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Browse LNG Development

INFILL SURVEYS OF BENTHIC HABITATS - JAMES PRICE POINT COASTAL AREA.

FINAL REPORT

- Rev 2
- 27 October 2011

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Acronyms and Abbreviations

BPP	Benthic Primary Producers
BPPH	Benthic Primary Producer Habitat
Contacts	Locations along each transect where the seabed was diverse, had features of interest, or were representative of the seabed along a transect
EPA	Environmental Protection Authority
DSD	Department of State Development
GPS	Global Positioning System
LADS	LiDAR Aerial Depth Survey (LIDAR - Light Detection and Ranging)
LNG	Liquefied Natural Gas
nm	Nautical mile
OEPA	Office of the EPA
'On the fly' classification	Classification of towed video transects undertaken *in situ* in real time as the video footage was being collected and recorded
WA	Western Australia
ZOMI	Zone of Moderate Impact

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Executive Summary

The proposed Browse Liquefied Natural Gas (LNG) Development is a joint venture between Woodside Energy Ltd (Woodside), as operator, BHP Billiton, BP, Chevron and Shell. The Development is based on the recovery of hydrocarbons from the Brecknock, Calliance and Torosa gas fields located approximately 425 km offshore Broome, Western Australia (WA). The downstream component of the Development is proposed to be located in the Browse LNG Precinct, located at James Price Point, approximately 60 km north of Broome.

The Precinct location has been selected by the Western Australian Government as the preferred location for LNG production facilities for export to international markets. The WA Department of State Development (DSD), as proponent of the Precinct, is progressing a Strategic Assessment of the Precinct to establish the framework for environmental management and monitoring for future activities likely to occur within the Precinct.

A key component of the Strategic Assessment involved the determination of potential environmental impacts to benthic biota including macroalgae, small algae, hard corals, soft corals and seagrass, or mixes of these biota types, and the underlying substrate, collectively identified as benthic primary producer habitats (BPPH). Previous habitat mapping identified the distribution of benthic habitats using high resolution bathymetry data, towed video and predictive modelling. While this mapping provided detailed and accurate maps of benthic biota distribution, sediment transport modelling completed as part of the assessment identified that the areas of potential impact, including Cumulative Predicted Zone of High Impact (i.e. permanent loss) and Zone of Moderate Impact (i.e. sub-lethal stress to partial mortality with recovery expected within five years) extended beyond the extent of the existing habitat mapping.

Therefore, additional information on the distribution and composition of BPPH outside the previously mapped area but within the predicted Zone of Moderate Impact (ZOMI) was considered necessary to add to and 'infill' the information already available to assess seabed features of interest or habitats that may be sensitive to potential dredging impacts.

The sampling plan for this infill survey was spatially designed to target specific areas and provide comprehensive, broad scale coverage of previously un-surveyed areas within the ZOMI. A combination of sidescan sonar technology and towed video surveys were used to collect a comprehensive dataset to extend the geographical coverage of previous mapping. The infill survey commenced in January 2011 with a sidescan sonar survey. The collected sidescan data were used to identify broad scale seabed features and to assist in developing a targeted towed video survey to verify the benthic habitats present on the different seabed features identified across the infill survey areas.

While the towed video survey was attempted in January 2011, poor weather and near zero visibility in the water column were encountered, resulting in poor quality video footage. The towed video survey was re-mobilised and successfully completed in late June 2011.

The results from the survey indicated that the substrate types and habitats surveyed within infill areas were similar in composition and distribution to those previously surveyed within the James Price Point (SKM, 2010) and wider Kimberley regions (Fry *et al*., 2008). The substrate and biota data collected reinforced the patterns of distribution identified in previous habitat mapping (SKM, 2010). Substrate types within the infill areas were found to be mostly bare sediment and sediment inundated low profile hard substrate. There were no areas of topographic complexity (high profile hard substrate) identified. The benthic biota identified were dominated by sessile invertebrates that were distributed across the infill survey area with varying densities and often in combination with other biota such as algae to form a mixed mosaic habitat. The key species composition for sessile invertebrates included sponges, gorgonians, soft coral, sea whips and ascidians that contain both photosynthesising and non-photosynthesising species.

Other prominent biota identified included algae which were often observed in a mixed mosaic habitat with other biota types, including dense *Sargassum* spp. beds in the northern infill area. Hard coral and seagrass were the least represented biota types within the infill areas and restricted to sparse patches within state waters in the northern part of the ZOMI. The western area of the survey area was dominated by sediment and sparse sessile invertebrates.

The mapping presented in this report was produced using a combination of methods deemed most appropriate for the way in which the data were collected, as well as the resolution and spatial density of the information. Compared to the existing mapping (SKM, 2010), the maps produced in this study have a coarser resolution. Consequently, there are limitations associated with interpreting and comparing the mapping products. The biota distributions identified from the infill survey data should be considered to be indicative of the likely or possible distribution, but are considered to be conservative as the methods employed will likely over estimate the distribution and extent of the benthic habitats present.

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1. Introduction

1.1. Project Background

The proposed Browse Liquefied Natural Gas (LNG) Development is a joint venture between Woodside Energy Ltd (Woodside), as operator, BHP Billiton, BP, Chevron and Shell. The Development is based on the recovery of hydrocarbons from the Brecknock, Calliance and Torosa gas fields located approximately 425 km offshore Broome, Western Australia.

The downstream component of the Development is proposed to be located in the Browse LNG Precinct, located at James Price Point, approximately 60 km north of Broome. The Precinct location has been selected by the Western Australian Government as the preferred location for LNG production facilities for export to international markets. The WA Department of State Development (DSD), as proponent of the Precinct, is progressing a Strategic Assessment of the Precinct to establish the framework for environmental management and monitoring for future activities likely to occur within the Precinct.

The proposed Browse LNG Development will comprise a series of nearshore marine construction activities including dredging and dredge spoil disposal. These activities are likely to suspend sediments into the water column, resulting in temporary elevation of turbidity levels above background concentrations that has the potential to impact benthic biota and habitats occurring in close proximity.

To assist proponents in determining the extent of potential environmental impacts to benthic habitats from dredging activities, the Environmental Protection Authority (EPA) of Western Australia has published guidelines, *Environmental Assessment Guideline No. 3* (EAG-3; EPA, 2009). These guidelines also provide the basis for EPA decision-making with respect to the protection of benthic primary producer habitat (BPPH) in Western Australia. EAG-3 defines BPPH as communities of biota in which algae, seagrass, corals or mixtures of these groups are prominent components.

A series of benthic habitat mapping studies have been undertaken in the past in the vicinity of the James Price Point to determine the distribution and composition of benthic habitats. The data and mapping outputs from these studies have primarily been used to support DSD's Strategic Assessment and to support environmental impact assessment and environmental management of the proposed LNG development activities off James Price Point.

An initial habitat mapping study conducted in the vicinity of James Price Point (Fry *et al*., 2008) used a combination of towed video and dredge tows to undertake a 'rapid assessment' of the marine benthic communities within the Kimberley region, including the proposed development

area between Quondong and Coulomb Point. A subsequent study (SKM, 2010) employed a combination of towed video assessment and habitat distribution modelling to investigate, predict and map the distribution of the different benthic habitats for a larger 500 km^2 area. Using a combination of high resolution LADS bathymetry and biota classifications derived from towed video, the combined distribution of different benthic habitats were predicted across the extent for which LADS data had been collected. The resulting mapping output provided a greater level of detail at a higher resolution than had been achieved previously (**Figure 1-1**).

1.2. Additional Requirements

As part of the Strategic Assessment, sediment transport/water quality modelling was conducted to predict areas of the nearshore benthic environment, including BPP habitat that may potentially be impacted (refer to Appendix C 13 in DSD, 2010). This involved establishing and determining various zones of potential impact to BPPH including a Cumulative Predicted Zone of High Impact (i.e. permanent loss) and Zone of Moderate Impact (i.e. sub-lethal stress to partial mortality with recovery expected within five years). The modelling results predicted that these zones extend beyond the extent of the existing habitat mapping (**Figure 1-2**).

Subsequently, in December 2010, the Office of the EPA (OEPA) requested further information be provided by Woodside on the distribution and composition of benthic habitats outside the previously mapped area but within the predicted ZOMI, hereafter referred to as the ‘infill survey areas’.

On 15th December 2010, Woodside presented a proposed approach to OEPA to address this request, identifying that the main focus of the additional infill surveys would be to describe the range of habitats found in State Waters immediately west and north of the existing LADS data extent and within the ZOMI. Further discussions between Woodside and the OEPA in January 2011 defined the areas to be surveyed:

- Turbid waters immediately west and outside of the LADS area;
- Areas inside 3 nm immediately north of the LADS survey area;
- Areas outside 3 nm north of the LADS area; and
- Deeper, offshore areas west of LADS area.

