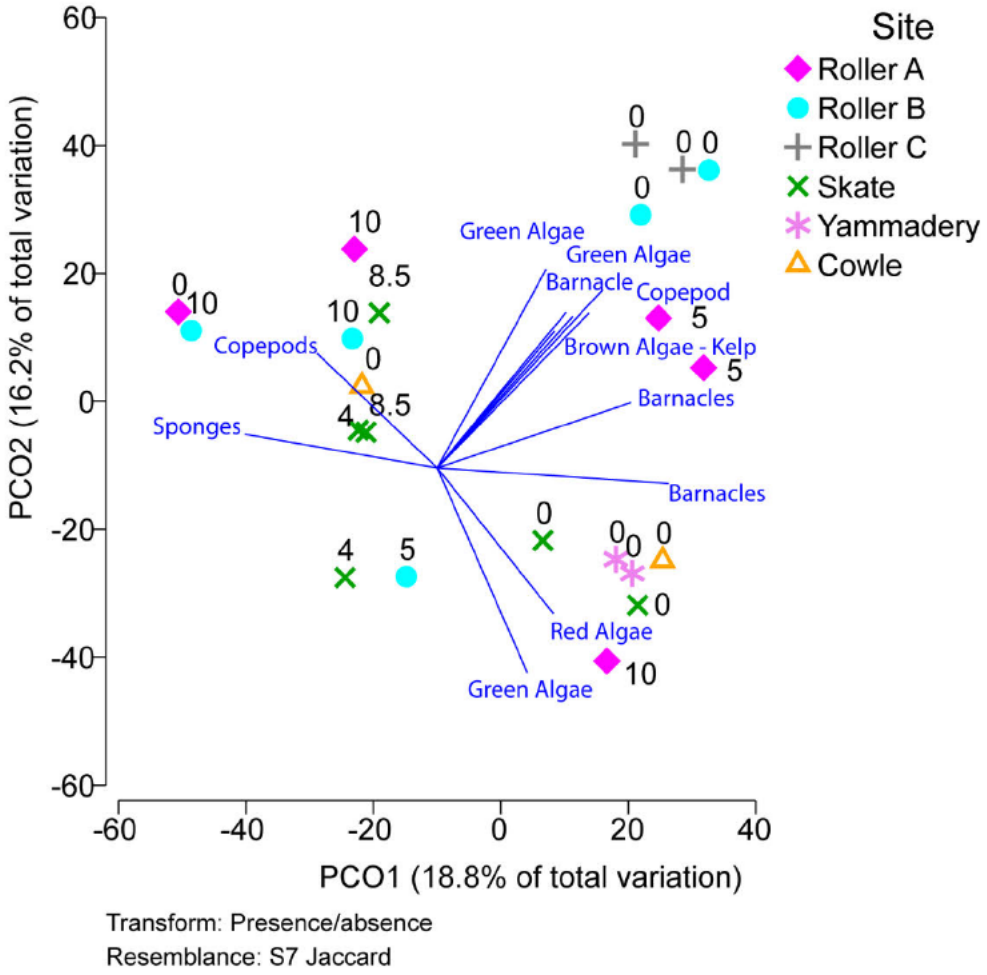

Figure 4-4 Principal coordinate ordination from the eDNA community assemblages (collapsed to family level taxonomy) detected with the 18S assay at each monopod structure around Thevenard Island oilfield infrastructure. The data set was transformed using a Jaccard similarity matrix from presence/absence transformed data for sampling location. Numbers indicate the depth (m) from where biofoul samples were collected. Overlaid eigen vectors display the common names of the most highly correlated families.

Table 4-4 Main PERMANOVA on monopod structures. Depth is treated as a co-variate.

Source	df	Pseudo-F	P(perm)	Unique permutations
Site	5	1.0255	0.4221	9926
Depth	1	1.5478	0.0972	9926

5.0 CONCLUSIONS AND RECOMMENDATIONS

This report documents a broad suite of biodiversity recovered by an eDNA survey of biofoul scrapes from offshore platforms associated with Chevron's Thevenard Island oilfield. The biodiversity from the structures was comprised of 12 animal and 2 plant phyla as well as some

brown seaweeds, fungi and single-celled organisms. Without control samples from nearby reefs it is outside the scope of this study to determine whether the biodiversity is consistent with a natural reef system.

There were significant differences between the tripod and monopod structures. However, the 3 tripod structures were not significantly different to each other and the 6 monopod structures were not significantly different to each other. The tripod structures, with biofoul samples collected from the surface to maximum 16 m, showed significant differences associated with depth. However, the monopod structures, with a smaller range (surface to maximum 10 m) did not exhibit significant differences associated with depth. In all structures, multiple families of green, red and brown algae as well as barnacles and copepods were highly associated with shallow samples. Deep samples were more correlated with sessile animals including multiple families of hydroids, worms and sponges.

According to information provided by Chevron, the Thevenard Island platform jackets are cleaned on an annual basis. This cleaning is aimed at reducing wave-loading on the structures during storms and cyclones and to this end, shallower areas are prioritised. However, the cleaning regime scope includes cleaning of the entire structure where possible. Despite the cleaning regime and opening up of bare substrate on jacket legs, which may have increased the risk of attachment on invasive species, no species of concern were identified. Regular cleaning may have also supressed some of the depth zonation that was expected to occur in biological communities on jacket legs. Alternatively, this lack of zonation in eDNA results may have been due to the limited depth range of Thevenard Island platform jackets (maximum depth 6m-15m) compared to other studied locations, such as Gulf of Thailand (maximum depth 65-75m).

There were no highly probable, probable or possible detections of AIS. The jellyfish *Blackfordia virginica* was considered an inconclusive detection due to the limitations in the 18S assay in differentiating some taxa to species resolution. However, as this species is planktonic it is not considered relevant by Chevron to the offshore assets study. The seaweed *Sargassum muticum* was also considered an inconclusive detection as it was unable to be distinguished from other sequences within the same genus. As at least 9 species of Sargassum have been recorded previously in surrounding waters, many of which are not represented in the NCBI database, it is possible that this detection is a native species yet to be sequenced. DNA identifications of AIS need to be conservative until local taxa (related to AIS) can be excluded. To be more definitive about the inconclusive AIS detections, additional DNA assays that can differentiate the AIS from other (native) taxa could be conducted.

The samples and DNA extracts derived from this study will be stored within eDNA frontiers premises for a period of 12 months. If samples are required to be stored longer a biobanking service can be provided at additional cost.

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Appendix 1

Targeted introduced marine pests that are able to be detected with the 18S metabarcoding assay. This list is based on the WA Prevention List for Introduced Marine Pests, Department of Fisheries (2016) for which 18S sequences have been generated by DPIRD from vouchered specimens.

Group	Species	Common name
Annelid	*Sabella spallanzanii*	Mediterranean fan worm
Annelid	*Marenzelleria arctia*	Red-gilled mud worm
Annelid	*Hydroides dianthus*	Tube worm
Cirripedia	*Amphibalanus improvisus*	Bay barnacle
Cirripedia	*Balanus glandula*	Acorn barnacle
Cirripedia	*Hesperibalanus fallax*	Epibiotic barnacle
Cirripedia	*Chthamalus proteus*	Atlantic barnacle
Clam	*Corbicula fluminea*	Freshwater clam
Clam	*Ensis directus*	Jack-knife clam
Clam	*Varicorbula gibba*	European clam
Clam	*Potanocorbula amurensis*	Asian clam
Clam	*Mya arenaria*	Soft-shell clam
Clam	*Anadara transversa*	Transverse ark clam
Cnideria	*Mnemiopsis leidyi*	Comb jelly
Cnideria	*Blackfordia virginica*	Black Sea jelly
Decapoda	*Pseudodiaptomus marinus*	Asian copepod
Copepoda	*Tortanus dextrilobatus*	Asian copepod
Decapoda	*Charybdis japonica*	Asian paddle crab
Decapoda	*Carcinus maenas*	European shore crab
Decapoda	*Callinectes sapidus*	Blue crab
Decapoda	*Carcinoscorpius rotundicauda*	Mangrove horseshoe crab
Decapoda	*Dikerogammarus villosus*	Killer shrimp
Decapoda	*Eriocheir sinensis*	Mitten crab
Decapoda	*Hemigrapsus sanguineus*	Japanese shore crab
Decapoda	*Hemigrapsus takanoi*	Pacific crab
Decapoda	*Pachygrapsus fakaravensis*	Polynesian grapsid crab
Decapoda	*Rhithropanopeus harrisii*	Harris' mud crab
Fish	*Tridentiger barbatus*	Shimofuri goby
Fish	*Tridentiger bifasciatus*	Shokohazi goby
Fish	*Tridentiger trigonocephalus*	Chameleon goby
Fish	*Acanthogobius flavimanus*	Goby
Fish	*Neogobius melanostomus*	Round goby
Fish	*Siganus luridus*	Dusky spinefoot
Fish	*Siganus rivulatus*	Marbled spinefoot
Gastropod	*Rapana venosa*	Veined rapa whelk
Gastropod	*Crepidula fornicata*	American slipper limpet
Macroalgae	*Codium fragile*	Green macro algae
Macroalgae	*Caulerpa taxifolia*	Green macro algae
Macroalgae	*Caulerpa racemosa*	Green macro algae

Group	Species	Common name
Macroalgae	*Sargassum muticum*	Asian seaweed
Macroalgae	*Grateloupia turuturu*	Red macro algae
Macroalgae	*Bonnemaisonia hamifera*	Red macro algae
Macroalgae	*Womersleyella setacea*	Red macro algae
Macroalgae	*Fucus evanescens*	Brown macro algae
Mussel	*Perna viridis*	Asian green mussel
Mussel	*Perna perna*	South African brown mussel
Mussel	*Perna canaliculus*	New Zealand mussel
Mussel	*Arcuatula senhousia*	Asian bag mussel
Mussel	*Limnoperna fortunei*	Golden mussel
Mussel	*Geukensia demissa*	Ribbed mussel
Mussel	*Mytella charruana*	Charru mussel
Mussel	*Mytilopsis sallei*	Black-striped mussel
Mussel	*Mytilopsis leucophaeata*	Dark false mussel
Mussel	*Dreissena bugensis*	Quagga freshwater mussel
Mussel	*Dreissena polymorpha*	Zebra freshwater mussel
Oyster	*Crassostrea gigas*	Pacific oyster
Oyster	*Crassostrea virginica*	American oyster
Oyster	*Crassostrea ariakensis*	Suminoe oyster
Oyster	*Anomia nobilis*	Saddle oyster
Sea star	*Asterias amurensis*	Northern pacific seastar

Appendix 2 - Glossary

Term	Definition
% value in data	Represents the percentage similarity of a DNA sequence recovered from a sample compared to reference sequences in a database (e.g. compared to DNA databases such as GenBank or references generated in-house)
(x) value in data	Represents the frequency the % value was recorded in the dataset
16S rRNA	The 16S rRNA refers to a conserved gene region of mitochondrial DNA, which codes for a subunit of the ribosome. 16S rRNA is found in all eukaryotes making it a good candidate for DNA barcoding
18S rRNA	The 18S rRNA refers to a conserved gene region of nuclear DNA, which codes for a subunit of the ribosome. 18S rRNA is found in all eukaryotes making it a good candidate for DNA barcoding
18S AIS reference database	Reference 18S rRNA sequences of invasive marine species that are available in DNA databases
AIS	Alien Invasive Species
Assay	In the context of eDNA metabarcoding an assay refers to a PCR 'test' that selectively targets a subset of biota from an environmental DNA sample. The use of multiple assay when combined will always detect a wider diversity of taxa than a single assay. eDNA assays should be selected to address the question relevant to the study.
Barcode	Refers to a region of DNA sequenced for many species that is able to (through variation in the DNA sequence) is able to differentiate species. DNA barcodes are the most common targets of eDNA studies that seek to explore taxon assemblages.
Biological inventory	A list of taxa generated from eDNA sequence data. It identifies what was able to be detected at a single point in time from the samples provided, not intended to be fully comprehensive of the entire ecosystem.
COI	The gene region that is being used as the standard barcode for almost all animal groups is a 648 base-pair region of the mitochondrial cytochrome c oxidase 1 gene ("CO1"). COI is proving highly effective in identifying birds, butterflies, fish, flies and many other animal groups. COI is not an effective barcode region in plants because it evolves too slowly, but two gene regions in the chloroplast, matK and rbcL, have been approved as the barcode regions for plants
CO1 AIS reference database	Reference COI sequences of invasive marine species that are available in DNA databases
DNA	Deoxyribonucleic Acid (DNA) is the hereditary material that contains the genetic information of an organism
DNA metabarcoding	Is a genetic technique that simultaneously amplifies and sequences barcode regions (e.g. COI, 18S, 16S) of many different species in parallel