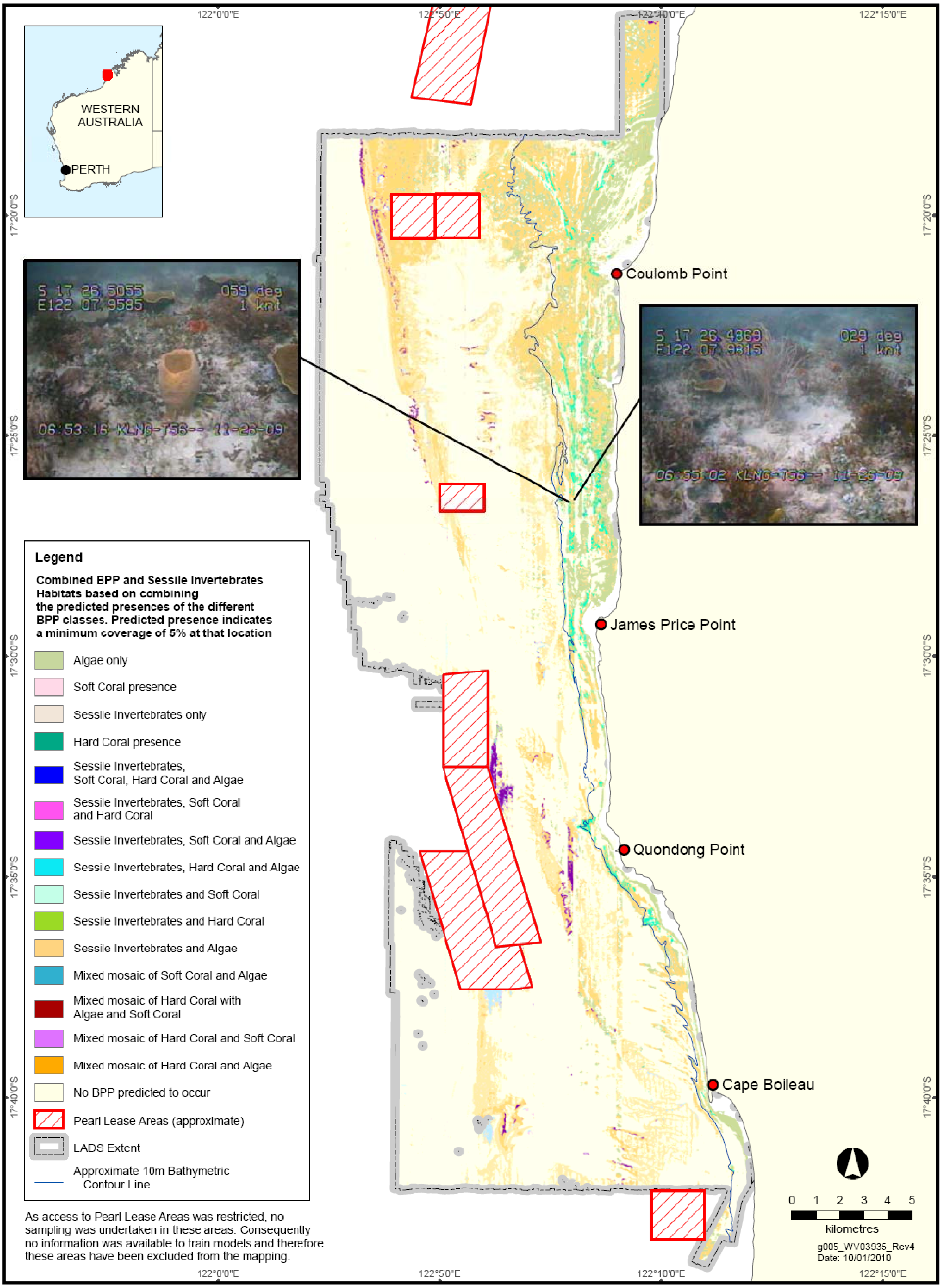
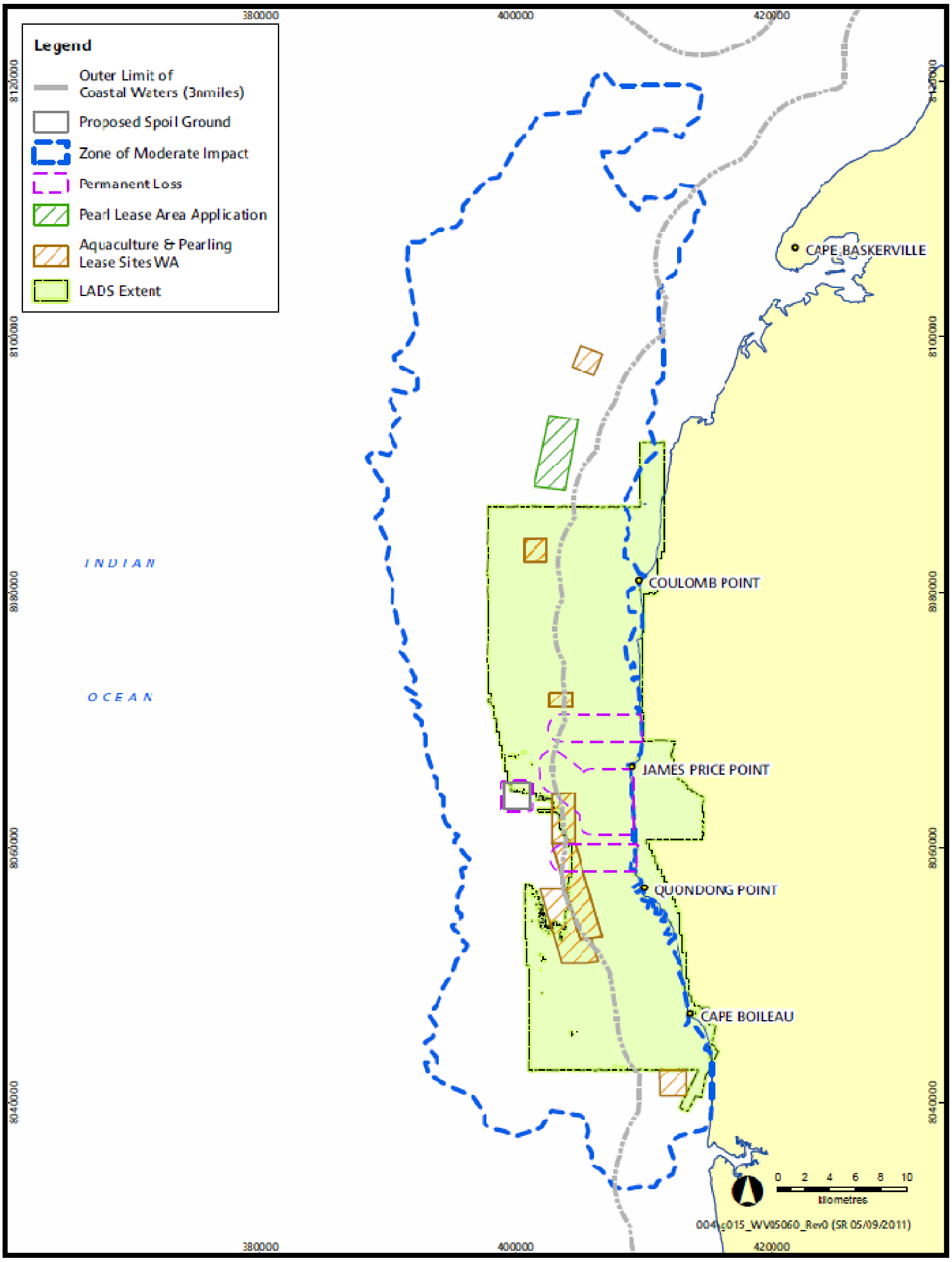


Figure 1-1 High resolution benthic habitat mapping derived from modelling across the LADS extent (SKM, 2010).
 # Seagrass distribution could not be modelled with confidence and is therefore excluded from this figure.



- **Figure 1-2 Cumulative predictive zones of High Impact (Permanent Loss) and Moderate Impact (zone of sub-lethal stress to partial mortality).**

The study commenced in January 2011 with a sidescan sonar survey to evaluate the broad scale seabed features present across the infill survey areas (SKM, 2011). The sidescan data was subsequently used to assist in developing a targeted towed video survey to verify the types of benthic biota present on the different seabed features identified. Poor weather and near zero visibility in the water column were encountered during the January survey, calling a halt to the towed video component of the survey. The towed video survey was re-mobilised and successfully completed in late June 2011, with video footage of the benthic habitats collected across all infill survey areas as well as at the 'Peanut' and an area in the southern part of the ZOMI.

The initial study scope was to provide a broad scale assessment of the benthic habitats present across the infill survey areas and did not include the generation of full coverage maps. However, during a meeting on 28th July 2010 when the preliminary results of the towed video survey were presented to the OEPA, the OEPA requested that a mapping component be included as an output of the study. As full coverage mapping was not part of the original scope, the survey designs were not optimized for producing detailed, fine scale mapping outputs. As a result, the limitations associated with the accuracy and scale of the full coverage mapping derived for this report should be acknowledged. Limitations and constraints are outlined further in **Section 2.4.3**.

1.3. Objectives and Scope of Works

The overall objective of this study was to collect the data necessary to describe the broad scale distribution and composition of benthic habitats within the identified infill survey areas. The infill survey extent consisted of selected areas within the ZOMI but outside the extent of the currently mapped area (**Figure 1-1**).

To achieve this objective, the specific scope of works included the following:

- Undertake a sidescan sonar survey to collect data that will be used to interpret the broad scale seabed features and seabed types present within the infill survey areas;
- Use the sidescan sonar data to develop a targeted towed video survey design;
- Undertake a towed video survey to collect footage of the benthic habitats present across the infill survey areas and more specifically, those habitats present on the different seabed features defined from the sidescan sonar data;
- Use the classified towed video footage to describe the distribution of the different biota present in the infill survey areas and provide a broad scale evaluation of whether there are any features (seabed) of interest or habitats that may be sensitive to and potentially impacted by dredging activities within the infill survey areas; and

- Produce a composite map showing the distribution of benthic habitats based on the previous high resolution habitat mapping (SKM, 2010) and the data collected as part of this study (objective identified post-survey).

1.3.1. Habitat definition - terminology

For the purposes of this study, the definition of BPPH follows that described in EAG3 (EPA, 2009) where BPPH is considered to be communities of biota in which algae, seagrass, corals or mixtures of these groups are prominent components, irrespective of the substrate type, e.g. hard substrates (reef) or unconsolidated substrates (sediment) or a mixture of both.

Biota types other than those included under the definition of BPPH, e.g. filter feeders, have been collectively referred to as sessile invertebrates. This group was identified as a main biota type and where found either by themselves or mixed with other biota types, also represented a distinct habitat or mosaic habitat. Sessile invertebrates included both photosynthesising and non-photosynthesis biota, such as sponges, that cannot be easily distinguished visually. Detailed descriptions of the classification used are included in the Methods (Section 2).

In the interests of clarity, and to avoid confusion with terminology, the biota type or mix of biota types living on the substrate are referred to as the habitat type in final mapping, rather than the biota/substrate combination (e.g. Algae and Hard Coral as opposed to Algae and Hard Coral on Reef with Sediment or Algae and Hard Coral on Reef). Including the substrate type in the final naming of a habitat resulted in an additional 13 categories (prior to any combinations of biota being considered) and thus, substrate type was removed to simplify the mapping outputs. Biota types and their combinations are mapped in the final combined habitat map (**Section 3.2**), which was consistent with previous habitat mapping undertaken using the LADS data (SKM, 2010) and equivalent to the BPPH categories outlined in EAG3.

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2. Methods

2.1. Survey Area

To determine the types and distribution of different seabed features and benthic habitats present in the infill survey areas, a combination of sidescan sonar and towed video surveys were employed. Sidescan sonar was selected because it provides a means of imaging the texture of the seafloor and is highly suited to characterising the substrate features found to be present in the survey area. The towed video footage was used to both confirm the interpretations of the seabed types from the sidescan data and to characterise and classify the different benthic habitats present.

The areas surveyed comprised four sub-areas (refer to **Figure 2-1** and **Figure 2-2**):

1) *Western Area*: Representing the gap in the existing habitat mapping immediately west of James Price Point;
2) The area referred to as the '*Peanut'* to the west of the existing mapping extent;
3) *Northern Area*: The area to the north of the existing mapping extent, both within and outside State Waters (3 nm limit); and
4) *Southern Area*: An area to the south of the existing mapping extent within State Waters.

The survey coverage excluded pearl lease areas. Permission to access these lease areas was sought by Woodside but not granted by the current lease holders.

2.2. Sidescan Sonar

The sidescan survey was undertaken from the 17th – 30th of January 2011 on the vessel *Empress*. A Tritech Starfish 450 sidescan sonar was towed from the survey vessel to collect data on the substrate types and features of the seabed along pre-determined transect lines. Side scan sonar is a specific type of sonar used to image the texture of the seabed. It transmits a narrow fan-shaped acoustic pulse (ping) perpendicular to its direction of travel. As the acoustic pulse travels outward from the side scan sonar, the seabed and other objects reflect some of the sound energy back in the direction of the sonar (known as backscatter). The travel time of the returned pulse is recorded together with its amplitude as a time series and sent to a surface unit console for interpretation and display. The surface unit console stitches together data from successive pulses, creating a long continuous image of the seafloor as the side scan sonar is towed from a survey vessel.

A total of approximately 150 km of sidescan data, comprising 52 transects were collected across three of the four sub-areas. This included 18 transects within the western area, including the Peanut, and 34 transects in the northern area (**Figure 2-1**). No sidescan transects were collected within the southern area.

Following completion of the survey, sidescan sonar data were examined in detail to interpret the range of substrate types present and to identify locations along each transect where the seabed was diverse, had features of interest, or were representative of the seabed along a transect. These locations, referred to as ‘contacts’, were used to help design the towed video survey to ensure that video footage was collected across areas of interest and across the different seabed features present, including featureless areas. Contact locations and descriptions are included in **Appendix A**. Contact data were also used in conjunction with classified video data to broadly map substrate distribution (see **Section 2.4.1** below).