Term	Definition
eDNA	Environmental DNA (eDNA) refers to genetic material that is recovered from an environmental substrate (e.g. water, sediment, air)
Eukaryotes	An organism where cells contain a nucleus surrounded by a membrane and has the DNA bound together by proteins (histones) into chromosomes. The cells of eukaryotes also contain an endoplasmic reticulum and numerous specialised organelles not present in prokaryotes, especially mitochondria, golgi bodies, and lysosomes
Fisheries	Department of Primary Industries and Regional Development, Fisheries Division, Aquatic Biosecurity Section
GenBank	Publicly available repository of genetic information. Contains the barcode information of genes that have previously been sequenced
Genome	A genome is all the genetic material of an organism. It consists of DNA (or RNA in RNA viruses). The genome includes both the genes (the coding regions) and the noncoding DNA. In eukaryotes it refers to the genomes of the nucleus, mitochondria and chloroplasts. In prokaryotes, there is a single genome (as they do not contain mitochondria or chloroplasts)
Illumina MiSeq	Next generation sequencing platform developed by the company Illumina
IMP	Introduced marine pests
Low abundance	Low abundance reads have been defined as those that constitute <0.1% of total reads for a particular sample
Metabarcoding assay	A PCR reaction using a specific set of primers that simultaneously amplifies the same gene target from multiple species. Also see definition of 'assay'.
Mitochondrial DNA (mtDNA)	The mitochondrion (plural mitochondria) is a double membrane-bound organelle found in all eukaryotic organisms. mtDNA markers (e.g. 16S or COI) are common DNA barcodes.
Mitogenomes	Refers to the mitochondrial genome
NGS	Next generation sequencing or second generation sequencing refers to massively parallel sequencing technology, as opposed to first generation sequencing or sanger sequencing where only a single template is sequenced at one time
Nucleotide	A compound consisting of a nucleotide linked to a phosphate group. Nucleotides form the basic structural unit of nucleic acids such as DNA
PCR	Polymerase chain reaction (PCR) is the technique that is used to amplify (akin to photocopying DNA) specific regions of the genome from specific groups of taxa
Primer	A short DNA strand (≈20bp in size) used in PCR to target particular groups of organisms and genes. Two of them are required for PCR (a forward and a reverse)

Term	Definition
Primer binding site	A primer-binding site is the target region of a genome where the primer attaches to start replication. The primer binding site is on one of the two complementary strands of a double-stranded nucleotide polymer, in the strand which is to be copied, or is within a single-stranded nucleotide polymer sequence
Prokaryote	Any of the typically unicellular microorganisms that lack a distinct nucleus and membrane-bound organelles and that are classified as a kingdom (Prokaryotae syn. Monera) or into two domains (Bacteria and Archaea)
RNA	Ribonucleic acid (RNA) is a polymeric molecule implicated in various biological roles in coding, decoding, regulation, and expression of genes
rRNA	ribosomal ribonucleic acid is the RNA component of the ribosome, and is essential for protein synthesis in all living organisms
Sequence	DNA sequencing is the process of determining the precise order of nucleotides within a DNA molecule. It includes any method or technology that is used to determine the order of the four bases—adenine, guanine, cytosine, and thymine—in a strand of DNA
Shotgun sequencing	Refers to randomly sequencing short pieces of DNA (≈150bp in size) after shearing or cutting DNA (e.g. fragmenting a genome)
EDNA frontiers	Trace and Environmental DNA laboratory, Curtin University
OTU	Operational Taxonomic Unit is a molecular biology term that describes unique DNA barcode clusters and how they are different from one another. It is usually defined by a % cut-off based on DNA sequence similarity. The value of OTUs is that biodiversity can be compared without the need to assign each sequence into a taxonomic framework and is most appropriate when there are large deficiencies in the underpinning taxonomic framework. OTU are very similar in function to ZOTUs (see below).
ZOTU	Zero-radius Operational Taxonomic Unit is a molecular biology terms that describes unique DNA barcode clusters and how they are different from one another. It is usually defined by a % cut-off based on DNA sequence similarity. The value of ZOTUs is that biodiversity can be compared without the need to assign each sequence into a taxonomic framework and is most appropriate when there are large deficiencies in the underpinning taxonomic framework. ZOTU are very similar in function to OTUs (see above) but describe more exact sequence variants

Appendix 3

Marine taxa assigned to family level detected by 18S eDNA metabarcoding on oilfield infrastructure sites near Thevenard Island. *Note: the taxa identifications in this table are the authors best approximation based on available reference data. If an incomplete database exists or the underpinning taxonomy is unstable, errors in assignment are possible*

Kingdom	Phylum	Class	Order	Family
Animalia	Annelida	Polychaeta		Opheliidae
			Capitellida	Capitellidae
			Eunicida	Eunicidae
			Golfingiida	Sipunculidae
			Phyllodocida	Polynoidae
			Phyllodocida	Syllidae
			Sabellida	Sabellidae
	Arthropoda	Malacostraca	Decapoda	Pilumnidae
			Decapoda	Pinnotheridae
			Mysida	Mysidae
		Maxillopoda	Calanoida	Centropagidae
			Harpacticoida	Dactylopusiidae
			Harpacticoida	Ectinosomatidae
			Poecilostomatoida	
			Sessilia	Balanidae
			Sessilia	Coronulidae
			Sessilia	Platylepadidae
			Sessilia	Pyrgomatidae
			Sessilia	Tetraclitidae
		Ostracoda	Podocopida	Paradoxostomatidae
	Bryozoa	Gymnolaemata	Cheilostomatida	Cribrilinidae
			Cheilostomatida	Cryptosulidae
	Chordata	Appendicularia	Copelata	Oikopleuridae
		Ascidiacea	Enterogona	Perophoridae
			Stolidobranchia	Pyuridae
			Stolidobranchia	Styelidae
		Thaliacea	Pyrosomata	Pyrosomatidae
	Cnidaria	Anthozoa	Actiniaria	Sagartiidae
			Alcyonacea	Nephtheidae
			Alcyonacea	Plexauridae
			Alcyonacea	Taiaroidae
			Pennatulacea	Anthoptilidae
			Scleractinia	Fungiidae

Kingdom	Phylum	Class	Order	Family
			Scleractinia	Rhizangiidae
		Hydrozoa	Anthoathecata	Asyncorinidae
			Anthoathecata	Bougainvilliidae
			Anthoathecata	Cladonematidae
			Anthoathecata	Clavidae
			Anthoathecata	Corymorphidae
			Anthoathecata	Eudendriidae
			Anthoathecata	Oceaniidae
			Anthoathecata	Pandeidae
			Anthoathecata	Pennariidae
			Anthoathecata	Proboscidactylidae
			Anthoathecata	Tubulariidae
			Leptothecata	Aglaopheniidae
			Leptothecata	Blackfordiidae
			Leptothecata	Campanulariidae
			Leptothecata	Malagazziidae
			Leptothecata	Melicertidae
			Leptothecata	Plumulariidae
			Leptothecata	Sertulariidae
			Leptothecata	Tiaropsidae
			Siphonophorae	
	Ctenophora	Tentaculata	Platyctenida	Coeloplanidae
	Echinodermata	Ophiuroidea		
	Mollusca	Bivalvia	Myoida	Hiatellidae
			Mytiloida	Mytilidae
			Ostreida	Ostreidae
			Pterioida	Isognomonidae
		Gastropoda		Limapontiidae
			Aplysiida	Aplysiidae
			Cephalaspidea	Cylichnidae
			Sorbeoconcha	Fasciolariidae
		Polyplacophora	Neoloricata	Acanthochitonidae
	Nematoda	Chromadorea	Chromadorida	Chromadoridae
	Nemertea	Enopla	Monostilifera	Amphiporidae
	Platyhelminthes	Turbellaria		Microstomidae
	Porifera	Calcarea	Clathrinida	Leucaltidae
			Leucosolenida	Grantiidae
			Leucosolenida	Leucosoleniidae
		Demospongiae	Axinellida	Heteroxyidae
			Axinellida	Raspailiidae
			Clionaida	Clionaidae

Kingdom	Phylum	Class	Order	Family
			Dendroceratida	Darwinellidae
			Dendroceratida	Dictyodendrillidae
			Dictyoceratida	Dysideidae
			Dictyoceratida	Thorectidae
			Merliida	Merliidae
			Poecilosclerida	Cladorhizidae
			Poecilosclerida	Guitarridae
			Poecilosclerida	Hymedesmiidae
			Poecilosclerida	Latrunculiidae
			Poecilosclerida	Microcionidae
			Poecilosclerida	Mycalidae
			Poecilosclerida	Myxillidae
			Poecilosclerida	Tedaniidae
			Polymastiida	Polymastiidae
			Suberitida	Halichondriidae
Chromista	Bacillariophyta	Coscinodiscophyceae	Thalassiosirales	Thalassiosiraceae
		Mediophyceae	Cymatosirales	Cymatosiraceae
	Bigyra	Labyrinthulomycetes	Thraustochytriida	Thraustochytriaceae
	Cercozoa	Imbricatea	Thaumatomonadida	Thaumatomastigidae
		Sarcomonadea	Cercomonadida	Cercomonadidae
		Thecofilosea		
	Ciliophora	Oligotrichea	Choreotrichida	Strobilidiidae
			Oligotrichida	Strombidiidae
		Spirotrichea		
	Haptophyta	Haptophyceae	Prymnesiales	
	Myzozoa	Dinophyceae	Gymnodiniales	Gymnodiniaceae
			Gymnodiniales	Kareniaceae
			Gymnodiniales	Warnowiaceae
			Peridiniales	Glenodiniaceae
			Peridiniales	Heterocapsaceae
			Peridiniales	Thoracosphaeraceae
			Prorocentrales	Prorocentraceae
			Suessiales	Suessiaceae
			Suessiales	Symbiodiniaceae
			Syndiniales	Amoebophryaceae
	Ochrophyta	Chrysophyceae		
			Ochromonadales	Paraphysomonadaceae
		Pelagophyceae	Sarcinochrysidales	Sarcinochrysidaceae
		Phaeophyceae		Phaeostrophionaceae
			Asterocladales	Asterocladaceae
			Dictyotales	Dictyotaceae

Kingdom	Phylum	Class	Order	Family
			Ectocarpales	Acrotrichaceae
			Ectocarpales	Chordariaceae
			Ectocarpales	Ectocarpaceae
			Ectocarpales	Ishigeaceae
			Fucales	Sargassaceae
			Laminariales	Laminariaceae
			Sphacelariales	Lithodermataceae
	Oomycetes	Peronosporea	Pythiales	Pythiaceae
Fungi	Ascomycota	Dothideomycetes	Pleosporales	
		Saccharomycetes	Saccharomycetales	Debaryomycetaceae
	Basidiomycota	Agaricomycetes	Polyporales	Coriolaceae
		Malasseziomycetes	Malasseziales	Malasseziaceae
		Tremellomycetes	Filobasidiales	Filobasidiaceae
	Chytridiomycota	Chytridiomycetes	Chytridiales	
Plantae	Chlorophyta	Chlorophyceae	Phaeophilales	Phaeophilaceae
		Mamiellophyceae	Mamiellales	Pycnococcaceae
		Prasinophyceae	Pyramimonadales	Pyramimonadaceae
		Trebouxiophyceae	Chlorellales	
		Ulvophyceae	Cladophorales	Cladophoraceae
			Ulvales	Monostromataceae
			Ulvales	Ulvaceae
			Ulvales	Ulvellaceae
	Rhodophyta	Bangiophyceae	Bangiales	Bangiaceae
		Compsopogonophyceae	Compsopogonales	
			Erythropeltidales	Erythrotrichiaceae
		Stylonematophyceae	Stylonematales	Stylonemataceae

WAPET PAINT AND PROTECTIVE COATING:

FIXED OFFSHORE STRUCTURES

AND

PRODUCTION FACILITIES.

Rev	Date	Description	Prepared By	Checked By	Approved By
2	20 July 96	Major Revision. (Supersedes WGS02.02-1)	s. 47F(1)		
1	1 Mar 93	Appendix II revision.			
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WEST AUSTRALIAN PETROLEUM PTY LIMITED	Document No.	Rev
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1.0 SCOPE

This general specification covers the minimum requirements for surface preparation, coating materials, application methods, and inspection for paint and protective coatings on offshore structures and production facilities. Any exceptions to the requirements of this specification shall be submitted in writing for approval by the Company.

Coatings for offshore pipelines are covered under a separate specification C1000-SL-0653 (formerly WGS20.03-1).

2.0 GOVERNING DOCUMENTS

The Contractor shall perform the work in accordance with the most recent issue of the applicable regulations, standards and codes issued by the following associations and approval bodies:

Standards Australia (SA)

AS 1627.0	Method selection guide for preparation & pre-treatment of steel surfaces.
AS 1627.1	Cleaning using liquid solvents and alkaline solutions.
AS 1627.2	Power tool cleaning.
AS 1627.4	Abrasive blast cleaning.
AS 1627.7	Hand tool cleaning of metal surfaces.
AS 1627.9	Pictorial surface preparation standards for painting steel surfaces.
AS 1650	Hot-dipped galvanised coatings on ferrous articles
AS CK13	Preparation of Metal Surfaces for Electroplating
AS 1790	Electroplated Coatings Cadmium on Iron or Steel
AS 1791	Chromate Conversion Coatings - Zinc & Cadmium
AS 1897	Electroplated Coatings on Threaded Components
AS 2105	Inorganic zinc silicate paint.

AS 2331	Methods for test for metallic & related coatings 1.3 Magnet Method, 1.4 Qualitative Adhesion Tests.
AS 2364	Paint for steel structure - high-build epoxy (two-pack).
AS 2602	Paint for steel structure - full gloss aliphatic polyurethane (two-pack).
AS 2700	Colour standards for general purposes.
AS 2855	Paints and related materials - Micaeous iron oxide pigment.
AS 3894.1	Site testing of protective coatings Method 1: Non-conductive coatings Continuity testing - high voltage ('brush') method.
AS 3894.3	Site testing of protective coatings Method 3: Determination of dry film thickness.
AS 3894.4	Site testing of protective coatings Method 4: Assessment of degree of cure.
AS 3894.10	Site testing of protective coatings inspection report - Daily.
AS 3894.11	Site testing of protective coatings equipment report.
AS 3894.12	Site testing of protective coatings inspection report - Coating.

ASTM

ASTM B602	Attribute Sampling of Electrodeposited Metallic Coatings & Related Finishes

Steel Structures Painting Council (SSPC)

Steel Structures Painting Manual, Volumes 1 and 2.

Australian Government

WorkSafe Western Australia,
Occupational Safety and Health Act.

State Of Western Australia - Petroleum Act 1967,
Schedule Of Onshore Petroleum Exploration And Production Requirements - 1991.

State Of Western Australia - Petroleum (Submerged Lands) Act - 1992,
Petroleum (Submerged Lands) Regulations - 1990.

3.0 TECHNICAL PROVISIONS

3.1 Service Conditions

Paint and protective coatings are materials applied to items to protect the surfaces from deterioration caused by the marine atmosphere during storage, shipment, and other causes. Paint may also be applied to surfaces for colour coordination and for coding various area designations and items.

3.2 Performance

Items that have had paint and protective coatings applied may be installed either outdoors in an unprotected area on an offshore platform or indoors. The paint and protective coatings shall be suitable for the environmental conditions specified for such installations in the project specification for the item being painted and coated.

3.3 Items To Be Painted and/or Coated

Items to be painted and/or coated include all new equipment, machinery, vessels, tankage, structural steel, metal buildings, platform jackets, platforms, and all other appurtenances except as noted below.

The following surfaces and items shall not be painted or coated.

- Surfaces, equipment, and appurtenances located below a point 3 metres lower than the Lowest Astronomical Tide (LAT) except for areas which are to be anti-fouled or where cathodic protection will not be effective or the submerged risers within the sub-structure.
- Non-metallic surfaces
- Corrosion resistance surface such as stainless steel (unless specifically noted)
- Weatherproofing on insulation (unless specifically noted)
- Machined surfaces
- Rubber hoses, belts, flexible braided connectors, nameplates, stainless steel tubing and fittings, gauges, valve stems, and motor shafts
- Galvanised surfaces (unless specifically noted)

Surfaces to be insulated shall be prepared in accordance with this specifications and shall receive only the specified primer coat approved by the Company.

3.4 Coating Materials

Coating and other consumable materials shall be new. Materials shall be supplied unopened in the coating manufacturer's containers. The unopened containers shall be clearly identified. Labels and tags shall be intact and no coating shall be used after the manufacturer's recommended shelf life has expired.

Mixing of different coating materials is not permitted whether or not from the same coating manufacturer.

Materials shall not be left in a spray pot longer than the coating manufacturer recommends. If this limit is reached, the pot shall be emptied and cleaned, the materials destroyed, and new material mixed.

The products of only a single coating manufacturer shall be used for each complete coating system discussed in this specification. The use of different coating manufacturer's products for successive coats on a single surface, or piece of equipment, is not permitted.

Thinning of coating materials is not allowed except when specifically called for in the coating manufacturer's recommendations. The procedure and limits for thinning shall be in accordance with the coating manufacturer's recommendations.

Successive coats shall be of a different colour or tint to provide a contrast so that incomplete coverage can be detected.

Unless otherwise specified, the Contractor shall comply with the finish coat colour schedule in Appendix I. Only the Company preferred coating brands in Appendix II shall be used, unless modified by the project specifications.

3.5 Application Conditions

Coatings shall be applied under the environmental conditions established by the coating manufacturer.

No coating shall be applied:

1. on damp or wet surfaces,
2. when the relative humidity is above 85%,
3. when the surface temperature is less than 3°C above the dew point,
4. when the wind speed exceeds 25 km/hr,

5. when ambient or surface temperatures are below 10°C or,

6. when substrate temperature exceeds 50°C.

Outdoor surface preparation and coating shall be conducted during daylight hours. Indoor painting is allowed 24 hours a day in a well lit building if the above environmental conditions are met inside the building at all times during preparation, painting, and curing.

The Contractor is fully responsible for obtaining and complying with the equipment manufacturer's recommendations for any particular coating or system.

3.6 Environmental Health and Safety Requirements

The Contractor's work procedures, material handling, and waste disposal methods shall include all precautions to prevent release of pollutants to the surrounding environment.

The contractor shall determine what safety precautions need to be taken for the coating systems being used and shall advise the Company and apply these to all the Contractor's personnel. The Contractor is responsible for ensuring that all other personnel on site are fully aware of and comply with any safety precautions that need to be observed.

The Contractor shall comply with all Statutory regulations for the handling and application of the coating systems.

The Contractor shall obtain and have available for inspection Material Safety Data Sheets (MSDS) for all chemicals, solvents and paint materials used.

4.0 SURFACE PREPARATION AND COATING SYSTEMS

4.1 Surface Preparation

Prior to beginning surface preparation, all fabrication shall be completed including all hole drilling and cutting. In some cases however, preparation and priming of structural steel members and piping may be approved in writing by the Company prior to final assembly.

Re-finishing of previously coated materials shall be necessary only if the coating has been damaged. Prior to the application of any protective coating, all damage to previously applied coatings shall be repaired. Damaged and loosely adhering coating(s) shall be removed, the area cleaned, edges of coating breaks feathered, and designated coat(s) reapplied.

Immediately prior to any coating application, environmental conditions shall be checked to ensure the environmental conditions are within the limits established by the coating manufacturer and as stated in 3.5.

Surfaces that are not to be coated shall be properly protected from abrasive blasting and painting, preferably with cloth or cloth tape. Any paint deposited on the surfaces shall be removed carefully.

Cloth, cloth tape, paper secured by tape, and/or grease protection is preferred for masking. Masking tape or other paper type shall not be applied directly to the protected surface. Following coating application, all such protection shall be removed and the underlying surface restored to the original condition.

4.1.1 Preparation for Abrasive Blasting

Prior to abrasive blasting, all burrs, sharp edges, slivers, laminations, and other surface imperfections shall be made flush or smooth by mechanical means.

Openings in vessels, piping, and other appurtenances shall be properly protected against entry of abrasive material.

Before and after blasting, all welds shall be closely inspected for the presence of welding flux and spatter, slivers, inclusions, lamination, and underlying mill scale. Imperfections shall be mechanically removed and the immediate area re-blasted.

Prior to blasting, all oil, grease, mill varnish, soil, salt, and other contaminants shall be removed by solvent cleaning in accordance with AS 1627.1, Cleaning using liquid solvents and alkaline solutions.

4.1.2 Materials and Conditions for Abrasive Blasting

Abrasive material shall be hard, virgin garnet with less than a 10 percent breakdown rate, or other Company approved abrasives. Rounded river sand or beach sand is not acceptable. Garnet shall be used only once.

To achieve the required anchor profile, abrasive particle size shall follow the surface preparation commentary of the SSPC Manual as necessary to comply with SSPC-SP-5, Surface Preparation Specification - White Metal Blast Cleaning.

Abrasive material shall contain no impurities or contaminants and shall be in compliance with all applicable regulations including WorkSafe Western Australia.

Blasting is not permitted if the relative humidity is greater than 85 percent, or if the surface temperature is less than 3°C above the air dew point.

The compressed air supply for blasting shall be free of detrimental amounts of oil and water. Adequate separators and traps shall be provided and shall be frequently checked and emptied.

Blasting to white metal shall be allowed only during daylight hours and only on surfaces that will receive the first primer coat before sundown of the same day that the white metal blast is complete. Surfaces that remain uncoated overnight shall be re-blasted to white metal prior to applying the first primer coat.

4.1.3 Abrasive Blasting

Abrasive blasting shall be done in an area remote from coating operations and coated surfaces that are not yet dry.

No abrasive blasting shall be permitted in the vicinity of project-related machinery, equipment with moving parts, instruments, or control mechanism.

Only bone-dry abrasive blasting procedures shall be allowed.

Blast cleaning of carbon steel surface shall comply with AS 1627.4 and shall conform to the pictorial standards shown in AS 1627.9. Unless specified, except for stainless steel materials, all structures shall be prepared to AS 1627.4 Class 3, "White Metal" blast finish. Stainless steel shall be uniformly blasted to the required anchor pattern.

Blasted surfaces shall have anchor patterns in accordance with the coating manufacturer's recommendations.

Surfaces, except those on which a splash-zone coating system is to be applied, shall have anchor pattern between a minimum of 40 microns and a maximum of 60 microns. Surfaces that will be finished with a splash-zone coating system shall have an anchor pattern of between 75 and 125 microns.

Surfaces previously coated with a splash-zone system shall be sweep blasted or disc sanded to roughen the surfaces. Surfaces shall be thoroughly cleaned of dust and contamination before new coatings are applied.

Surface blasting to white metal shall extend a minimum of 150mm beyond the area to be coated during the same day. Surface blasting to white metal shall continue a minimum of 25mm into adjoining previously coated surfaces. The edges of the previous coating shall then be feathered.

No acid washes, cleaning solutions, solvents, or inhibited washes intended to prevent rusting shall be applied to surfaces after abrasive blasting and prior to the first primer coat application.

4.2 Coating

Coating shall be applied in accordance with the requirements established by this specification and the recommendations of the coating manufacturer. Any area not specifically covered shall be in accordance with the principles and guidelines set forth in the SSPC Manual.

No coating shall be applied to surfaces that have not been prepared in accordance with the requirements of this specification.
Prior to painting, surfaces blasted to white metal shall be dust free. The surfaces shall be dusted preferably by dry brushing or by vacuuming with an industrial vacuum cleaner. Pressure air blowing is permitted if suitable precautions are taken to ensure that the air is free of moisture, oil, and other contaminants.

Coatings shall not be applied within 150mm of unprepared surfaces or within 150mm of edges prepared for subsequent welding.

The initial primer coat shall be applied as soon as possible after surface preparation. In all cases the primer coat shall be applied during daylight hours on the same day the surface is prepared. Surfaces showing signs of flash rusting shall be completely re-blasted.

In general, intermediate and finish coatings shall be applied following final assemble of component parts. Surfaces shall be in the final configuration.

Any surfaces inaccessible for proper coating application and/or inspection, shall be coated prior to final assembly. Specifically, flange faces and bolt holes shall be coated prior to final installation. The Company will designate inaccessible areas.

Prior to applying a succeeding coat, all coatings shall be allowed to dry at site ambient conditions for at least minimum time specified by the coating manufacturer and not longer than the maximum time for site ambient conditions.

No coating shall be applied over a previous coating that is not thoroughly dry.

Coatings shall be applied by brush in accordance to 4.5.2 to all crevices, corners, edges, and other hard-to-spray areas.

The coating film thickness referred to in this specification shall be the dry film thickness (DFT) measured by a properly calibrated film thickness gauge and are minimum values.

The Coating System Numbers used in the following sections 4.2.1 to 4.2.10, are not intended to be in a continuous numerical order, and they refer to the same Coating System Numbers used in WAPET Specification C1000-PL-0300, "WAPET Standard Coating And Protective Coating Guide: Systems And Selections".

Company preferred materials for each Coating System are listed in Appendix II of this document.

4.2.1 Coating System No. 1 - Structural steel & carbon steel surface operating up to 55°C

Coating System No. 1 shall be applied to all structural steel, drilling conductors, pipeline risers and other appurtenances from above the splash zone up to and including the underside of the lower deck.