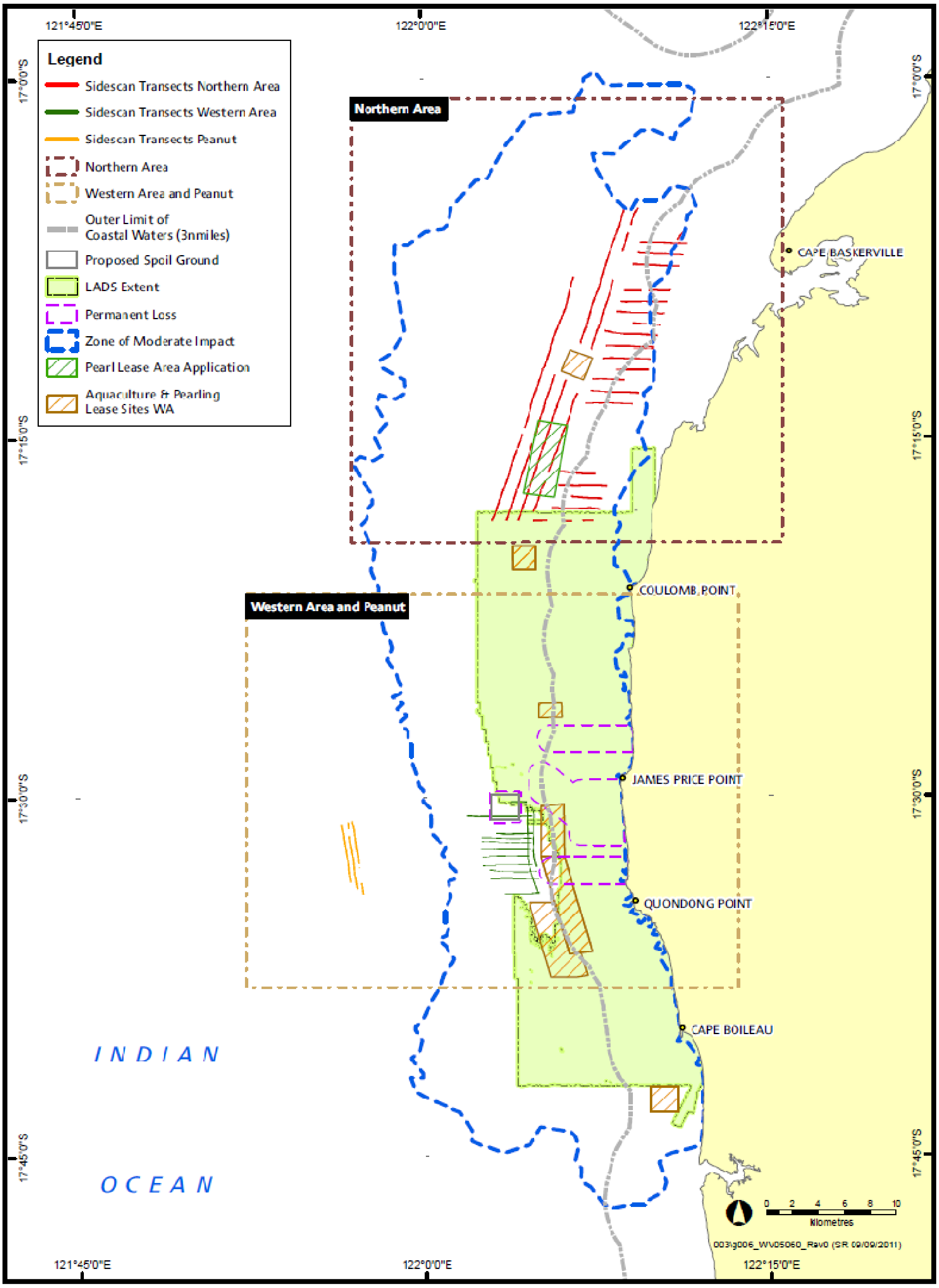


Figure 2-1 Location of sidescan sonar transects in each of the infill survey areas.

2.3. Towed Video

The towed video survey was scheduled to follow the sidescan sonar survey in January 2011. However, when the camera was deployed, near zero visibility in the water column was encountered, rendering the video footage unreliable. Consequently, the towed video survey was re-mobilised and conducted under more suitable weather and metocean conditions between 23rd – 28th June 2011.

During the survey, the towed video camera was deployed from the vessel *Atlas* and towed approximately 1 m above the seafloor at approximately 1 knot. The position of the vessel was recorded using Global Positioning System (GPS) to enable the video footage to be accurately geo-referenced and estimates of camera layback recorded. This allowed for a correction to be applied to the vessel coordinates to account for the distance that the camera was being towed behind the vessel. A total of 138 video transects were collected across the infill survey areas (56 in the western area including the Peanut, 78 in the northern areas and 4 in the southern area) resulting in approximately 65 km of benthic habitat video footage (**Figure 2-2**). Towed video surveys were conducted in waters greater than 5 m deep. Shallow areas of state waters to the north could not be surveyed due to the presence of extensive reefs (0-5 m deep) and the danger this presented to the survey vessel.

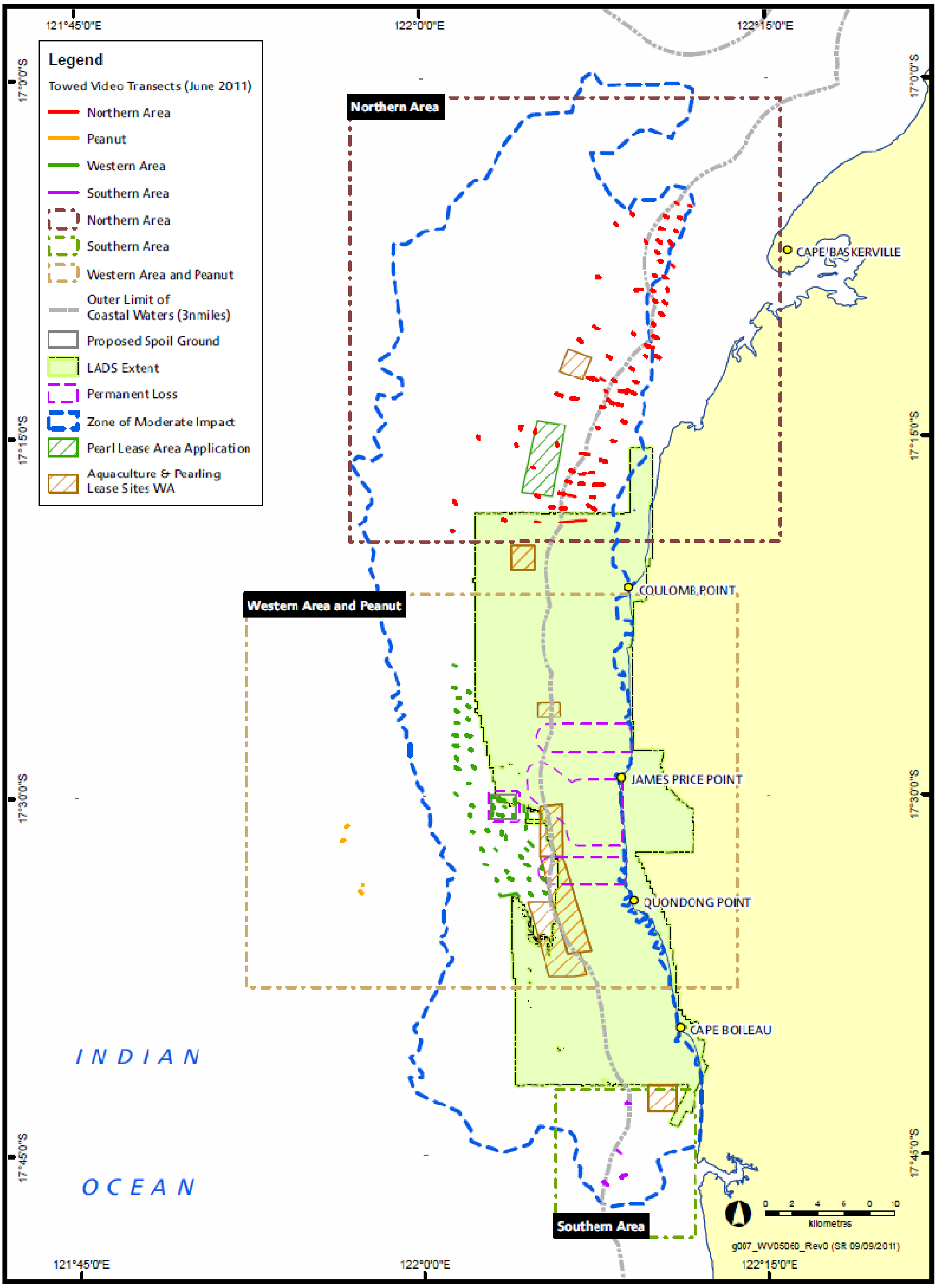
2.3.1. Classification and Analysis

While the video footage was being collected, '*On the Fly'* classification was undertaken in real time to record the dominant biota present along each transect. While this classification provided a rapid, broad scale assessment of the different biota encountered across the study area (SKM, 2011), post-processing of the video footage was also completed to produce a more comprehensive and detailed classification of the different biota density and substrate types present along each video transect. During post-processing, substrate and biota types were assigned to the video footage for biota types considered to be 'present' (**Table 2-1** and **Figure 2-3)**. The presence was determined based on the biota types covering an area greater than 5% of the total substrate area over a 5 m distance. Changes in biota or substrate were recorded, allowing each second of footage to be classified. Estimates of the combined cover (density) of all observed biota types were made using density categories of sparse (5-25%), sparse/medium (25-50%), medium/dense (50-75%) and dense (>75%).

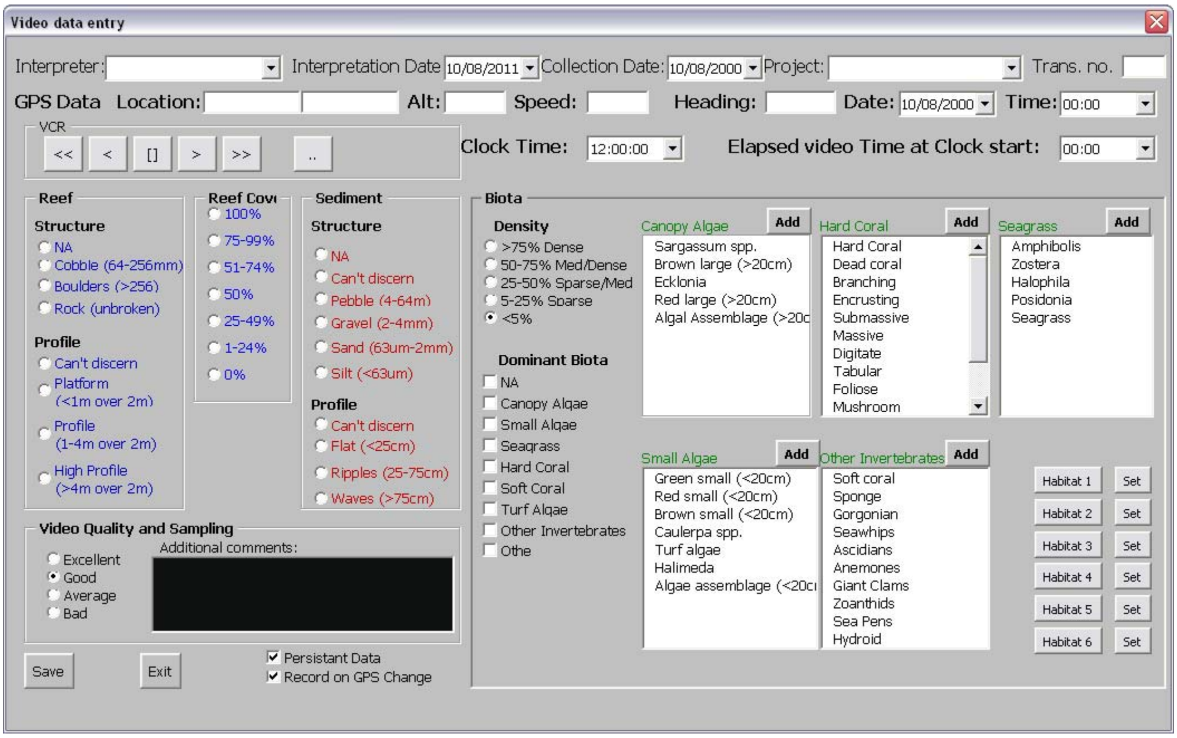
Following post-processing classification, the data was plotted to show the distribution of the main biota types (canopy algae, small algae, hard coral, seagrass and sessile invertebrates) present along each transects and the respective, combined qualitative biota cover.

Table 2-1 Substrate and Biota types classified

Substrate and Biota Types	
Substrate	
Hard Substrate (Reef)	Consolidated reef substrate of varying profile
Sediment	Unconsolidated substrate with either sand/fine sediments or coarser sediment (pebbles or gravel).
Hard Substrate (Reef) with Sediment	Consolidated , hard reef substrate with sediment infilling portions of reef structure
Biota (BPPH categories)	
Canopy Algae	Macro algae >20 cm (e.g. Sargassum, red, green or brown)
Small Algae	Macro algae 20 mm-20 cm (e.g. red, green, brown, assemblage)
Seagrass	Can be separated into genus (e.g. *Halophila*)
Hard Coral	Morphological groups (e.g. branching, digitate, tabular, encrusting, foliose, massive and sub massive)
Soft Corals	Known photosynthetic (BPPH) soft corals (*Alcyonacea*, and *Sinularia*)
Turf algae	Hair-like algae <20 mm
Sessile Invertebrates	Sponge, Gorgonian fans, other soft corals, sea whips, sea pens (including BPP and non-BPP)



■ **Figure 2-2 Surveyed towed video transects within the infill survey areas.**



- **Figure 2-3 Custom visual basic software interface used for post classification.**

2.4. Mapping

2.4.1. Substrate Distributions

The raw sidescan images were reviewed to interpret the different seabed types present and to identify characteristic features of interest along each transect. The towed video footage was then reviewed to verify the seabed features and substrate types identified from the sidescan imagery. These data were geo-referenced and overlaid with additional data layers (e.g. LADS bathymetry and Royal Australian Navy Hydrographic Office marine charts), in order to provide increased confidence in the interpretation of potential substrate boundaries between transects. Areas where sidescan contacts/feature positions and towed video transects overlapped with existing LADS data provided an effective quality control method for reconciling contact features with potential habitat types. Polygons defining the distributions and likely boundaries between the different substrate types were then derived. It is noted that these boundaries are indicative only and in reality, boundaries are transitional and can vary due to the highly mobile nature of the sediments in the area.