- Primer coat: 75-100 microns DFT of water based alkali zinc silicate (AS 2105, Type 3)
- 1st intermediate coat: * 200 microns DFT of high build high solid epoxy, with micaceous iron oxide (MIO) or glass flake pigment
- Finish coat: ** 50-75 microns DFT of catalysed acrylic

* In severely aggressive and abrasive environment, an additional intermediate coat shall apply.

** For insulated surfaces, subject to Company approval, the finish coat may be omitted

4.2.2 Coating System No. 2 - Carbon steel surface operating up to 95°C

Coating System No. 2 shall be applied externally to carbon steel piping, vessels, and equipment with surface operating temperatures up to 95°C. The carbon steel may be on either the inside or outside of buildings.

- Primer coat: 75-100 microns DFT of water based alkali zinc silicate (AS 2105, Type 3)
- Intermediate coat: * 200 microns DFT of high build high solid epoxy, with micaceous iron oxide (MIO) or glass flake pigment
- Finish coat: ** 50-75 microns DFT of aliphatic polyurethane

* In severely aggressive and abrasive environment, an additional intermediate coat shall apply.

** For insulated surfaces, subject to Company approval, the finish coat may be omitted

4.2.3 Coating System No. 3 - Splash Zone

Coating System No. 3 is generally applied to all jacket legs, structural braces, drilling conductors, pipeline risers, disposal caissons and other members passing through the splash zone. The size and location of this zone and the coating systems required above, below and within the splash zone will be defined by the Company.

3a) Monel Sheathing

1.6mm (16 gauge or 0.062") ASTM B-127 Monel Sheathing shall be continuously welded to abrasive blasted steel. All joints shall be overlapped 100mm.

3b) Vulcanised Neoprene

12.7mm minimum, shop-applied Vulcanised Neoprene shall be factory applied over an AS 1627.4 Class 3, white blast surface preparation and a 75 to 100 microns anchor profile.

3c) Submerged and Splash Zone Epoxy Coating

2 x 1500 microns DFT minimum, epoxy coating shall be applied over an AS 1627.4 Class 3 surface finish with a 75 to 100 microns anchor pattern. The final coating profile shall be smooth and free of local hollows greater than 150 microns deep measured crest to hollow.

3d) Submerged and Splash Zone Glass Flake Polyester Coating

2 x 1500 microns DFT minimum, polyester coating shall be applied over an AS 1627.4 Class 3 surface finish with a 75 to 100 microns anchor pattern. The final coating profile shall be smooth and free of local hollows greater than 150 microns deep measured crest to hollow.

3e) Submerged and Splash Zone Antifoul Coating

On top of Coating System No. 3c or 3d, one of the two following options of antifoul shall be applied:

Option 1: "Tri-butyl-tin free" Antifoul Paint

- Tie Coat: 50-70 microns DFT of modified epoxy
- Antifoul Coat: 3 coats (150 microns DFT each) of TBT free. Total DFT shall be 375 microns minimum.

Option 2: Polymeric sheathing embedded with copper-Nickel Mesh.

3f) Coating Above Splash Zone

This section applies to section above LAT +4m.

Apply 1500 microns DFT minimum ultra high-build epoxy coating or polyester coating over an AS 1627.4 Class 3 surface finish with 75 to 100 microns anchor profile. The epoxy or polyester coating shall be 100% holiday tested in accordance with AS 3894.1. Defects shall be repaired as per 4.3.2 & re-tested. Apply finish coat of 50 microns DFT of aliphatic polyurethane.

4.2.4 Coating System No. 4 - Carbon steel surface operating from 100°C to 400°C

Coating System No. 4 shall be applied externally to carbon steel piping, vessels, and equipment with surface operating temperatures from 100°C to 400°C. The carbon steel may be either inside or outside of buildings.

- Primer coat: 75 microns DFT of water based alkali zinc silicate (AS 2105, Type 3)
- Finish coat: 2 x 25 microns DFT of modified silicone - ambient curing

4.2.5 Coating System No. 6 - Plates and non-skid surfaces

Coating System No. 6 shall be applied to the plate on decks, pancake sections, steps, ladder rungs and top plates on the helideck.

- Primer coat: 75-100 microns DFT of epoxy primer
- Intermediate coat: 200 microns DFT of high build high solid epoxy, with micaceous iron oxide (MIO) or glass flake pigment
- Non-skid coat: 200 microns DFT of high build high solid epoxy, with micaceous iron oxide (MIO) or glass flake pigment

  Non-skid aggregate broadcast into the wet epoxy film to result in an uniform spreading rate of 1.5 kg/m^2. Once dried, remove all loose aggregate before applying sealer.
- Sealer: 50-75 microns DFT of aliphatic polyurethane

4.2.6 Coating System No. 12 - Produced water/oil vessel interiors up to 80°C

Coating System No. 12 shall be applied to the interiors of vessels in high temperature/high pressure service and/or requiring resistance to carbon dioxide, produced water and most oil field chemicals. Maximum (wet service) temperature shall not exceed 80°C, otherwise refer to Coating System No. 13 below.

- First coat: 75 microns DFT of amine-adduct phenolic epoxy
- Second coat: 75 microns DFT of amine-adduct phenolic epoxy
- Third coat: 75-100 microns DFT of amine-adduct phenolic epoxy

The application of stripe coats in corners and on edges is preferred, but care has to be taken not to increase the total DFT by more than 100 microns.

4.2.7 Coating System No. 13 - Produced water/oil vessel interiors up to 105°C

Coating System No. 13 shall be applied to the interiors of vessels in high temperature/high pressure service and/or requiring resistance to hydrogen sulphide, carbon dioxide, produced water and most oil field chemicals. Maximum (wet service) temperature shall not exceed 105°C.

- First coat: 500 microns DFT unsaturated vinyl ester filled with flake glass
- Second coat: 500 microns DFT unsaturated vinyl ester filled with flake glass

Total DFT shall be 1000 microns minimum.

4.2.8 Coating System No. 32 - Exterior of stainless steel well heads & Christmas trees, and risers operating up to 95°C

Coating System No. 32 shall be applied to the exterior surfaces of stainless steel well heads & Christmas trees, and on sections of the stainless steel risers as directed.

The surface shall be roughened by abrasive blasting with dry, virgin garnet, relatively free from halides and other contaminants, to a finish with 20-30 microns anchor profile. The Company may request tests to be carried out to ensure that the treated surface is free from halides and soluble salts.

- First coat: 125-150 microns DFT high build epoxy with low halide pigments
- Second coat: 50-75 microns DFT aliphatic polyurethane

4.2.9 Coating System No. 33 - Hot dipped galvanised surfaces

Coating System No. 33 shall be applied to hot dipped galvanised surfaces requiring additional protection against the aggressive environment or colour coding. The surface shall be abrasive whip-blasted to a finish with 20-50 microns anchor profile. The abraded surface shall be coated immediately before any surface deterioration due to oxidation of zinc layer.

- First coat: 75 microns DFT zinc-rich epoxy primer
- Second coat: 200 microns DFT of high build high solid epoxy, with micaceous iron oxide (MIO) or glass flake pigment
- Finish coat: 50-75 microns DFT of catalysed acrylic

4.2.10 Coating System No. 41 - Equipment, machinery and repair/touch-up

Coating System No. 41 shall be applied to equipment and machinery as directed. Some of these items may or may not have a factory applied coating. Bare steel shall receive the full three coat treatment listed below. Undamaged factory coated item shall receive the Second and Third Coats.

- First Coat: 75 microns DFT of zinc-rich epoxy primer
- Second coat: 100-150 microns DFT of mastic-modified epoxy
- Third coat: 50 microns DFT aliphatic polyurethane

4.3 Special considerations

4.3.1 Equipment and Machinery

If surfaces on machinery and equipment cannot be abrasive blasted without damage or contamination of moving parts or other critical surfaces, the surface shall be solvent cleaned as specified in AS 1627.1, Cleaning using liquid solvents and alkaline solutions. After solvent cleaning, the surfaces shall be cleaned by power tool and/or hand as specified in AS 1627.2, Power tool cleaning and AS1627.7, Hand tool cleaning of metal surfaces. The surface shall have a rough whorled finish and be cleaned to AS 1627.9 Class St 3.

Surfaces that have already received an equipment manufacturer's coating system, which is approved in writing by the Company Project Manager, shall be solvent cleaned as specified by AS 1627.1. After cleaning, an appropriate tie coat (if needed) and the intermediate and top coat of System No. 41 shall be applied.

If the equipment manufacturer's coating system was not a Company preferred coating or brand, it shall either be removed to bare metal and re-coated in accordance with System No. 41, or with Company approval, it may be top coated. If top coated, the surface shall be solvent cleaned per AS 1627.1 and primed with a suitable universal primer.

The intermediate and finished coats from System No. 41 shall then be applied. The Contractor shall be fully responsible for compatibility between the equipment manufacturer's prime coat, the universal primer and the intermediate coat.

4.3.2 Coating Repair/Touch Up

The following touch up and repair philosophy shall only apply to the repair of coating damage following transportation to site, hook-up and commissioning. All repair in the fabrication yard shall be carried out by reinstating the specified coating system.

Repair and touch up shall be divided into two categories, major and minor. These two categories are defined below.

<u>Major Repair/Touch Up</u>

Major repair shall be defined as all repairs to Coating System Nos. 3a, 3b, 4, 12, 13 and 32 (regardless of the extent of the repair) plus either of the following repairs for Coating System Nos. 1, 2, 3c, 3d, 3e, 3f, 6 and 33 :-

- repair to damaged areas greater than 3000 square millimetres
- or a combination of smaller repair areas that would, in the judgement of the Company, justify the mobilisation of a dedicated painting crew.

Minor Repair/Touch Up

Minor repair shall be defined as all repairs not covered by the major repair above. Minor repairs shall only be permitted on Coating System Nos. 1, 2, 3c, 3d, 3e, 3f, 6 and 33.

4.3.2.1 Major Repair/Touch Up Procedure

All major repairs shall be carried out by reinstating the coating to comply with the original specification. The areas to be repaired shall be abrasive blast cleaned to remove all damaged and disbonded coating material. The edges of the blast area shall be feathered for a minimum of 25mm to provide a smooth transition from the new to the old coating. All specified requirements for the preparation, application, inspection and testing of the original coating system shall apply equally to the repair/touch up area.

4.3.2.2 Minor Repair/Touch Up Procedure

All minor repairs shall be carried out to comply with the following requirements.

Surface Preparation

Solvent clean in accordance with AS 1627.1 by swabbing the area using solvent.

Power tool clean (using impact tools, sanders, grinders and linishers) to comply with the requirements of AS 1627.2, with a surface finish to AS 1627.9 Grade St 3. Hand tool cleaning shall only be permitted in applications where power tool cleaning is impractical. The use of hand tool cleaning shall be subject to approval by the Company. Hand tool cleaning, if approved, shall be achieved by wire brushing followed by hand sanding and shall comply with the requirements of AS 1627.7 St 2.

Repair/Touch Up System

Damage to Coating System 3c, 3d, 3e, and 3f shall be repaired by trowel application of the original ultra high-build epoxy or polyester coating material to the cleaned and prepared area, followed by the antifoul or finish coat as appropriate.

Damage to Coating System Nos. 1, 2, 6, and 33 shall be repaired by the application of a Zinc-rich Epoxy Primer in System No. 41 followed by the recommended finish coat originally specified for the relevant coating system.

4.4 Metallic Coating

4.4.1 Galvanised Surfaces

Unless otherwise specified all gratings, ladders, cages, stairways, handrails, and miscellaneous hardware shall be hot-dip galvanised in accordance with AS 1650, Hot dipped galvanised coatings on ferrous articles. Silicon content of the steel to be galvanised shall not exceed 0.04%, unless the silicon percentage is 2½ times the phosphorus percentage then the silicon shall not exceed 0.09%. Where the design life of the structure is in excess of 5 years, galvanised areas shall then be preheated, alkaline degreased, zinc phosphate/chromate converted, dried and then powder coated. Alternatively, System No. 33 shall be used. Grating panels which can be removed and replaced without cutting may be left as galvanised only.

Fabrication shall be completed (including all cutting, shipping, welding and clean-up) prior to beginning solvent cleaning and acid treatment of surfaces to be galvanised.
The weight of zinc coating shall conform to the requirements of AS 1650.

Preferably, all surfaces to be galvanised shall be coated in a single hot dip. If the size or configuration of the item does not permit a single dip, additional dipping may be performed as long as the final galvanised surface is free of overlaps, spikes, teardrops, cracks, or flakes.

The Contractor shall notify the Company immediately of any damaged galvanised surfaces. With Company approval, the Contractor shall repair the damaged surfaces by:

1. abrasive blast the affected area to AS 1627.4, Class 2½ bare steel
2. apply two coats of zinc-rich epoxy primer from Coating System No. 33 to a minimum 150 microns total DFT.

If a hot dipped galvanised item is to be coated, for colour coding or for extra protection against the aggressive environment, the whole surface is to be whip-blasted to a surface finish with 20-50 microns profile before applying Coating System No. 33.

4.4.2 Cadmium Plating

The used of Cadmium Plating shall be limited to smaller items such as bolting components. For offshore use, all cadmium plated bolts which will not normally be undone after tightening, shall be painted after final tightening. The paint system shall comprise an epoxy intermediate coated followed by a finish coat using materials specified under System 41.

Threaded Components: AS 1897 Service Condition 2 (moderate).

Non Threaded Components: AS 1790 Service Condition 2.

All threaded components shall be able to hand threaded over the full length of the thread without damage to coating.

All plated components shall be subsequently chromate treated in accordance with AS 1791 Type C (yellow iridescent).

The plating shall contain not less than 98.5% cadmium and shall be free of mercury. Total impurity, excluding zinc and nickel, shall not exceed 0.5%.

Handling of the passivated cadmium plated components shall be minimal for 24 hours after passivation to allow the conversion coating to fully harden.

Inspection shall comprise the following tests as a minimum. These tests shall be carried out on a batch by batch basis with a batch being either all components prepared and costed as a continuous production run or a single order, whichever is smaller.

Visual Inspection
All components shall be thoroughly inspected to ensure they are free from misses, high spots or other obvious defects likely to compromise plating performance.

Plating Thickness
Plating thickness testing shall comply with AS 2331.1.3 with the minimum thicknesses as noted above.

Adhesion Testing
Adhesion testing shall comply with AS 2331.4.1 section 2.1 "Burnishing Test". The Cadmium plating shall remain adherent to the substrate.

Sampling for plating thicknesses and adhesion testing shall comply with the Table below, extracted from ASTM B602 "Attribute Sampling of Electrodeposited Metallic Coatings and Related Finishes"

Batch Size	Sample Size	Acceptance Number †
1 to 20	all	0
20 to 280	20	0
281 to 1200	80	1
1201 to 3200	125	2
3201 to 10000	200	3
10001 to 35000	315	5
over 35000	500	7

† Acceptance Number is the maximum number of defective product items for the batch to be acceptable.

4.5 PTFE Coating

This system is suitable for application over components which have been cadmium plated in accordance with Clause 4.4.2.

The PTFE coating shall be Xylan Series 1070 (Blue) manufactured by Whitford Corporation or other Company approved equivalent.

Dry film thickness shall be not less than 25 microns and shall be not greater than 40 microns.

Sampling for visual inspection and coating thickness tests shall be carried out in accordance with the same requirements as detailed in Clause 4.4.2.

For visual inspection, the samples must be free of runs, sags, misses or other discernible defects likely to compromise coating performance or thread fit.

Coating thickness tests shall be carried out in accordance with AS 1580 Method 108.1 and shall be taken on both ends and nut faces of sample of the coated components.

Adhesion tests shall be carried out if requested. Tests shall be in accordance with AS 1580 Method 408.2 Intersecting Cut Method and shall be carried out on both ends and nut faces. Coating adhesion shall have a rating of 4 or better.

The sampling frequency shall be as follows:

Batch Size	Sample Size	Acceptance Number †
2 to 10	1	0
11 to 25	2	0
26 to 100	5	0
101 to 1200	13	1
1201 to 35000	32	2
over 35000	55	3

† Acceptance Number is the maximum number of defective product items for the batch to be acceptable.

Test certificates shall be supplied with each batch or order of components. The supplier shall retain the originals for 2 years from the date of purchase of the components.

4.6 Paint Application

4.6.1 Spray application

Spray coating shall comply with the following:

- Coating manufacturer's recommendations
- Spray equipment manufacturer's recommendations for the coating material
- This specification

4.6.1.1 Spray equipment

Conventional air spray equipment shall be suitable for the intended purposes. The type of gun, air caps, nozzles, and needles shall comply with the coating manufacturer's application instructions and data sheets.

Suitable traps and separators shall be installed to remove water, oil and other contaminants from the air supply. Traps and separators shall be of the continuous-bleed type and shall be checked frequently to prevent carryover.

Suitable regulators and gauges shall be installed in the air supply to the pressure pot and the gun.

Airless spray or air assisted airless spray equipment is acceptable if the minimum requirements established in this specification are met, if airless spray application is recommended by the coating manufacturer, and if specific equipment is approved by the Company.

4.6.1.2 Application

Prior to application, all coating materials shall be vigorously stirred and/or agitated in spray pots until pigments, vehicles, and catalysts and thoroughly mixed. During application, coatings shall be continuously stirred by mechanical spray pot agitators or other approved means.

Prior to adding new material, lines, pots, and guns shall be thoroughly cleaned following each application. Solvents left in the equipment shall be completely removed before coating the prepared surfaces.

For optimum spraying effectiveness, the pressure on the material in the pot and of the air at the gun shall be adjusted and maintained to deliver the material at the rate specified by the coating manufacturer. Air pressure and volume shall be the minimum required to properly atomise the coating material.

The spray pattern shall be adjusted so that the coating is deposited in uniform layers with the correct wet film thickness.

The spray gun shall be held perpendicular to the surface at all times and at a distance that will ensure depositing a fully wet layer of material on the surface. Arching of the spray gun is not permitted.

Parallel, even passes shall be made that overlap the previous spray coating by 50 percent. Large continuous surfaces shall be coated by two passes made at right angles to each other.

All runs, air bubbles, sags, and other imperfections shall be brushed out immediately or the coating shall be removed and the surface re-sprayed.

4.6.2 Brush application

Coatings shall be applied with a brush in all areas that cannot be spray coated properly. Brushes shall be of a style, quality, and composition (pure bristle or nylon bristle) that enable proper coating application.

Round or oval brushes are the most suitable for rivets, bolts, irregular surfaces, and rough or pitted steel. Wide flat brushes are suitable for large flat surfaces. A brush width greater than 125mm is not acceptable.

Successive coats shall be applied by crosshatching the previous coat.

Runs, air bubbles, and sags shall be brushed out immediately.

Coating shall be worked into all crevices and corners. Surfaces not accessible to brushes shall be coated with daubers.

4.7 Examination and Testing

4.7.1 General

Materials, equipment, procedures, and work shall be subject to inspection at any time by the Company. The contractor shall provide the Company representative with ready access to all work areas, materials, equipment, and surfaces.

The Company shall have the right to reject any and all equipment, material, or work that is not in compliance with the minimum requirements established in this specification. Any defective materials, equipment, or work shall be replaced, repaired, or redone entirely as necessary to meet the minimum requirements established by this specification. All such corrective actions shall be at the contractor's expense without additional charges to Company.

The Contractor shall give the Company representative at least 2 days notice prior to starting any work covered by this specification.

Work shall not proceed beyond the inspection points defined in 4.7.3 in the absence of the Company representative without the representative's prior knowledge and written consent and without approval by the Company.

The Company may elect, at Contractor's expense, to have representatives of the coating manufacturer present on the job site with the Company representative.

4.7.2 Responsibility

At all times, the Contractor shall furnish and maintain on the job site in proper working condition the following inspection and test equipment:

- Surface magnifier
- Humidity and ambient temperature gauges
- Surface profile indicator (Testex Inc. Pres-O-Film tape or Company approved equivalent)

- Dry film thickness gauge (Mikrotest or Company approved equivalent)
- Dry film thickness gauge calibration standards
- Wet film thickness gauge (post type)

The Company representative(s) shall be allowed to witness all inspections and testing by the Contractor and/or conduct independent inspections and testing to verify completeness and accuracy of results.

4.7.3 Inspection and Test Requirements

Corrective actions considered necessary to comply with the minimum requirements established by this specification shall be completed and the material, equipment, or work re-inspected, before allowing work to proceed. The Contractor shall furnish an experienced, qualified, and capable coating inspector to conduct all inspections and testing.

4.7.3.1 Start-up procedures

Prior to starting any work covered by this specification, the following inspections shall be performed.

- Available equipment and materials shall be visually inspected for compliance with the minimum requirements established by this specification.
- Additional equipment and materials furnished by the Contractor during the course of work performance shall be inspected prior to use.

4.7.3.2 Preparation for first coating application

Upon completion of initial surface preparations as required in 4.1 and prior to the first application of coating material, the following inspections shall be performed.

- Surfaces shall be visually inspected to ensure that the entire area to be coated is properly prepared, clean, dry, and free of contamination in accordance with the AS 1627.9 and the minimum requirements established in 4.1 of this specification.
- The anchor pattern of all surfaces that have been abrasive blasted to white metal shall be inspected to ensure compliance with the coating manufacturer's recommendations and the requirements established in 4.1.3. Inspection of the anchor pattern shall include checks made with Pres-O-Film tape.

4.7.3.3 Preparation for succeeding coats

Prior to application of the succeeding coat, the following inspections shall be performed to the previously coated surfaces.

- Surfaces shall be visually inspected to ensure the absence of skips, sags, drips, holidays, air pockets, foreign particle contamination, and any other defects.
- Wet film thickness of the coating shall be measured to ensure that the coating will have the proper film thickness when dry.
- Surfaces shall be inspected to ensure that all coating material is thoroughly dry.
- Coating dry film thickness (DFT) shall be checked using a Mikrotest or equivalent DFT gauge to ensure compliance with the applicable requirements given in 4.2. Immediately prior to making checks with the DFT gauge, the instrument shall be accurately calibrated in accordance with the gauge manufacturer's instructions.

4.7.4 Completion

Upon completion of all work covered by this specification the following inspections shall be performed.

- Surfaces and equipment shall be inspected in accordance with 4.7.3.3 to verify compliance with the finish coat colour schedule provided in Appendix I unless modified by the project specifications.
- Surfaces and equipment shall be visually inspected for coating damage prior to full acceptance at the location (or time) when the Contractor's responsibility for the item or equipment terminates.

4.7.5 Special inspection requirements for ultra High-Build Epoxy Coatings

Surface preparation shall be observed for cleaning and profile.

Wet coating thickness shall be measured with a depth gauge.

The area covered and the amount of material applied shall be recorded to confirm that the coverage is in accordance with the manufacturer's recommendations.

The dry coating thickness shall be measured with Mikrotest Model No. SI-10 or Company approved equivalent.

The coated surface shall be smooth and free of local hollows greater than 150 microns deep measured crest to hollow.

4.7.6 Special inspection requirement for splash zone and vessel interiors

The internal surfaces to be coated for chemical immersion services require thorough attention to the following (but not limited to) details:

- Surface preparation shall be observed for cleaning and profile.
- Paint materials are not to be thinned down with thinners.
- Adequate ventilation shall be provided inside the tank with blowers capable of a minimum of 12 air changes per hour during application and curing/drying of each coat of paint.
- Wet coating thickness shall be measured during application of each individual coat to ensure strict compliance with the paint manufacturer's recommended dry film thickness.
- Excess paint thickness (greater than 20% of the maximum thickness recommended by the paint manufacturer) in 90° bends and corners shall be rejected.
- The area covered and the amount of material applied shall be recorded to confirm that the coverage is in accordance with the manufacturer's recommendations.
- The dry coating thickness shall be measured with Mikrotest Model No. SI-10 or Company approved equivalent.
- The coated surfaces shall be 100% holiday tested in accordance with AS 3894.1, Method 1: Non-conductive coatings - Continuity testing - high voltage ('brush') method. This test is to be conducted after application of the final coat and within the time interval recommended by the coating manufacturer for over-coating repair. Defects shall be abrasive blast-cleaned back to bare metal for coating repair. Repair method shall be submitted to the Company for approval in writing. Repairs shall be re-tested.

4.7.7 Documentation Requirements

Documentation requirements shall be in accordance with project specifications, with the additional requirements that the Contractor shall obtain and keep readily available at all times at the job site the following reference materials and information:

- This complete specification and all other project-related transmittals (for example, written approvals and waivers).
- Copies of the coating manufacturer's product data and safety data sheets, application instructions, and recommended practices for each coating material.

Clean copies of the above shall be transmitted to the Company representative upon completion of the work.

- Copies of the latest edition of the Australian Standards and the Steel Structures Painting Council Specifications referred to in this specification.
- A current painting schedule detailing the coating system and each coating material to be applied to each surface and equipment item.
- The results of all inspection and testing. All the information shall be presented to facilitate easy identification and cross referencing between results and finished components.
- Data recorded on reports sheets in accordance with:
  AS 3894.10 Inspection report - Daily,
  AS 3894.11 Equipment report, and
  AS 3894.12 Inspection report - Coating.

4.8 Workmanship

The Contractor shall comply with the minimum requirements established by this specification, but has exclusive control over the detailed manner for performing the required work. The Contractor shall work in a careful, diligent, and prudent manner and shall achieve results that exhibit high quality craftsmanship.