2.4.2. Biota Distributions

Full coverage mapping of the main biota types was undertaken for the western and northern infill areas using the classified towed video data. The mapping for these areas was undertaken using different techniques (described below) depending on the location of the survey data and the level of detail available. Consequently, the accuracy of the mapping varied with the different techniques used.

As the biota considered to define BPPH could occur on a variety of substrate, e.g. hard substrate, unconsolidated substrate and sand inundated hard substrate, only the distribution of the different (and combined) biota types was mapped. Combinations of substrate and biota were excluded from the interpolation mapping, as much of the area was either sediment or reef obscured with sediment. Any subsequent reference to the term habitat refers to the presence of both biota (dominant type or mixed biota) and the underlying substrate. As it was not possible to separate out whether some sessile invertebrates where located on soft sediment or sediment obscured reef, mapping of Sessile Invertebrates, regardless of substrate, identified the habitat. All other remaining types (excluding seagrass) were typically found only on sediment obscured reef.

Biota mapping was not undertaken within the southern infill area or across the Peanut area due to the limited video sampling conducted in these areas.

2.4.2.1. Spline Interpolation

For points located within 1500 m of another, spline interpolation (undertaken in ArcGIS 9.3; ESRI, 2008) was used to derive and map the likely distribution of the different biota types: canopy algae, small algae, soft coral, hard coral, sessile invertebrates and seagrass. Spline Interpolation was used as it can ‘predict’ the likely distribution of habitats based on a limited number of point samples (e.g. the geo-referenced habitat classifications from the video footage) to define polygon boundaries. The underlying premise of interpolation is that the spatial distribution of habitats is correlated, with locations closer together being more similar than those further apart. Spline interpolation uses a mathematical function to create the continuous surface between these points. The greater the distance between the sampled points, the less confidence can be placed in the resultant interpolated surfaces.

To convert the output values of the spline interpolations into ‘presence/absence’ data/maps, output values below 0.5 were considered to represent absences. Values between 0.5 – 0.8 were considered to be areas where a particular biota may be found to occur (i.e. possible) and values >0.8 were mapped as areas considered likely to find that biota type. As the interpolated surfaces are likely to be highly conservative, i.e. overestimate the distribution of biota between the observed point data, the use of these cut-off values provides greater discrimination of the potential distribution of the different biota types.

2.4.2.2. Point Buffering

Points that were greater than 1500 m away from another point were not included in the interpolations as this distance was considered to be beyond that which it would be reasonable to interpolate between. Classified video points outside of the interpolation area were buffered by 500 m to create polygon boundaries around those points for areas of similar habitat. Adjacent habitat polygons with the same values were dissolved to create a continuous polygon for each habitat type. The buffered distance of 500 m was based on the assumption that biota identified from video were likely to be consistent within that distance from each point and is considered conservative. Variations in biota types may still occur within this distance.

2.4.2.3. Combining Mapping Outputs

Spline surfaces and polygon outputs from the point buffering for each biota type were combined to produce a final map showing the distribution of all biota types and a combined map showing where different biota overlapped in the western and northern infill survey areas. This allowed visualisation of the mixed mosaic of habitats common to the area.

2.4.3. Limitations of the Mapping

The mapping undertaken in this study varies in resolution and accuracy from the previous mapping undertaken (SKM, 2010) due to the type and quality of the data available, i.e. no high resolution LADS data (<6m cell size) was available for the infill survey areas, so no high resolution distribution modelling/mapping could be undertaken. Furthermore, the mapping was produced following a request by the OEPA after the data had already been collected.

The substrate mapping was based on interpretation of the sidescan sonar and towed video data and provides a likely representation of the distribution of different substrate types across the infill areas. The boundaries between the different substrate types can be considered to be indicative only and are unlikely to represent actual boundaries given the spacing of samples.

The method of spline interpolation employed in this study was selected because it was considered to represent the most rigorous approach possible given the data and level of information available. Interpolation methods are best employed with regularly spaced samples of numerical data with best results achieved when the distances between points are relatively small. The towed video sampling points in this study were irregularly spaced and clustered unevenly across the study area in line with the observed distribution of the different seabed features. Some samples were greater than 1.5 km apart. This was due to the original aim being to collect video across the spatial extent of the infill survey areas to describe what types of benthic biota were present and to verify the sidescan imagery, rather than to produce high resolution mapping products.

It is therefore important to note that each output surface (mapped distribution) is likely to be a result of how the data was sampled (survey design) and not necessarily represent where the actual boundaries between habitats occurred. If additional or different data sampling locations had been included, a different output would likely result. As such, these methods were intended to illustrate where dominant types may occur and the maps should be interpreted cautiously.

In addition, given that the sampling locations were up to 1.5 km apart in distance, the distinction of a boundary is approximate only and does not necessarily capture the variation that existed between the sampled points. The mapping is intended to give an indication only of the dominant biota types found within the infill areas. The resolution of this mapping is substantially coarser than that provided previously for the LADS extent to the south (6 m x 6 m resolution) (SKM, 2010).

3. Results

3.1. Substrate

Interpretation of the sidescan sonar imagery and the collected video footage indicates that the infill survey areas appear to consist of four main types of seabed morphology (**Figure 3-1**).

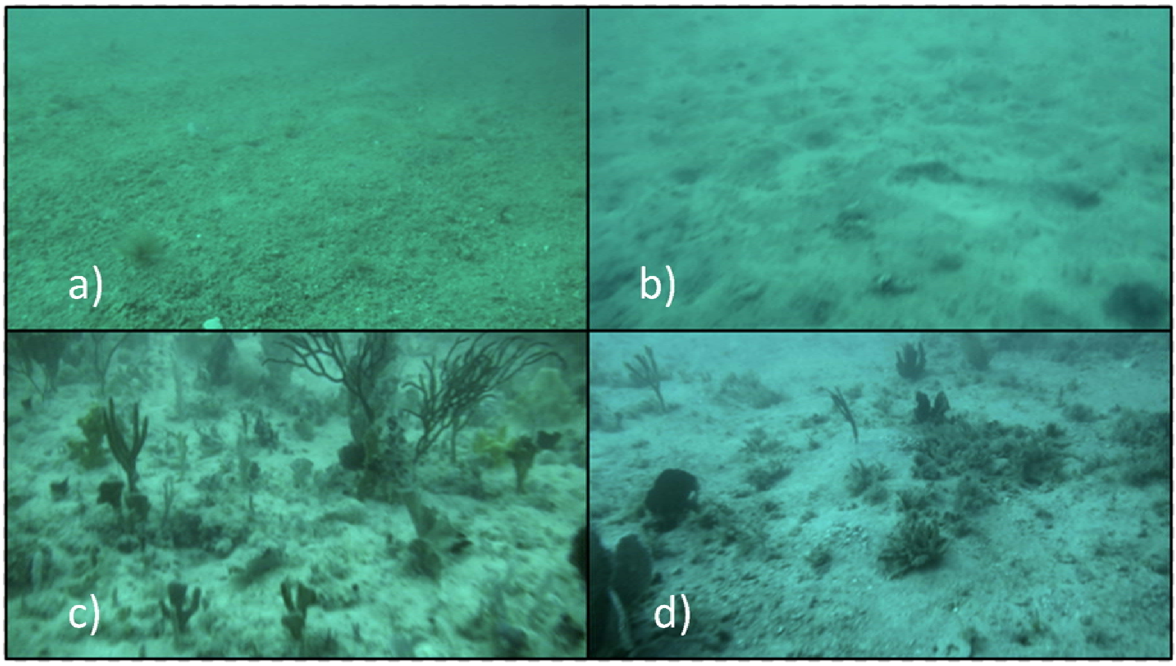
a. *Sediment*: Flat and/or finer unconsolidated, soft sediment which is represented as a featureless, smooth texture on the sidescan imagery.

b. *Sediment with Features*: Sediment areas where there are patterns of different sediment morphology or texture (e.g. rippled sediment of varying sizes), or possibly of a coarser texture which appear darker in contrast on the sidescan imagery.

c. *Hard Substrate with Sediment Infill*: low profile, hard substrate reef which has sediment infilling or inundating, to varying degrees of thickness, portions of the reef. Interpreted from observations of irregular patterns with some reef relief that casts longer shadows in the sidescan record.

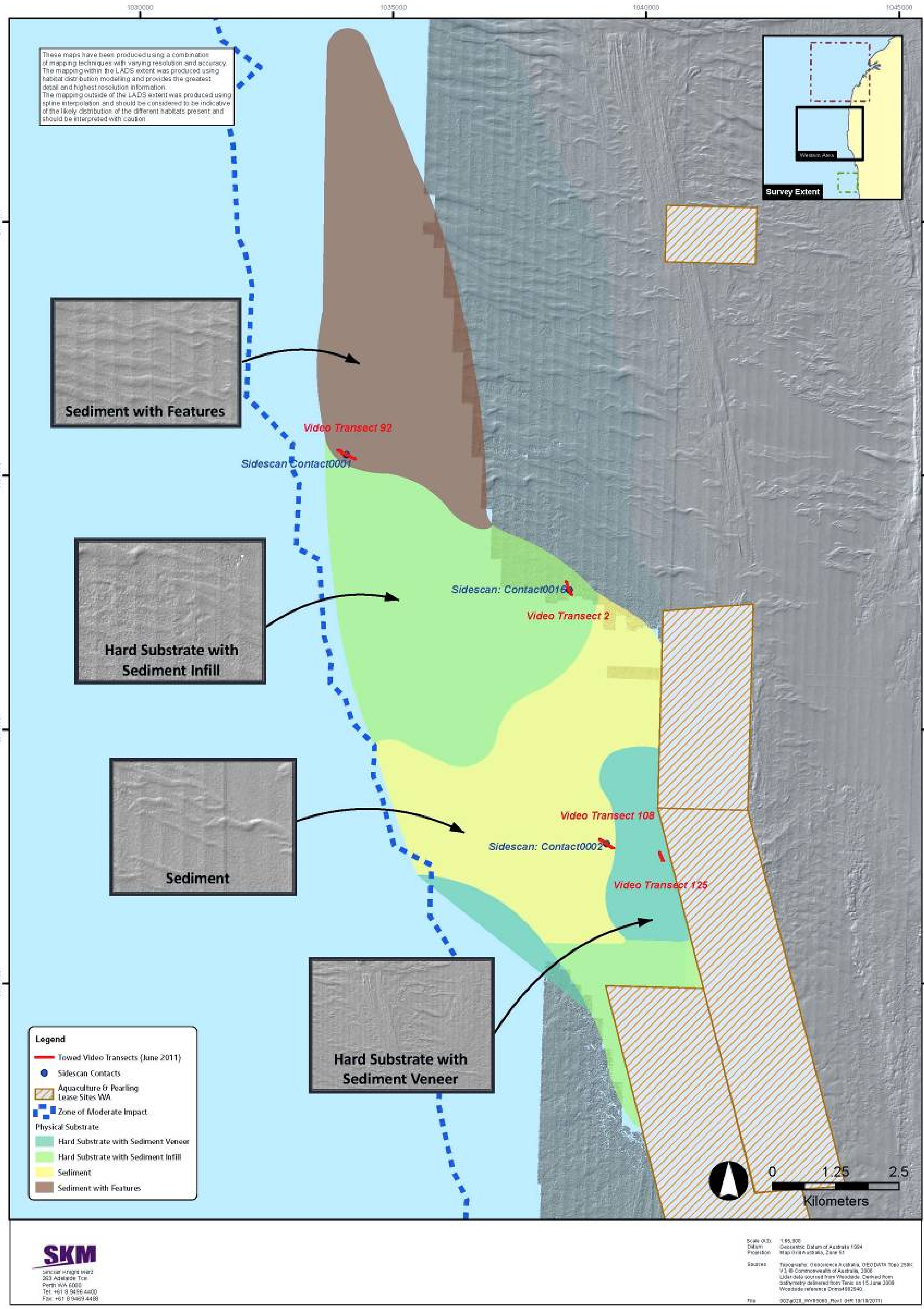
d. *Hard Substrate with Sediment Veneer:* Continuous occurrence of hard substrate with a very thin veneer of sediment.