Prior to beginning work, all Contractor personnel shall be thoroughly familiar with the material, equipment, this specification, and all applicable standards and codes.

Care shall be exercised at all times to prevent splashing, dropping, spillage, and over-spray of coating and abrasive materials.

The Contractor shall protect all equipment, walls, floors, ceilings, and other surfaces from damage by coating materials and other contaminants.

The Contractor shall clean any accidentally applied material from all surfaces. No permanent colour or stain shall remain from accidentally applied materials.
Good housekeeping procedures shall be established and followed at all times. When work is completed, the Contractor shall leave all work areas in a condition equal to that when work began.

4.9 Safety

4.9.1 General

A safe area shall be established and clearly identified for handling and storage of all flammable materials and for waste disposal. No source of ignition shall be permitted within the safe area at any time.

The Contractor shall take proper precautions before and during work in confined areas and/or in areas with the potential for fire or explosion.

All electrical equipment intended for such areas shall be of an approved type in accordance with the requirements and area classification established by NFPA 70, National Electrical Code (NEC).

If possible, all electrical equipment shall be located remote from the hazardous work area in a well-ventilated, non-hazardous space.

The Contractor shall provide and maintain fire extinguishers approved for the expected fire hazard near or in all work areas.

The Contractor shall provide and install sufficient scaffolding and staging for easy access during surface preparation, coating application, and inspection of all surfaces.

The supporting structure and the surface or item being worked on shall be constructed so that the workers will have free use of body and arms.

The structures shall be proved with safety features that will help prevent accidents.

The structures shall comply with all applicable WorkSafe Western Australia requirements.

The Contractor shall exercise extreme care and caution when working in the vicinity of in-service facilities. All valves, switches, and controls shall remain unmoved and undisturbed.

4.9.2 Spray and blasting operations

Abrasive blasting and spray coating shall be performed with approved equipment by experienced operators.

The Contractor shall provide all operators with hoods for protection against abrasives and with paint masks that are WorkSafe Western Australia approved for extended service. The hoods and masks shall be worn at all times when work is being done.

Pressure vessels, such as sand hoppers and compressed-air volume tanks, shall be protected from over-pressurisation with automatic pressure relieving devices.

Pressure nozzle controls shall be of the fail-safe, dead-man type.

Pressure hose connections shall incorporate a positive locking mechanism to prevent accidental disconnection. (for example, quick-connect connections shall have safety wire in place).

Adequate ventilation shall be provided in confined areas with blowers capable of a minimum of 12 air changes per hour.

Spray and blasting equipment in confined areas shall be securely grounded to dissipate static electricity.

Hand tools shall be made of spark-proof materials.

5.0 QUALITY ASSURANCE

The Contractor shall maintain effective quality control or the quality of supplies and/or services (including sub-contracts), provide test facilities and perform all examinations and tests stated in the contract to demonstrate conformance of supplies and/or services to the technical requirements of the Contract and shall offer for acceptance only supplies and/or services that conform to these requirements.

5.1 Quality Control Plan

The Contractor shall, within fourteen(14) days of the effective date, provide a Quality Control Plan (QCP) to the Company. The plan shall include details, commensurate with the complexity of the supplies and the requirements of the contract, of the Contractor's proposals for management and control of quality for the Contract. Where any element of the QCP is found to be ineffective it shall be amended to conform with the Company requirements. The Company may additionally designate inspection or test stages to be performed by or on behalf of the Company. All such amendments and additional inspections or test shall be introduced within seven(7) days of the Company notifying same to the Contractor, unless otherwise agreed between the Contractor and the Company.

The QCP shall address any specific quality requirements, tests or procedures and shall also provide for, but not be limited to, details of the proposed system for controlling as applicable, design, development, software, firmware, non-conforming supplies, sub-

contract, proving, documentation, records, technical data, handling, storage, inspection equipment and its calibration, special processes, manufacture, assembly, complete item or sub-assembly inspection and testing, reliability analysis, delivery, installation, commissioning and acceptance testing.

5.2 Inspection/Surveillance

The Company reserves the right to perform any examinations or tests to ensure that supplies and/or services conform to the technical requirements of the Contract.

5.3 Quality Records

The Contractor shall be responsible for the provision of objective evidence demonstrating that the controls applied and instructions carried out are effective.

6.0 ACCEPTANCE

Acceptance of all supplies and services shall be subject to the Company's agreement that the quality requirements have been fulfilled. The Company reserves the right to reject any supplies which fail to meet the technical requirements of the Contract.

7.0 HANDLING, DISPATCH AND STORAGE

Care should be taken to avoid damage to coating systems during loading, transport, unloading, storage and erection. All slings, rope and chain shall be rubber sheathed or otherwise suitably protected. Belt slings are preferred. Adequate timber blocking shall be provided when stacking coated members, and no members shall be stacked directly on the ground or on other steelwork.

Handling and stacking of coated items after completion of coating application shall not be permitted until the applied coating system has sufficiently cured.

8.0 INFORMATION REQUIRED WITH TENDER

Coating materials furnished by the Contractor shall meet the minimum requirements specified in 4.2 and be of the brands specified in Appendix II or Company preferred equivalents.

The Contractor shall include a complete and detailed description of the intended coating material for each protective coating system. The description shall be for the Company's review and approval.

As a minimum, the following descriptive information shall be included in the proposal for each coating material.

- Coating manufacturer's name and address
- Trade name and ordering number
- Complete generic description
- Percent zinc content by weight for primer coats and percent non-volatile solids content by volume for intermediate and finish coats
- Colour cards for all finish coats as specified in Appendix I, unless modified by the project specifications
- The proposal shall include the coating manufacturer's standard product data and safety data sheets for each coating material.

APPENDIX I: FINISH COAT COLOUR SCHEDULE

Finish colours shall be as follows:

Jacket, deck and structural steel	silver grey N24
Vessels, tanks and heat exchangers (external)	serpentine green G22
Stack	silver grey N24
Pumps, compressors, mixers and drivers	serpentine green G22
Piping (external)	
- General	serpentine green G22
- Control valves	serpentine green G22
- Fuel gas	serpentine green G22
- Nitrogen piping at utility stations (for 760mm above valve)	serpentine green G22
Un-insulated valves, flanges and other items in insulated piping systems	serpentine green G22
Fire equipment	signal red R13
Safety barriers	vivid yellow Y13
Miscellaneous un-galvanised structural steel	silver grey N24
Electrical panels, equipment, housing and other items	silver grey N24
Handrails and ladders	vivid yellow Y13
Helidecks	
- Letter "H"	white
- Safety net, aiming edges and lettering	vivid yellow Y13
- Background	Signal red R13

Colour cards shall be submitted for the Company's approval prior to commencement of painting. All colours refer to AS 2700 "Colour Standards for General Purposes".

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 1

Supplier	Primer Coat	First Intermediate Coat	Second Intermediate Coat (This additional coat is required for aggressive environment.)	Finish Coat
Courtaulds	Interzinc 225	Intergard 475 HSE	Intergard 475 HSE	Interfine 629
Dulux	Zincanode 215	Ferrodor EPX	Ferrodor EPX	Acrathane IF
Jotun	Jotaprime 5	Penguard Stayer	Penguard Stayer	Jotacote 372

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 2

Supplier	Primer Coat	First Intermediate Coat	Second Intermediate Coat (This additional coat is required for aggressive environment.)	Finish Coat
Courtaulds	Interzinc 225	Intergard 475 HSE	Intergard 475 HSE	Interthane 800
Dulux	Zincanode 215	Ferrodor EPX	Ferrodor EPX	Luxathane
Jotun	Jotaprime 5	Penguard Stayer	Penguard Stayer	Imperite 300

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 3

SYSTEM No. 3a: MONEL SHEATHING

Supplier	Product Name
To be nominated	To be nominated

SYSTEM No. 3b: VULCANISED NEOPRENE

Supplier	Product Name
To be nominated	To be nominated

SYSTEM No. 3c: EPOXY COATING

Supplier	Product Name
Courtaulds	Intertuf 485 UHB
Dulux	Luxepoxy UHB
Jotun	Jotacote UHB

SYSTEM No. 3d: POLYESTER COATING

Supplier	Product Name
Jotun	Boltoflake

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 3

SYSTEM No. 3e: SUBMERGED AND SPLASH ZONE ANTIFOULING
COATING AS PER SYSTEM No. 3c or 3d above followed by one of the two following antifoul options.

Option 1: Conventional "TBT free" antifoul paint with 3-5 years max. life span.

Supplier	Tie coat	Antifoul coat(s)
Courtaulds	50 - 75 Intertuf JXA 464/465 modified Epoxy	3 coats x 150 microns DFT Intersmooth Hisol BGA 560 Series
Jotun	50 -75 microns DFT Vinyguard Silvergrey 88	3 coats x 150 microns DFT Seamate 99

Option 2: Polymeric sheathing embedded with Copper-nickel antifoul mesh. Anticipated design life in excess of 10 years.

Supplier	Product Name
SeaMark Systems Approved applicator in WA: Vulcan Engineering, Henderson 6166., Western Australia	SeaMark Cladding with 0.375 mm mesh size for 15 years max life span or SeaMark Cladding with 0.600 mm mesh size for 30 years max life span

SYSTEM No. 3f: COATING ABOVE SPLASH ZONE

Supplier	Tie coat (Epoxy)	Antifoul coat(s)
Courtaulds	Intertuf 485 UHB	Interthane 800
Dulux	Luxepoxy UHB	Luxathane
Jotun	Jotacote UHB	Imperite 300

Supplier	Tie coat (Polyester)	Antifoul coat(s)
Jotun	Boltoflake	Imperite 300

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 4

Supplier	Primer Coat	Finish Coat (2 x 25 microns DFT)
Courtaulds	Interzinc 225	Intertherm 510
Dulux	Zincanode 215	Hi Temp 600 (with cure additive)
Jotun	Jotaprime 5	Solvalitt

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 6

Supplier	Primer Coat	Intermediate Coat	Non-skid coat	Sealer
Courtaulds	Interzinc 225	Intergard 475 HSE	Intergard 475 HSE	Interthane 800
Dulux	Zincanode 215	Ferrodor EPX	Ferrodor EPX	Luxathane
Jotun	Jotaprime 5	Penguard Stayer	Penguard Stayer	Imperite 300

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 12

Supplier	Primer Coat	Second Coat	Finish Coat
Jotun	Copon KS16W (White)	Copon KS16W (Red oxide)	Copon KS16W (White)
Wattyl-Sigma	Sigma 5435-2174 (Buff)	Sigma 5435-2186 (Red buff)	Sigma 5435-2174 (Buff)

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 13

Supplier	Primer Coat	Finish Coat
Corrocoat (Aust) P/L	Polyglass VE (bufff)	Polyglass VE (white)
Jotun	Chemflake (buff)	Chemflake (white)

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 32

Supplier	Primer	Finish Coat
Courtaulds	Intergard 310/711 Aluminium	Interthane 800
Jotun	Jotacote 605	Imperite 300

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 33

Supplier	Primer Coat	First Intermediate Coat	Finish Coat
Courtaulds	Interzinc 72	Intergard 475 HSE	Interfine 629
Dulux	Zincanode 202	Ferrodor EPX	Acrathane IF
Jotun	Barrier	Penguard Stayer	Jotacote 372

APPENDIX II: COMPANY PREFERRED MATERIALS - SYSTEM No. 41

Supplier	Zinc Rich Epoxy [1,2]	Intermediate Coat [3]	Finish Coat [4]
Courtaulds	Interzinc 72	Duramastic 2020	Interthane 800 or Interfine 629
Dulux	Zincanode 202	Amerlock 400	Luxathane or Acrathane IF
Jotun	Barrier	Jotamastic 87	Imperite 300 or Jotacote 372

1 The Zinc-rich Epoxy shall also be used as a minor repair primer for 4.3.1.

2 For equipment's with bare steel or damaged factory applied coating, prime or spot touch-up with Zinc rich epoxy then followed by Intermediate and Finish Coats.

3 For undamaged factory coated equipment's, paint with Intermediate Coat followed by the Finish Coat.

4 For repair & touch-up of System Nos. 1, 2 & 6, Finish coat material & colour to match the original System specification.

APPENDIX III: COATING SYSTEMS SCHEDULE (Sub-structure)

Sub-structure	System No.
Below Mud-line	No coating
Mud-line to LAT +4m - all structures and appurtenances - external conductor & riser - ladders and cages	3c + 3e or 3d +3e
Above LAT +4m	
- all structures and appurtenances	3f
- external conductor & riser	3f
- ladders and cages	3f
All ladder rungs	6
Grating and handrails	Galvanised + 33
Nuts and bolts	Cadmium plates † & PTFE

† Where nuts are to be welded, then coating shall be painted only after welding.