There was no imagery that indicated the presence of any areas of topographic complexity or areas with high profile hard substrate. In the absence of high profile reef features, it can be concluded that the majority of the survey areas consisted mainly of flat substrate that was either sediment or hard substrate with an infill of sediment.

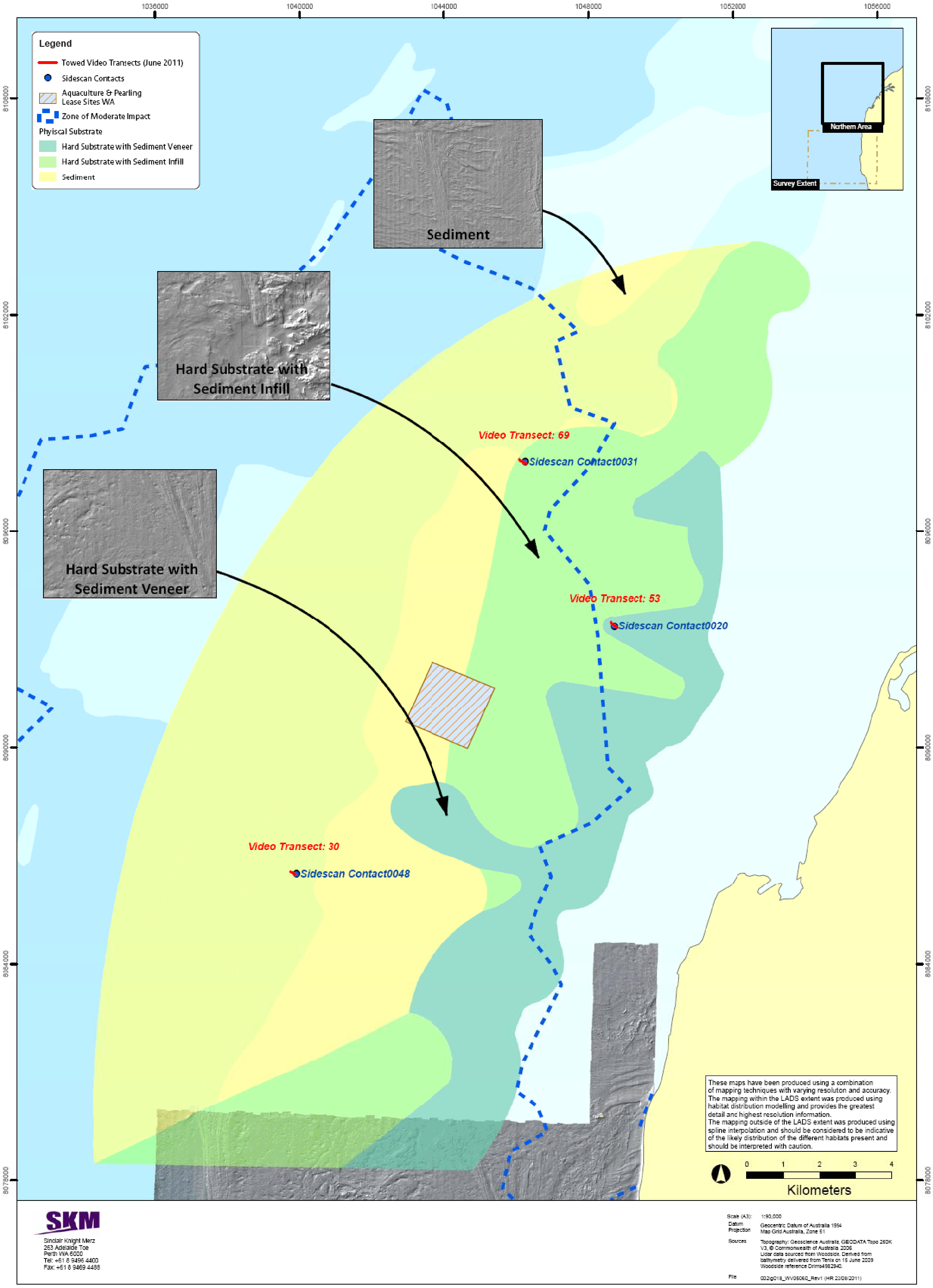


- **Figure 3-1 Images from the towed video showing (a) flat sediment, (b) textured sediment (c) hard substrate with sediment veneer, and (d) hard substrate with sediment infill.**

The collected data were interpreted to create a broad scale map showing the distribution of the main substrate types present (**Figure 3-2** and **Figure 3-3**). Substrate boundaries were naturally indistinct, with transitional areas of varying substrate type and thus, mapped polygons of substrate types are only abstract delineations of the likely seabed features present based on the available data (which was not 100% coverage). The mapped boundaries do not represent abrupt changes in substrate type and should be interpreted as a transitional boundary zones (as described in **Section 2.4.3**). The various substrate types within each of the infill survey areas are described in more detail in the following sections. No mapping or description is provided for the southern area given that there were no sidescan sonar transects undertaken in this area. Similarly, no mapping was undertaken for the Peanut given that only flat, featureless sediment was observed.



- **Figure 3-2 Distribution of the main substrate types within the western infill area, with representative examples of these substrates as observed within the LADS extent.**



- **Figure 3-3 Distribution of the main substrate types within the northern infill area, with representative examples of these substrates as observed within the LADS extent.**

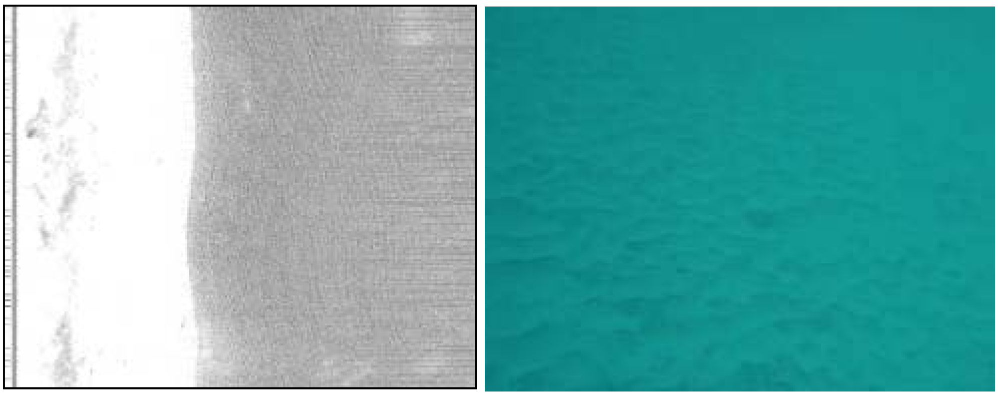
3.1.1. Western Area and Peanut

The western area appeared to consist of mostly flat bare sediment with a mix of hard substrate with sediment infill (of varying thickness). Areas of different sediment morphologies were present, e.g. rippled or bioturbated sediment. There was no evidence of seabed with any high profile present from the imagery collected or any areas of significant topographic features, although a small, low ledge was observed along one transect. The Peanut was also observed as comprising bare, flat and featureless sediment.

All four main substrate types identified across the infill survey areas were identified in the western area (**Figure 3-2**). These were sediment, sediment with features, hard substrate with sediment infill and hard substrate with sediment veneer. Each of these substrate types identified within the area is provided in the following sections together with examples from the sidescan sonar waterfall imagery and the towed video footage.

3.1.1.1. Sediment

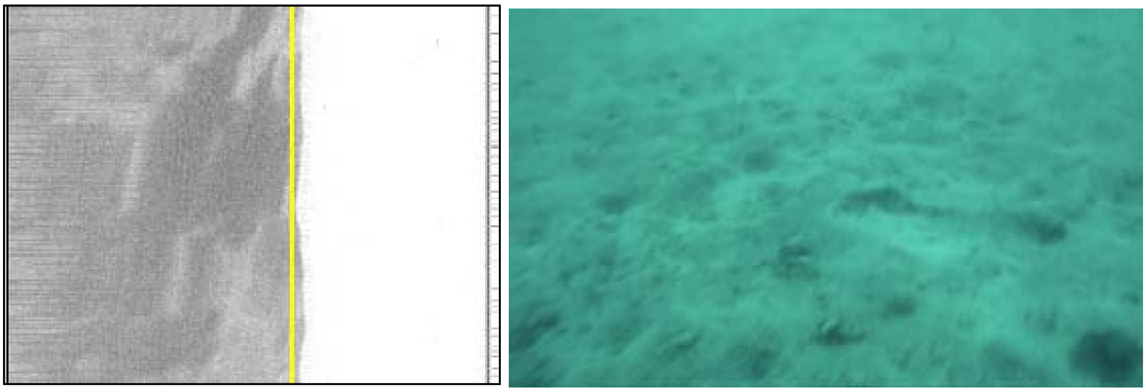
An area of flat sediment was identified across the western area (**Figure 3-2**) and confirmed by the video footage (**Figure 3-4**).



- **Figure 3-4 Sidescan contact (0002) and the corresponding video transect displaying featureless sediment.**
  # refer to Figure 3-2 for the location of the contact.

3.1.1.2. Sediment with Features

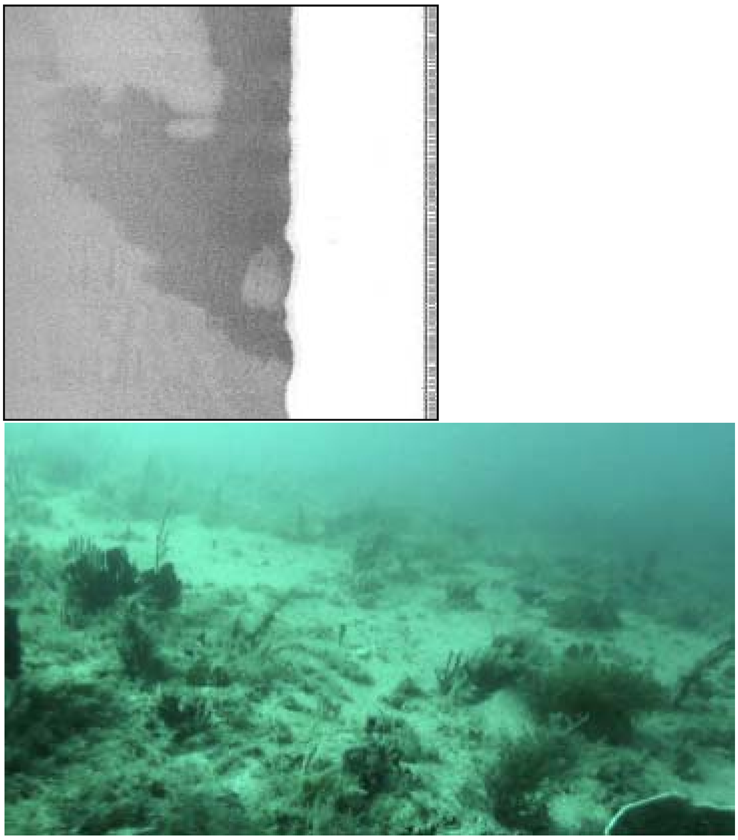
The substrate type of sediment with features was identified to be widely distributed within the northern section of the western infill area (**Figure 3-2**). The sediment was observed to contain a slightly undulating surface and some bioturbation and burrows (**Figure 3-5**).



- **Figure 3-5 Sidescan contact (0001) and the corresponding video transect (92) displaying sediment with features.**
  # refer to Figure 3-2 for the location of the contact and the video transect**.**

3.1.1.3. Hard Substrate with Sediment Infill

Two areas of hard substrate with sediment infill were identified across the western area (**Figure 3-2**). This substrate type was characterised by an underlying hard substrate layer, indicated by the overlying biota coverage, and an infill or inundation of sediment (**Figure 3-6**). Sediment depth varied with some patches of deeper sediment restricting biota coverage. Observed patterns on the sidescan sonar were likely due to either the changing depth of the sediment or the overlaying sediment and biota type.



- **Figure 3-6 Video transect (19) displaying hard substrate with sediment infill and corresponding sidescan example.**

3.1.1.4. Hard Substrate with Sediment Veneer

Two patches of hard substrate with sediment veneer were identified across the western area (**Figure 3-2**). This substrate type was the least represented and characterised by continuous areas of low profile hard substrate with only a very thin veneer of sediment. Biota density was generally higher on this substrate type, given the presence of hard substrate. No suitable sidescan contacts were identified from the available waterfall data, however, it is likely to be similar to the sidescan imagery of hard substrate with sediment infill (**Figure 3-6**). An example of this substrate type from the video footage is represented in **Figure 3-7**.

- **Figure 3-7 Towed video transect (125) displaying hard substrate with sediment veneer.**
  # refer to Figure 3-2 for the location of the video transect**.**

3.1.2. Northern Area

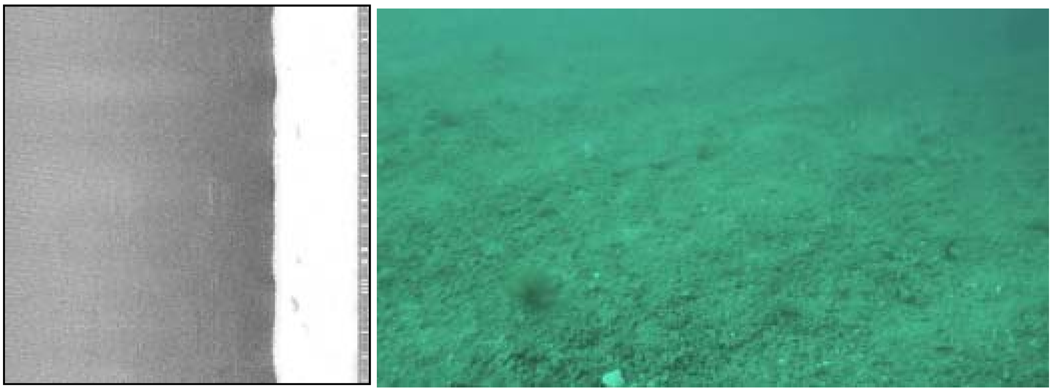
In the northern area, the seabed was identified to be mainly coarse or rippled sediment or smooth and fine sediment particularly to the west (**Figure 3-3**). Large scale sedimentary features such as mega ripples (running perpendicular to shore) dominated the shallower northern western parts. In comparison, the deeper water (>15 m) further west was dominated by flatter and featureless sediment.

The seabed in the south-eastern part of this area identified a higher proportion of hard substrate, e.g. isolated and broken low profile hard substrate (**Figure 3-3**) which correlated with the existing mapping that previously identified the presence of low to high profile hard substrate. The sidescan sonar data indicated that this pattern of topographic complexity extended approximately 3 – 4 km north, of the existing mapping extent. Beyond this location, the seabed was observed to be replaced with flat sediment.

A total of three of the four substrate types that were observed in the western area, were identified in the northern area, including sediment, hard substrate with sediment infill and hard substrate with sediment veneer. These substrate types followed a distinct progression from east to west, consistent with the coastal reef formations and deeper, offshore, mobile sediment. A description of the distribution of each substrate type is provided with examples from the sidescan sonar and towed video transects in the following sections.

3.1.2.1. Sediment

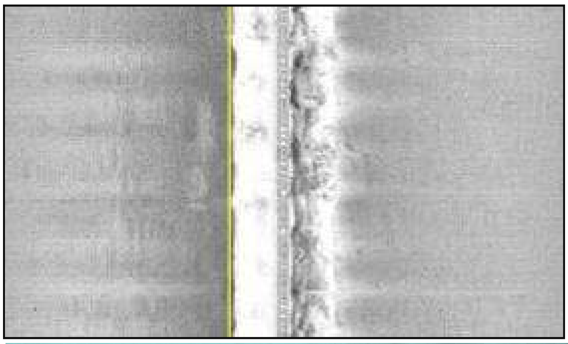
The deeper water (>15 m) in the west of the northern area was dominated by flat, featureless sediment (**Figure 3-8**). This was the most prevalent substrate type present in this area.



- **Figure 3-8 Sidescan contact (0048) and the corresponding video transect (30) displaying featureless sediment.**
  # refer to Figure 3-3 for the location of the contact and the video transect.

3.1.2.2. Hard Substrate with Sediment Infill

Hard substrate with a sediment infill was predominantly encountered to the east of the featureless sediment substrate described above. This substrate type was characterised by an indistinct, underlying, low profile hard substrate feature with an inundation of sediment. The depth of sediment was variable, with deeper patches likely restricting biota coverage (**Figure 3-9**). The underlying hard substrate layer may also be patchy with inconsistent cover separated by areas of sediment.

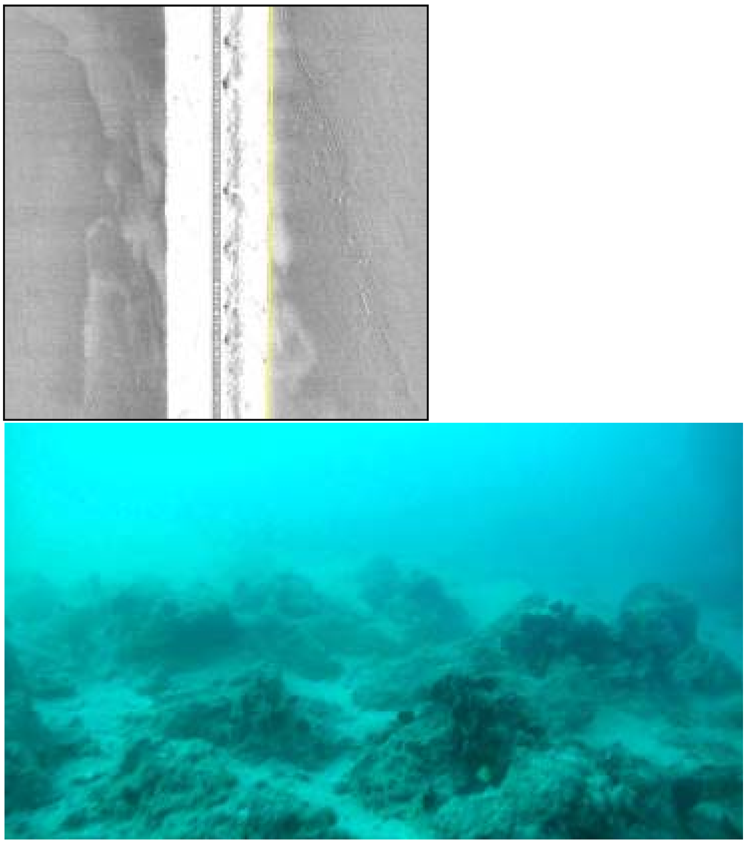


- **Figure 3-9 Sidescan contact (0031) and the example towed video transect displaying hard substrate with sediment infill.**

  # refer to Figure 3-3 for the location of the contact.

3.1.2.3. Hard Substrate with Sediment Veneer

The eastern boundary of the northern infill area was identified as hard substrate with a sediment veneer. This substrate type was characterised by continuous, low profile hard substrate with only a very thin inundation of sediment. The sidescan sonar waterfall imagery and video footage from this area (**Figure 3-10**) shows emergent, low profile hard substrate.



- **Figure 3-10 Sidescan contact (0020) and the corresponding towed video transect (53) displaying hard substrate with sediment veneer.**
  # refer to Figure 3-3 for the location of the contact and the video transect**.**

3.2. Biota

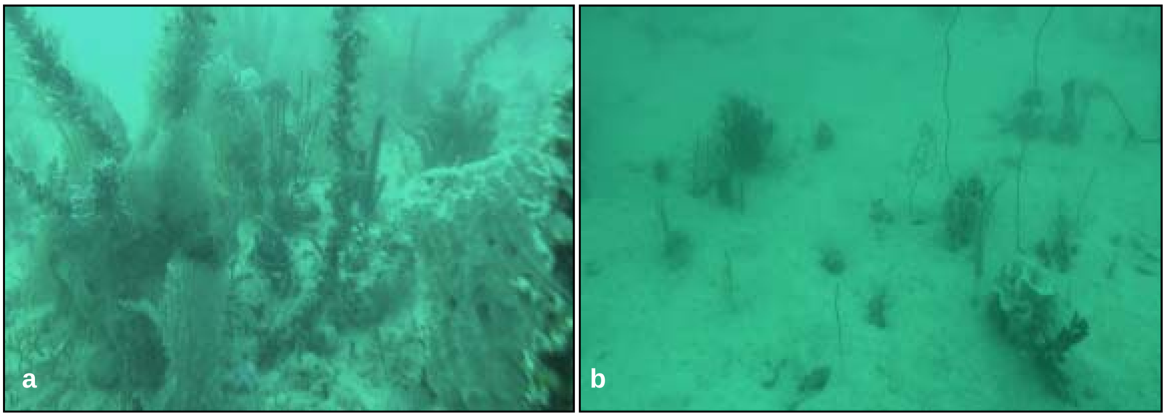
The dominant benthic biota observed across the infill survey areas were sessile invertebrates (mainly filter feeding organisms) and a mix of small and canopy algae. Seagrass and hard coral were observed in the northern area but only with sparse cover. All biota observed during the infill survey were previously identified and represented within the study area from prior surveys (SKM, 2010). Figures representing the distribution of the main biota types within the infill survey areas, based on post-processes classification, are provided in **Appendix B**. These represent the BPPH categories outlined in EAG3 (see **Section 1.3.1**). The following sections provide an overview of the biota observed for each of the infill survey areas, as derived from the post classification and interpolation.

3.2.1. Western Area and Peanut

Benthic habitats in the western area consisted mainly of bare sediment with microphytobenthos (MPB) or sea urchins. The most prominent biota observed throughout the area was sessile invertebrates (filter feeders). Commonly identified examples included sponges, soft coral, gorgonian fans, sea whips and ascidians (**Figure 3-11**). Biota cover varied from sparse to dense and other biota types were often observed in mixed assemblages with sessile invertebrates.

Sparse canopy algae was present on a few transects and consisted mainly of *Sargassum* spp. Small algae were generally also present in combination with canopy algae and were dominated by small understory genera such as *Caulerpa* spp., *Halimeda* spp. and small filamentous red algae. Seagrass was only observed on two transects and in sparse densities. Hard coral was present on a few transects but was always observed as isolated colonies or scattered colonies at less than 10% coverage. Hard coral was dominated by *Turbinaria* spp. and massive morphologies. Overall, combined biota density was generally less than 25% coverage but some transects had a greater observed coverage between 25-50% and 50-75% (**0**). Observed biota were similar to those identified in neighbouring sites during previous surveys (SKM, 2010).