APPENDIX III: COATING SYSTEMS SCHEDULE (Top-side)

Topsides	System No.
Undersides of deck exposed to spray including pipes, appurtenances, up to deck level.	1 or 2
Structural steel including appurtenances at and above cellar deck level.	1 or 2
Deck plate, steps, helideck plate.	6
Handrails.	Galvanised.
Deck grating (removable)	Galvanised.
Deck grating (non-removable)	Galvanised + 33.
Nuts and bolts	Cadmium plates † & PTFE
External surfaces of piping & vessels with operating temperature up to 95°C	2

† Where nuts are to be welded, then coating shall be painted only after welding.

RecfishWest - South Thevenard Artificial Reef: SD2022-4020

MScience Pty Ltd
6 Kitchener Street
Nedlands, WA 6009

28 July 2022

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Summary

In Australia, artificial reefs are subject to permitting by the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection (Sea Dumping) Act* 1981 (the Act). In February 2022, DCCEEW (then DAWE) received an application for an artificial reef permit from Recfishwest to construct and emplace the South Thevenard Artificial Reef on the southern side of Thevenard Island in Western Australia's Pilbara Offshore meso-scale bioregion. Following a technical review, for and by DCCEEW, of the documentation supplied, Recfishwest were requested to provide further information to demonstrate that the proposal complied with relevant requirements of the London Protocol under the Act.

This document provides an independent technical review of the proposal, including the additional information as supplied by Recfishwest in July 2022. Compliance with the Protocol was evaluated using the guidance within Section 3 "Technical criteria for the assessment of artificial reef projects" of the United Nations Environment Program's Regional Seas Reports and Studies No. 187: *London Convention and Protocol/UNEP: Guidelines for the Placement of Artificial Reefs*, 2009 (the Guidelines). The preliminary technical review has been updated here on the basis of Recfishwest responses supplied to DCCEEW in July 2022. Text updated on the basis of those responses is presented in blue and headed as Response together with the Item number from Recfishwest table of responses.

This technical review was conducted by Dr James Stoddart, Chief Scientist at MScience Pty Ltd, who has over 35 years' experience with the environmental management of marine construction and resources projects, including the development and monitoring of artificial reefs.

Overall Finding:

The application and supporting documents as supplied to DCCEEW in July 2022, including the table of responses, demonstrate that the proposal meets the following requirements of the guidelines:

- Complies with relevant legal criteria and has consulted stakeholders;
- Is underpinned by suitable resourcing and planning;
- Plans to use suitable materials for construction;
- Is planned to be in a location conducive to its socio-economic objectives;
- Is unlikely to cause negative impacts on other users of the area;
- Has considered decommissioning options;
- Should be capable of meeting its stated objectives for fishers.

Some responses do not fully meet the requirements of the Request for Additional Information. These are addressed below.

Issues that Should be Addressed:

A number of issues are not completely addressed in the permit documentation. These are listed below in Table 1.

Table 1: Issues to be addressed and their location in this review.

Issues to be resolved in documentation	**See Item #**
Add an item to the LTMP Monitoring program to liaise with Thevenard Is turtle monitoring to confirm lack of adverse impacts on hatchlings	6
Resolve the apparent conflict in habitat mapping between Figures 15 and 16 of the LTMP and correct the scale shown in Figure 16	11
Comment on the potential toxicity of residual paint on structures.	15
Add missing citations to the References section of the LTMP	23
Issues which can be addressed in permit conditions	
Ensure deployment adopts standard conditions for the protection of marine fauna	1
Ensure marine fauna observers are trained personnel.	2
Require that the anchoring plan during operations takes account of updated information on marine benthos as described in Proponent response to Item 11.	11

1. Overview

In Australia, artificial reefs are subject to permitting by the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) under the *Environment Protection (Sea Dumping) Act* 1981 (the Act). In February 2022, DCCEEW (then the Department of Agriculture Water and the Environment) received the documents listed below to support an application from Recfishwest on behalf of Recfishwest and the Western Australian Department of Primary Industries and Regional Development, as joint proponents (hereafter the Proponent) of the artificial reef, for an artificial reef permit.

The suitability of artificial reef permit applications is currently assessed against their compliance with the requirements of the London Convention (1972) and Annex 2 of the London Protocol (the Protocol).

This technical review of the Recfishwest application was conducted to determine if the application satisfied the aims of the London Protocol and identify any further information from the Proponent which might be required to complete the technical review. Compliance with the Protocol was evaluated using the guidance within Section 3 "Technical criteria for the assessment of artificial reef projects" of the United Nations Environment Program's Regional Seas Reports and Studies No. 187: *London Convention and Protocol/UNEP: Guidelines for the Placement of Artificial Reefs*, 2009 (the Guidelines).

The latter guidelines specify the following criteria:

1. General Criteria: Legal and Technical
2. Specific Criteria: Design, Materials, Location
3. Function-Specific Criteria: criteria dependent on the aims of the reef

DCCEEW (previously DAWE) have requested that specific attention should be given within the review to the adequacy of the information provided by the applicants on the following issues:

a) Suitability of location of the proposed artificial reef, including proximity to nearby natural reefs

b) Potential for human entrapment in the artificial reef

c) Potential marine pollution effects

d) Potential for any components of the artificial reef to be dislodged from their placement location by extreme weather or natural events

e) Suitability of long-term monitoring plans

f) Potential impacts to migratory, threatened or protected marine species

g) Potential for invasive species to populate the structure

h) Environmental impact of the proposed decommissioning options

i) Appropriate consultation with all relevant stakeholders, including indigenous groups, other recreational users and tourism groups.

j) Compare the information requested by the Customer and the responses given by the Applicant to understand if the Applicant has provided all the requested information.

The Recfishwest initial documentation (February 2022) reviewed was:

South Thevenard Artificial Reef: Commonwealth Sea Dumping Permit Application, February 2022. WA Recreational and Sportfishing Council Inc
South Thevenard Artificial Reef: Commonwealth Sea Dumping Permit Application, Long Term Monitoring Plan, February 2022. WA Recreational and Sportfishing Council Inc,
Attachment 1: Reef Location (map)
Attachment 2: Reef Boundaries (map)
Attachment 3: Reef Layout (drawing)
Attachment 4: Fish Associations with Platforms and Natural Habitats at Thevenard Island. Curtin University, Report to Chevron Australia, June 2020
Attachment 5: EPBC Protected Matters Report
Attachment 6: *Onslow Integrated Artificial Reef Stability Report*. Subcon, June 2021
Attachment 7: Chevron Letter of Support
Attachment 8: DPIRD Co-applicant Confirmation Email

Documents contained with the Recfishwest response to the Additional Information request (July 2022), and which now constitutes the permit application documentation are listed as below:

Attachment 1 - Onslow Artificial Reefs

Attachment 2 - Reef Boundary

Attachment 3 - Reef Configuration

Attachment 4 - Fish Associated with Thevenard Island Platforms

Attachment 5 - EPBC Act Protected Matters Report

Attachment 6 - Stability Report

Attachment 7 - Chevron Letter

Attachment 8 - DPIRD Co-applicancy

Attachment 9-R1512A_ TTF - Wheatstone Downstream Metocean Criteria

Attachment 10 - eDNA_Thevenard_Rev0_Feb20

Attachment 11 - Yammaderry Substructure GA

Attachment 12-Cowle Substructure GA

Attachment 13 - Cowle Additional Well GA

Attachment 14 - Cowle External Riser Caisson GA

Attachment 1 5-WAPET Paint and Protective Coatings: Fixed Offshore Structures and Production Facilities

Attachment 16 - WMP Approval Roller

Attachment 17 - WMP Approval Yamm, Cowle, Roller A

Attachment 18 - Approval to Decommission Cowle-4 and Yammaderry-2

Attachment 19 - WMP Approval_ ROLLER-6, ROLLER-TH, ROLLER-8, ROLLER-10, AND ROLLER-11

Attachment 20- letter to Chevron from Chair_ TVI offshore closure plan Approved

South Thevenard Artificial Reef - Long Term Management Plan

South Thevenard Artificial Reef - Permit Application

South Thevenard Artificial Reef - Request for Additional Information

2. General Criteria

Legal (including stakeholder consultation)

Section 3.1 of the LTMP notes, the *Fish Resources Management Regulations* require approval by the WA Fisheries CEO for fish attracting devices such as the proposed AR. At this stage the application is silent on that approval – it is assumed that it and other approvals will be forthcoming prior to the Proponent proceeding.

Sections on the LTMP devoted to approvals for well plugging and management are not relevant to the SDP approval process and should not form part of this application.

The stakeholder consultation section of the LTMP appears comprehensive with the single exception that there has been no consultation noted with the Western Australian Environmental Protection Authority or its service department, the Department of Water and Environmental Regulation. Section 6.7 of the LTMP states that it is important to contact relevant state regulatory authorities, but this does not seem to have occurred. While it is highly unlikely that EPA would assess such a project, **the project is sited in Western Australian State waters (inside the Territorial Baseline) and should be discussed or referred to EPA/DWER.**

The issue of response to concerns raised by the WA Department of Biodiversity Conservation and Attractions is covered in Section 5 of this review.

Responses

(Item 3)

The Proponent has provided a response which outlines that the relevant regulator of petroleum activities in Western Australia (Department of Mines, Industry Regulation and Safety) has considered and approved the well decommissioning activities proposed to source the materials for the artificial reef.

(Item 4)

The Proponent has removed original Section 3.2.4 from the LTMP which implied that well plugging was in some way regulated under the Sea Dumping Permit.

(Item 7)

The Proponent notes that the Chevron Decommissioning and Rehabilitation Plan for the Thevenard Island Assets does indicate the intent to repurpose decommissioned assets

as an artificial reef and that this document has been reviewed and signed off by the WA EPA. Thus it appears WA EPA has been included in stakeholder consultation for the project but was not described in the original documents.

(Item 8)
The Proponent advises that all PPA issues raised have been resolved to PPA satisfaction as a result of progressing the Navigable Waters application through the WA Department of Transport.

(Item 12)
DCCEEW requested further advice on the planned decommissioning of Cowle to demonstrate that reef components were sourced legally. The Proponent has provided Attachments 12 – 14 covering the Cowle decommissioning which illustrate the plan and the Response notes its approval.

Technical

Feasibility: The Proponent and their contractor demonstrate considerable experience in the development of similar artificial reefs off Western Australia. Based on that experience and the offer of funding from Chevron (Attachment 7), the current proposal appears adequately resourced and well designed.

Functionality: The artificial reef as proposed appears likely to fulfill its function of providing fish for recreational anglers. See following sections for a more detailed review of this aspect.

Environmental Compatibility: The reef design and proposed location are likely to meet goals for fish habitat without negatively impacting any beneficial uses, although the potential for placement of the reef to cause damage to the existing benthic communities cannot be properly assessed on the minimal information supplied on these habitats (see later Sections 5 & 6).

Durability and Stability: Attachment 6 contains calculations on the stability of the decommissioned structures and the bombora modules. Calculations are detailed, although without access to their reference B1, which contains the metocean data on which calculations are based, it is not possible to assess whether they accurately reflect the reef site hydrodynamics. Calculations of stability for the decommissioned structures assume a water depth of 9.4 to 9.6 m LAT. The description of bathymetry at the reef site (LTMP Section 8.3) lists depths as between 6.3 and 10.2 m LAT. **The design component**

of the application should ensure that the reef components are not sited in areas shallower than those used to demonstrate their stability in Attachment 6.

Response

(Item 9)
The Proponent has committed to place all reef infrastructure at depths at or below those which were used for the stability assessment. Figure 6 of the Permit Application has been revised to show this requirement.

Suitability of Monitoring: See Section 7 of this report.

Suitability of Dismantling Arrangements: Section 13.7 of the LTMP discusses decommissioning options. Options allow for a range of possible decommissioning strategies which is appropriate as the 30-year timeframe to decommissioning is likely to provide a different social-environmental imperative than that of today.

3. Specific Criteria

Design

The LTMP sets out the design of the reef and covers the design of each type of component. The function of the design of the concrete domes in terms of supporting fish is addressed and has been demonstrated previously. Section 9.1.2 of the LTMP describes the repurposed infrastructure sections and their function in the artificial reef for fish and benthic habitat. The mixture and layout of these items appears to present a diverse and functional approach to creating an artificial reef for fish production.

Section 3 of the review raises the requirement that the design of the reef should relate the proposed location of structures to minimise impacts to the existing benthic communities.

See comments above in Section 3 Technical on the implications of the stability assessment for reef design.

Materials

Sections 9.1.2 and 9.3.4 of the LTMP provide details of preparation of the decommissioned structures for deployment to the seabed. The protocols and other details set out in those sections appear to have thoroughly considered the potential for contaminants or rubbish from the decommissioned structures and have committed to remove all items with such risk. The conclusions that removal of paints and other coatings would not be practical and that leaving these has a low environmental risk is supported. The documented growth of benthos on the wet-side plant supports the contention that coatings are not toxic to marine life. Topside coatings designed for areas of human use or occupancy are likely to be similarly benign.

The decommissioned structures of the platform's decks and helipad substantially increase the risk of entrapment of SCUBA divers in an area not known for an abundance of cave structures. The reef will be in water readily accessed by divers (in terms of depth and proximity to a tourism base) as pointed out in Sections 12.3.12 and 12.3.13 of the LTMP. While Section 12.3.13 does appear to underestimate the risk of diver entrapment by structures such as those shown on pages 57 & 58 of the LTMP, it is agreed that the elevated risk is likely to be low to experienced divers such as those who might use this reef.

Response

(Item 13)

DCCEEW requested further details on the helideck placement and its safety implications. The Proponent confirms that the helideck will be placed in an upright position and leave a minimum clearance of 2m at all points above the seabed for egress. As the deck is only 5m wide, it is unlikely to prevent a significant barrier to safe egress with divers a maximum of 2.5 m from clear water at any point.

(Item 14)

In response to concerns on the stability of the helideck wing sections, the Proponent has withdrawn these from use in the artificial reef: as confirmed in the Responses, Stability Report and LTMP.

(Item 15)

In response to the query on paints used on the facility to be decommissioned, the Proponent responds that material data safety sheets were likely to be unavailable at the time of construction. However, the Proponent document supplied (WAPET Paint and Protective Coatings: Fixed Offshore Structures and Production Facilities) states in its

section 3.6 "The Contractor shall obtain and have available for inspection Material Safety Data Sheets (MSDS) for all chemicals, solvents and paint materials used." The further information supplied in that document and Tables 17 & 18 of the LTMP make no mention of the toxicity rating of any of the paints used. While the justification for not removing paints shows this is impractical, if the painted structures are to be deployed, some assessment of any residual toxicity should be presented.

(Item 19)
The Proponent has clarified that infrastructure from Cowle and Yammaderry has been included in past surveys for introduced marine pests and provided the relevant report.

Location

Section 8.7 of the LTMP presents the rationale for the selection of this area for the artificial reef construction. Socio-economic and logistic benefits listed in that section are justified and information is provided in Section 11 of the LTMP to support those findings. However, the conclusion that the reef and its construction would have no significant environmental impacts is unable to be supported from the information provided in the application and its attachments. This is principally the result of inadequate information provided on the local benthic environment within the proposed reef area.

The reef components are substantial structures and will occupy a significant area of seabed. The general description of benthic communities in the project area suggests that much of it will be 'mixed benthos' with a cover above 10%.

The great majority of data used to describe the proposed reef site is derived from Chevron's surveys of the Yamaderry monopod surrounds – but is only presented in general terms (the entire description of the benthic communities is limited to one paragraph in Section 8.5 of the LTMP). Where the LTMP references findings from Chevron surveys for Yamaderry, it should be clear how the area surveyed for Chevron relates to that proposed for the artificial reef (maps should show the two areas overlaid).

Section 10 of the LTMP is either generic information or details of marine protected areas distant (often by more than 100 km) from the reef site. That is not helpful in placing the artificial reef site into a regional context, or in assessing the benthos of the site. See Location in the following section for recommendation.

Detailed discussion of the characteristics and potential impacts on Marine Protected Areas greater than 50 km from the proposed reef is not helpful and confuses the assessment. These sections should be dropped.

RESPONSE

(Item 5)

It would appear that despite the use of the term 'constraint mapping' , the location was selected primarily on the basis of comments from recreational fishers. The Proponent points to information within the LTMP covering potential constraints. While there is no formal assessment in a constraints management sense, none of the values listed in the LTMP would invalidate the selection of the proposed site.

(Item 10)

The Proponent's view that while the data on sediment chemistry is almost 10 years old, it is still valid, is supported. The sediment survey presented in the application documents was conducted post cessation of production operations, thus there is minimal risk that the intervening years have seen an increase in contamination.

(Item 11)

The Proponent has provided little additional data/detail on BCH. The added image of 100% sand and 6-10% seagrass cover is not helpful in assessing where the various habitats occur in the project area. Despite this, the mapping does suggest that the proposed reef area would be unlikely to impact on locally or regionally significant BCH. Nevertheless, the mapping presented contains a number of inconsistencies:

Corals like *Danafungia* (incorrectly labelled as ahermatypic) and *Turbinaria* do not grow on sand substrates: thus the >10% benthic invertebrates (which is listed to contain these species) is unlikely to co-occur with sandy substrate. Figure 15 appears to show the proposed project area as all sand, whereas Figure 16 appears to show >10% benthic invertebrates. It is difficult to resolve this inconsistency as the scale in Figure 16 would appear to be incorrect by a factor of 100 to 1000, making it difficult to relate to the project footprint.

Despite the issues with the current description of habitats, there is no evidence from mapping that locally significant or sensitive areas exist inside the reef disturbance zone. The Proponent commitment to further the map the area during anchor placement to avoid any potential significant reefal development should provide additional security.

Note that this response is also relevant to issues raised originally in Sections 4 and 5 below.

(Item 16 & 17 & 25)
Provision of the Wheatstone Metocean Design Study (which was only referenced and not provided in the initial documentation) now allows assessment as to the degree to which metocean data used in the stability assessment is likely to be representative of that experienced at the reef site. That document and the stability report show site WNP4 as that used to represent reef site conditions. While WNP4 is considerably south of the reef site, it is the most similar to that site (in terms of depth and location) of any of the sites where data were recorded. As Thevenard Island might be expected to shelter the reef site from weather coming from some directions (particularly the north which is the most likely cyclone-weather direction) the data should not underestimate metocean conditions at the reef site.

(Item 18)
The extensive discussion of distant MPAs of little relevance to the reef location has now been contracted to a table.

4. Function-Specific Criteria

Function-specific criteria are shown under three headings:

1. Reefs for Enhancement of Productivity and Biodiversity
2. Reefs for Ecosystem/Resource Protection
3. Reefs for Leisure or Recreation Purposes

Section 13.2 of the LTMP makes it clear that the objective of the artificial reef is to provide fish for recreational fishers. In that regard, function-specific criteria from type 1 artificial reef above have been used in the following review.

Socio-Economic Considerations

The socio-economic aspects of the development of the artificial reef have been extensively addressed throughout the LTMP. The Stakeholder Consultation and the assessment of the value of the proposed artificial reef to recreational fishers demonstrate a strong net socio-economic benefit of the project.

Purpose Design and Materials

This topic has been covered in sections above. The design and materials seem well suited to deliver the aims of an artificial reef which will provide enhanced fishing amenity for recreational fishers.

Location

As discussed in the preceding section, the description of the benthic habitats of the area within the proposed bounds of the artificial reef site is inadequate to allow assessment of the potential impacts of material placement or construction works.

Section 8.5 of the LTMP should provide a detailed map of the areas habitats and the figures showing the proposed layout of structures and anchoring of construction vessels should be overlaid on that habitat map. This would allow an assessment of the potential impacts of the project on existing habitat. The ecological value of any habitat to be destroyed should be placed in a regional context.

In stakeholder consultation, the Department of Biodiversity, Conservation and Attractions is reported as raising the concern that increasing fish density in the artificial reef may negatively impact on local, high value, turtle nesting sites by increasing predation on juvenile turtles (Table 4 LTMP). This potential impact is not discussed anywhere in the LTMP or Application and is not addressed in monitoring**. The LTMP should address the DBCA concern as to whether increased fish predation on juveniles of vulnerable or endangered turtle species is a likely consequence of the artificial reef and whether any monitoring will address that issue.**

Response

(Item 6)

This is a difficult issue and the response from the Proponent is overly dismissive. The paper cited by the Proponent (Wilson 2019) shows an example of how an artificial structure that has attracted predatory fish can lead to an apparent large increase in mortality of hatchling turtles at the adjacent Thevenard Island. The Proponent suggests that it is likely there would be no increase on predation of hatchlings as a result of the artificial reef because the reef is:

1. Likely to have a lower level of predation than the coastal reefs;
2. Too far from the turtle beach used in the Wilson study;
3. Surrounded by largely sandy substrates; and
4. Placed where the Yammaderry monopod has existed as a FAD for 30 years.

None of the above mitigate against a view that the deployment of an artificial reef in this location will be a factor which causes some increase in hatchling predation. Taking the arguments individually:

1. While the relative impact on hatchling predation is likely to be less than that of fish on coastal reefs, it is unlikely to be zero;
2. As for #1, fewer hatchlings will cross the area of increased predation than were exposed in the Wilson study area, but this will not be zero: as the Wilson study notes, while nesting levels may be high at their study beach, turtles nest all around Thevenard Island;
3. Fish species studied in the Wilson experiment are likely to be essentially those attracted by the artificial reef. Those species ranged widely in the areas around the jetty (FAD) and are likely to do the same as they seek to feed around the artificial reef.
4. With removal of the Yammaderry infrastructure, the associated historic elevation of fish numbers will disappear. The issue to consider is that the artificial reef will raise the local abundance of predatory fish above 'natural' levels, not how that number relates to historically disturbed states.

The function of the artificial reef is to raise the number of fish (predominantly predatory fish) within this area. These fish need to eat. Turtle hatchlings will form some component of that diet. Thus, there will be some level of hatchling predation above that which would occur if the reef did not exist. The question is whether that level is locally significant. Based on information in the current LTMP, it seems more likely that the level of predation will remain close to that of the past years when the Yammaderry facility was in place, than materially increasing.

Chevron support an ongoing effort to monitor turtle populations of Thevenard Island. It would be worth including an objective in the Artificial Reef monitoring program to confirm that turtle populations are not declining consistent with increased hatchling predation. The methodology of that monitoring could be simply by liaising with ongoing turtle monitoring programs such as the Chevron one.

5. Deployment of the Reef

Repurposed sections of the production platforms and monopods are large and require large vessels to transport and deploy them. Anchoring these vessels prior to operations requires the deployment of large anchor modules and chains. This poses a substantial risk to sessile benthic communities. **The construction management section of the LTMP should contain a detailed map of the benthic communities to allow**

optimisation of anchor placement to minimise impacts on existing benthic communities.

Response

(Item 1 & 2)
The Proponent response accepts that observations for marine fauna during operations to deploy the reef will be undertaken by trained observers. The Proponent documentation has not been updated to reflect this, but it is assumed that this will be part of the Proponent's response to the Permit condition to be imposed as set out in Item 1 which will formalise the more comprehensive requirement.

(Item 24)
Attachment 3 has now been labelled fully and also shows the tentative layout relevant to bathymetry. The Proponent has requested some flexibility in the final layout. The present design appears driven predominantly by convenience of construction and alterations are unlikely to compromise its ecological function. The only issue that might limit flexibility is the requirement to meet the minimum depth of placement to comply with the stability assessment.

6. Monitoring

Section 13 (Monitoring) contains a number of paragraphs and tables setting out actions and objectives lumped as monitoring. The content of this section is not always consistent between the text and tables. Of most importance, there is no clear statement of who will undertake the various monitoring programs. The intent for some programs appears to be that recreational fishers using the reef will undertake them. Recreational fishers should provide good quality data on fish but might struggle in areas of benthos or introduced pest species. Some monitoring will require specific skills and qualifications: for instance, the precise relocation of structures to determine whether movement triggers are being exceeded, is likely to require conduct by expert surveyors using equipment well beyond simple "GPS and sonar"; and the identification of an organism as one that should be considered an introduced species and will trigger the investigation path in Table 37 would require an experienced marine scientist.

Much of the section is a general presentation on equipment used for monitoring. However, this is generic and there is no direct linkage as to what equipment and methods are being proposed for each specific program.

Monitoring which relies on volunteers, such as proposed here with recreational fishers, will be beyond the direct control of the proponents and should be identified as aspirational. Monitoring which is a formal commitment from the proponents and will be conducted should be identified separately from aspirational monitoring.

Monitoring programs should be placed into a single table containing headings of: *Objective, Trigger, Data type, Method, Who will undertake the monitoring*. Within that table, data type should be clearly paired with the method used to derive it.

Response

Item (20, 21, 22)

The description of the monitoring program to be undertaken for the reef has been greatly improved from the original in the LTMP. It now meets the requirements to show objectives and methods and should be auditable.

7. Referencing Problems

The LTMP references a number of reports and publications but does not contain a list of citations for those references.

The LTMP should provide citations in a recognised citation style for all references within its body.

Response

Item (23)

The LTMP has now been updated with a list of references to documents cited. However, the list remains incomplete with some citations missing: notably references used to support the conclusions on turtle hatchling predation (Wilson 2018 and Onate-Casado 2021) do not appear in the reference list.