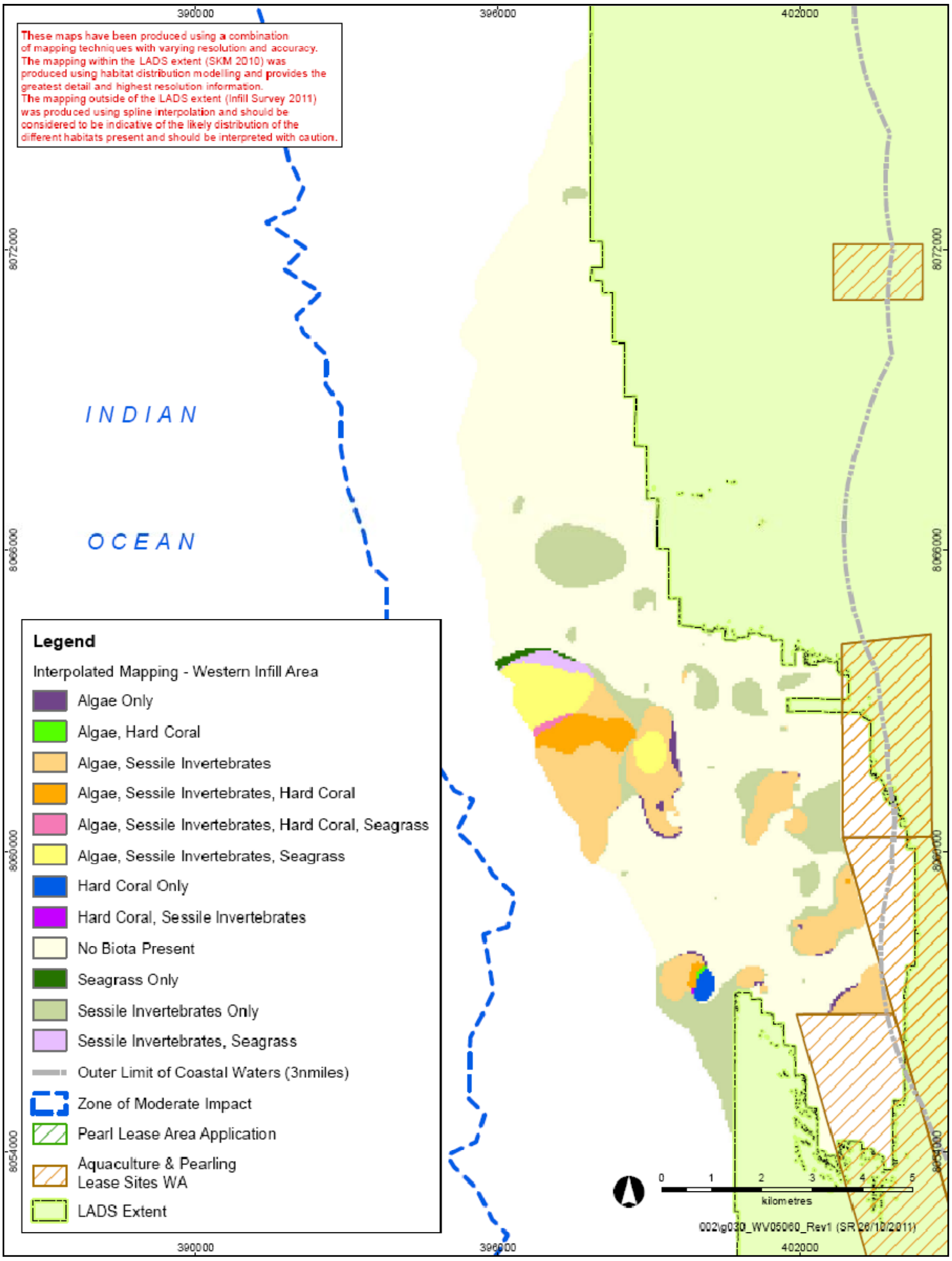
Within the area known as the Peanut, only bare sediment was observed with no biota coverage.



- **Figure 3-11 Images of (a) typical dense (transect 92) and (b) sparse (transect 126) sessile invertebrates from the western infill area.**

3.2.1.1. Mapping biota within the Western Area

Sessile invertebrates were the most widely distributed biota type with large aggregations throughout the area, particularly in the southern portion of the western area (**Figure 3-12**). Small algae and canopy algae were the second most widely distributed biota type but their distribution was restricted to small, isolated aggregations in the southern section of the interpolated area. Given that very little hard coral and seagrass were observed within the western area, mapping revealed only very small, isolated patches (within a few squared kilometres) of hard coral and seagrass on the western boundary of the interpolated area. Maps of the distribution of individual biota types are shown in **Appendix A**. A combined map was produced showing the distribution of the main biota types, including seagrass, hard coral, sessile invertebrates, canopy algae and small algae (**Figure** 3-12). This map represents the BPPH and Sessile Invertebrates (including BPP and non-BPP) of the western area. Sessile invertebrates were the dominant biota type, and occurred in combination with other biota as a mixed mosaic habitat.

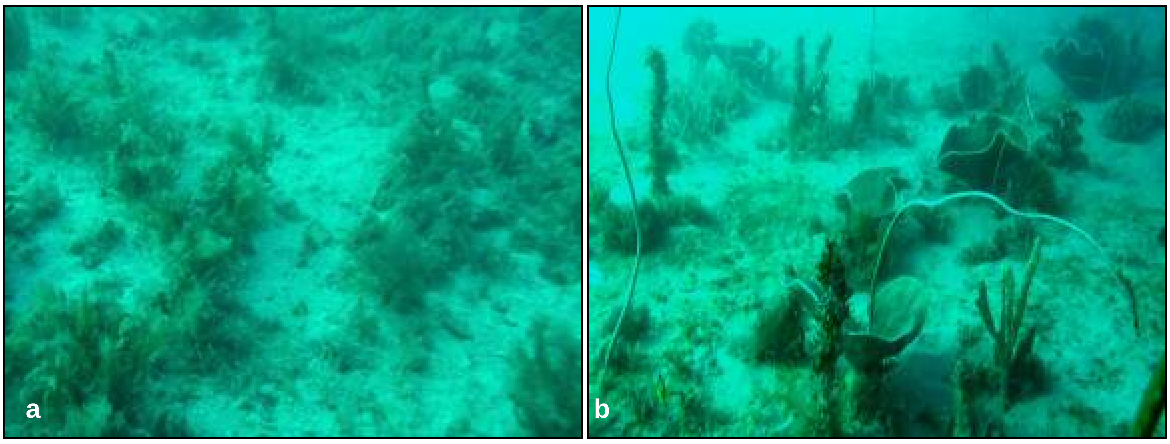


- **Figure 3-12 Combined distribution of the benthic biota in the western area as determined from spline interpolation mapping.**

3.2.2. Northern Area

The biota observed within this area comprised a mix of sessile invertebrates, macroalgae and some hard coral. Biota density was highly variable, with transects closer to shore generally containing a greater density of biota compared with those further offshore (**0**). This was not unexpected given that the substrate in this area was characterised by water depths < 20 m and dominated by a mix of bare sediment and low profile, flat, broken reef structure that was covered by a thin veneer of sand (as also identified from substrate mapping).

Algae (canopy and small) were widespread throughout the area and present along the majority of transects. Similar morphologies and genera that were identified in the western area were also present in the northern area. However, macroalgae coverage was greater in the northern area and there were large areas of dense *Sargassum* spp. (**Figure 3-13**). Sessile invertebrates were similarly widely distributed and present on most transects and dominated by sponges, soft coral, gorgonian fans, sea whips and ascidians. Seagrass was observed adjacent to the northern and southern boundaries of the northern infill survey area, indicating two main areas of seagrass distribution, however densities were always sparse. Common genera were *Halophila* spp. Hard coral was widespread along transects located closer to shore and were observed in densities less than 10% and in a mix with other biota types. Hard coral was dominated by *Turbinaria* spp. and massive morphologies (**Figure 3-13**).



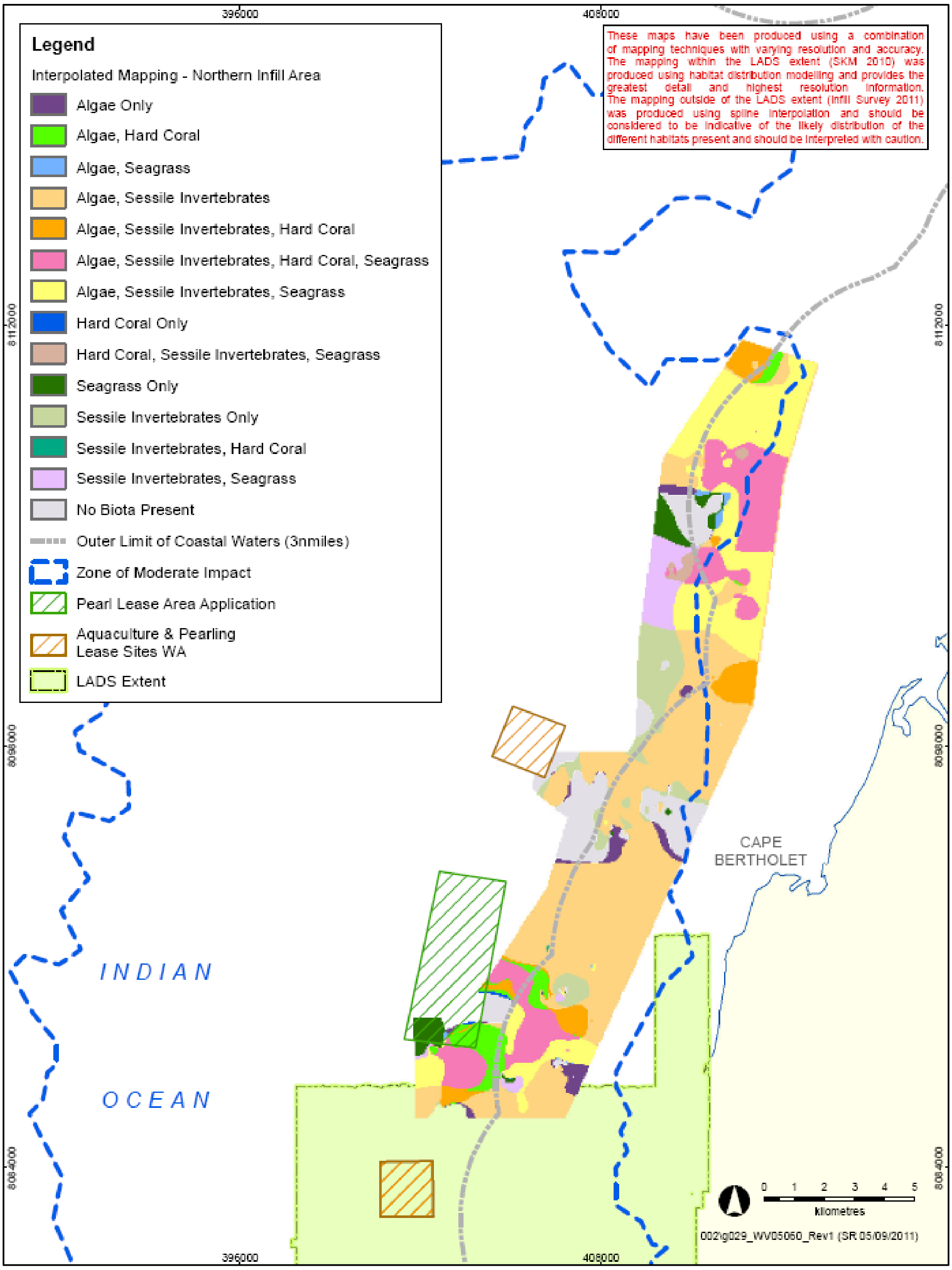
- **Figure 3-13 Images of (a) typical canopy algae habitat (transect 83) and (b) mixed sessile invertebrates with hard coral (transect 38).**

3.2.2.1. Mapping biota within the Northern Area

In the northern area, sessile invertebrates were the most widely distributed biota type and interpolation revealed almost full coverage within the mapping boundary. Sessile invertebrates were frequently observed along the majority of transects and associated distribution is likely to be widespread within this area. Small algae and canopy algae were also observed to a slightly lesser extent than sessile invertebrates. Both canopy algae and small algae had a similar distribution to each other. Small algae were more frequently observed outside of the interpolation boundary in comparison to canopy algae. Therefore, the mapped distribution of small algae extended further to the west. Two defined areas of sparse seagrass were identified to the north and south, although typically as part of a mixed mosaic with other biota types.

Maps presenting the distribution of individual biota types are represented in **Appendix D**. A combined map was produced showing the distribution of the main types, including seagrass, hard coral, sessile invertebrates, canopy algae and small algae and the mixed mosaic of these types (**Figure 3-14**).

Sessile invertebrates were again the dominate biota and the majority of areas contained sessile invertebrates in a mixed mosaic with other biota. For example, algae and sessile invertebrates were widely distributed within the northern area (**Figure 3-14**). There were very few areas that contained a single biota type and where this occurred, it was limited to small areas of algae or seagrass.

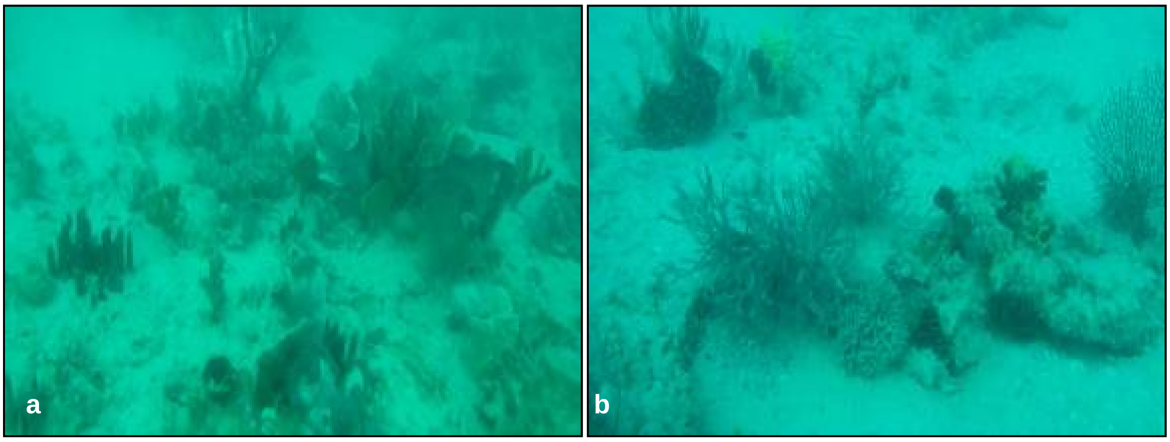


- **Figure 3-14 Combined distribution of the benthic biota in the northern area as determined from spline interpolation mapping.**

3.2.3. Southern Area

Observed biota was typically a mix of sessile invertebrates and hard coral with patches of canopy and small algae (**Figure 3-15**). Biota density was generally sparse with some dense patches (**0**). No seagrass was observed in this area.

As only four transects were surveyed in the southern area, no mapping was undertaken.



- **Figure 3-15 Images of (a) typical mixed sessile invertebrates and (b) hard coral habitat from the southern infill area (transect 143).**

3.2.4. Combining current and previous mapping outputs

The interpolated mapping outputs were displayed in combination with the previous predictive modelling outputs (SKM, 2010) (**Figure 3.16**). This allowed for an overall visualisation of the mapping produced to date in the region of James Price Point. As the mapping techniques for the two studies varied, due to the availability of data, the outputs are of varying spatial resolution and are not directly comparable. However, the combined map provides an interpretation of the various benthic biota present, including BPPH and Sessile Invertebrates (BPP and non-BPP) for the entire James Price Point coastal area.

As stipulated, these maps should be interpreted with caution given the varying scales of information and techniques used. For example, seagrass distribution was not mapped in 2010 due to limited sampling points available for high resolution predictive mapping across the extent of the LADS data (see SKM, 2010). Hence seagrass categories are not included in the legend contained in previous predictive modelling outputs (SKM, 2010) in **Figure 3.16**. In 2011 sparse seagrass was observed from a limited number of video transects in the northern infill area. These data have been used to broadly interpolate where sparse seagrass may be found mixed with other biota within infill areas, hence biota combinations for the two survey outputs are marginally different.

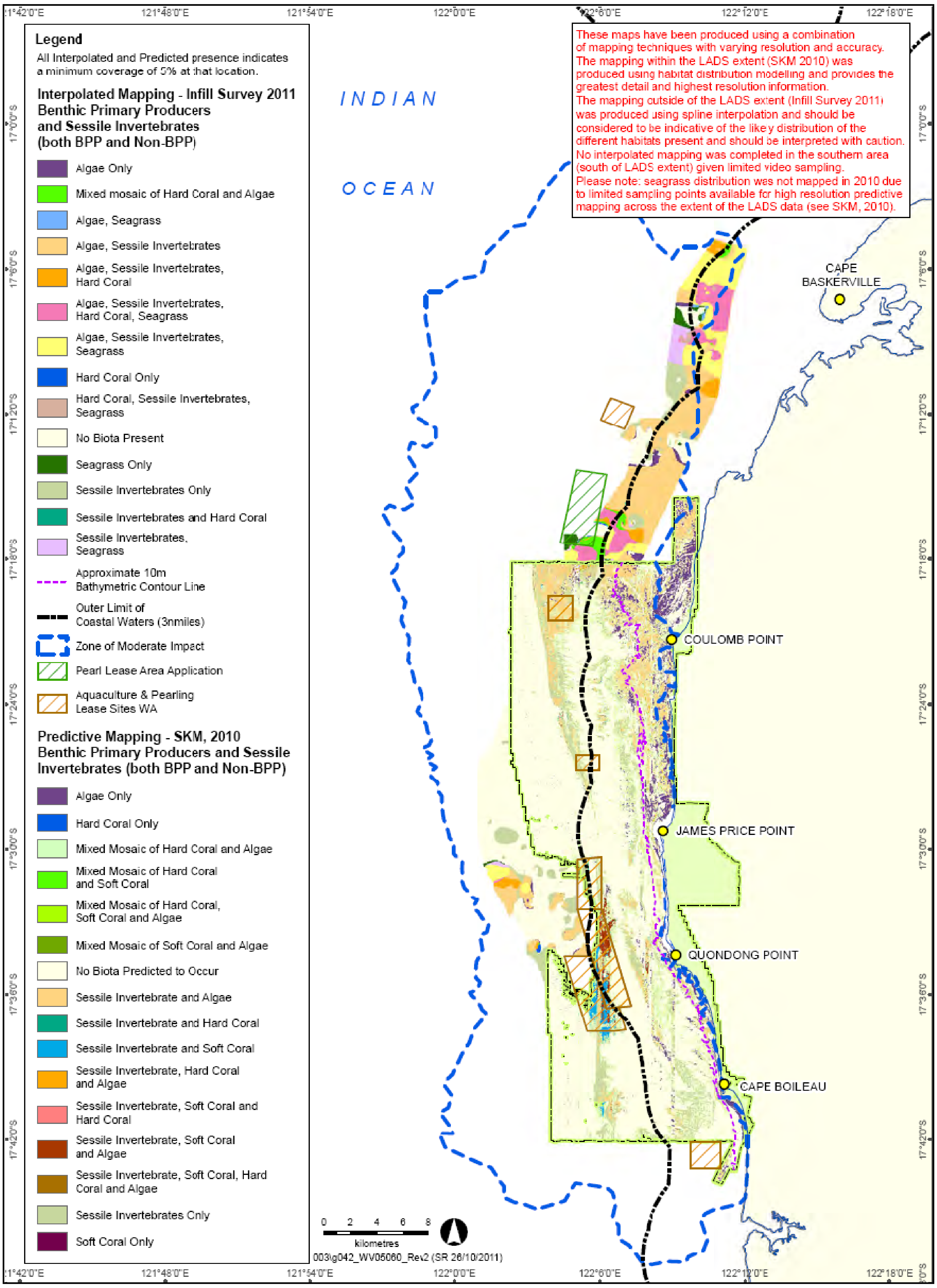


Figure 3-16 Benthic habitats off James Price Point as described from predictive modelling (SKM, 2010) and interpolation mapping.

4. Discussion

The substrate and biota types observed across the infill survey areas were similar to, and consistent with those identified from previous mapping surveys completed in the region (Fry *et al.*, 2008; SKM 2010). The main substrate types observed across the infill survey areas consisted of flat, bare sediment or sediment inundated hard substrate with little topographic complexity. The dominant biota types consisted of sessile invertebrates (mainly filter feeding organisms) and a mix of small and canopy algae with cover varying from sparse to dense. Only sparsely distributed, patchy seagrass and hard coral were observed.

The key findings from the survey included:

- Few areas of low profile hard substrate were identified within the infill survey areas and no areas of high profile hard substrate were identified from either the sidescan or towed video data. These types of reef typically contain hard corals, considered the most sensitive to the effects of dredging.
- A mixed mosaic habitat of macroalgae, seagrass, hard coral and sessile invertebrates were found throughout. Sessile invertebrates (mainly filter feeders) were the most widely distributed biota type.
- Hard coral and seagrass, which are considered sensitive receptors to dredging effects, were typically patchy and sparsely distributed, when observed.
- The western area and southern area were dominated by sediment and sparse sessile invertebrates, which was consistent with previous high resolution mapping adjacent to the area (SKM, 2010)
- The northern area is dominated by sediment inundated low profile hard substrate with medium density mixed mosaic of sessile invertebrates and algae.
- The substrate types and biota observed across the infill survey areas are similar to adjacent areas mapped in previous surveys

The observed substrate types within the western infill survey area are also consistent with and corresponded to the existing bathymetric data and mapping (SKM, 2010). No differences were observed. The previous mapping identified the areas to the west of James Price Point consisted of bare sediment with limited distribution of sessile invertebrates. Although employing a different survey and mapping technique, the infill survey data confirmed this pattern continued into the deeper water at the western edge of the Zone of Moderate Impact. The composition and distribution of sessile invertebrates in this study was similar to that observed in the previous mapping (SKM, 2010). This biota group was generally observed in isolation in sparse/medium density (5-50%) and dominated by sponges, gorgonian fans, sea whips and soft corals. Interpolated maps indicate that

sessile invertebrates are widely distributed and represent the dominant biota in the western infill area.

Substrate types within the northern area are dominated by sediment inundated low profile reef to the east and sediment only to the west. The existing mapping identified an area of hard, low profile substrate and mixed biota to the north of Coulomb Point (SKM, 2010). As this low profile feature extended to the limits of the previous mapping, the full extent of the feature had not previously been mapped. The infill survey data showed that this feature occurred in the area immediately north of the previous mapping extent, but that it only extended approximately 3–4 km beyond the boundary of the two surveys.

The observed benthic biota within the northern infill area was similar in composition to those previously observed in the northern extent of the previous mapping (SKM, 2010). A mixed mosaic habitat generally containing small algae, canopy algae and sessile invertebrates (filter feeders such as sponges, gorgonians, sea whips and ascidians) was identified. As previously identified, there were some dense areas of the canopy algae *Sargassum* spp. Small algae were similarly dominated by previously observed morphologies and genus such as *Caulerpa* spp. and *Halimeda* spp.

Sparsely distributed seagrass and hard coral were observed in the northern area, with seagrass growing on areas of sediment inundated reef. Densities were generally less than 25% and patchily distributed amongst other biota. Hard coral were dominated by *Turbinaria* spp. and seagrass by *Halophila* spp. This combination of biota types, although observed in previous video surveys, was not mapped previously, due to the limitations of modelling seagrass distributions with previous data (SKM, 2010).

Overall, the benthic biota mapped formed mosaic habitats that became increasingly patchy and sparse heading north and west, with comparably less biota outside state waters compared to within state waters. This was evident by a gradual reduction in the density of biota along transects from east to west, particularly for macroalgae, and an increase in the presence of bare sediment.

The physical substrate and biota observed and mapped within the infill study areas were also indicative of the benthic habitats previously identified across the wider region (Fry *et al*., 2008) and do not show any unique or local examples of difference. For example, benthic habitats in the Kimberley region are characterised by the presence of mixed communities, typically consisting of complex habitats of hard coral, interspersed among filter feeding communities such as ascidians, sponges and algae (Fry *et al*., 2008). Similarly, macroalgae communities are common and well represented throughout the region. The overall distribution of seagrass in the region is poorly documented but appears to be generally patchy and sparse with isolated areas of denser seagrass usually consisting of *Halophila* spp.

The interpolation and point buffering approaches have produced habitat maps that are considered representative of the distribution of benthic habitats in the infill survey areas. Compared to the existing mapping (SKM, 2010), the maps produced in this study are of a coarser resolution and do not provide the same level of spatial accuracy. However, while this means that they should be interpreted with caution, the maps are considered to be conservative. This is because the methods used will likely over estimate the distribution and extent of the benthic habitats present. However, the exercise has enabled broad scale evaluation of seabed features of interest and identification of the types of habitats that may be sensitive to potential dredging impacts.

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5. Conclusion

The results of this study indicated that the benthic habitats observed in the infill survey areas were consistent with those previously identified and mapped (SKM, 2010). Observed seabed features were similar to those previously sampled and with little high profile reef features. Sediment inundated low profile reef or sediment only was widespread throughout the infill survey areas. Overall, benthic habitats contained a mix of biota, including macroalgae, hard coral and sessile invertebrates. Sessile invertebrates were the dominant and most diverse biota, while seagrass and hardcoral were the least densely distributed. Biota growing on hard substrates were more likely to be found within state waters in the northern infill survey area. In comparison, the western area was dominated by sediment and sparse sessile invertebrates.

No significant seabed features (high profile hard substrate) or habitats were identified during the infill survey. Given the nature of these geological features, it is considered likely that the surveys undertaken to date have presented a representative picture of the different seabed features and benthic habitats present across the ZOMI. The collected substrate and biota data has also demonstrated a high correlation with the previous habitat mapping work (SKM, 2010) and the observed patterns of distribution extending beyond previously mapped areas.

The combined mapping outputs provide a realistic, but conservative representation of the likely distribution of the different benthic habitats across the ZOMI. However, as the map consists of outputs from different methods with different resolutions and limitations, boundaries between the different habitats should be considered indicative only and be interpreted with caution.

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Appendix A

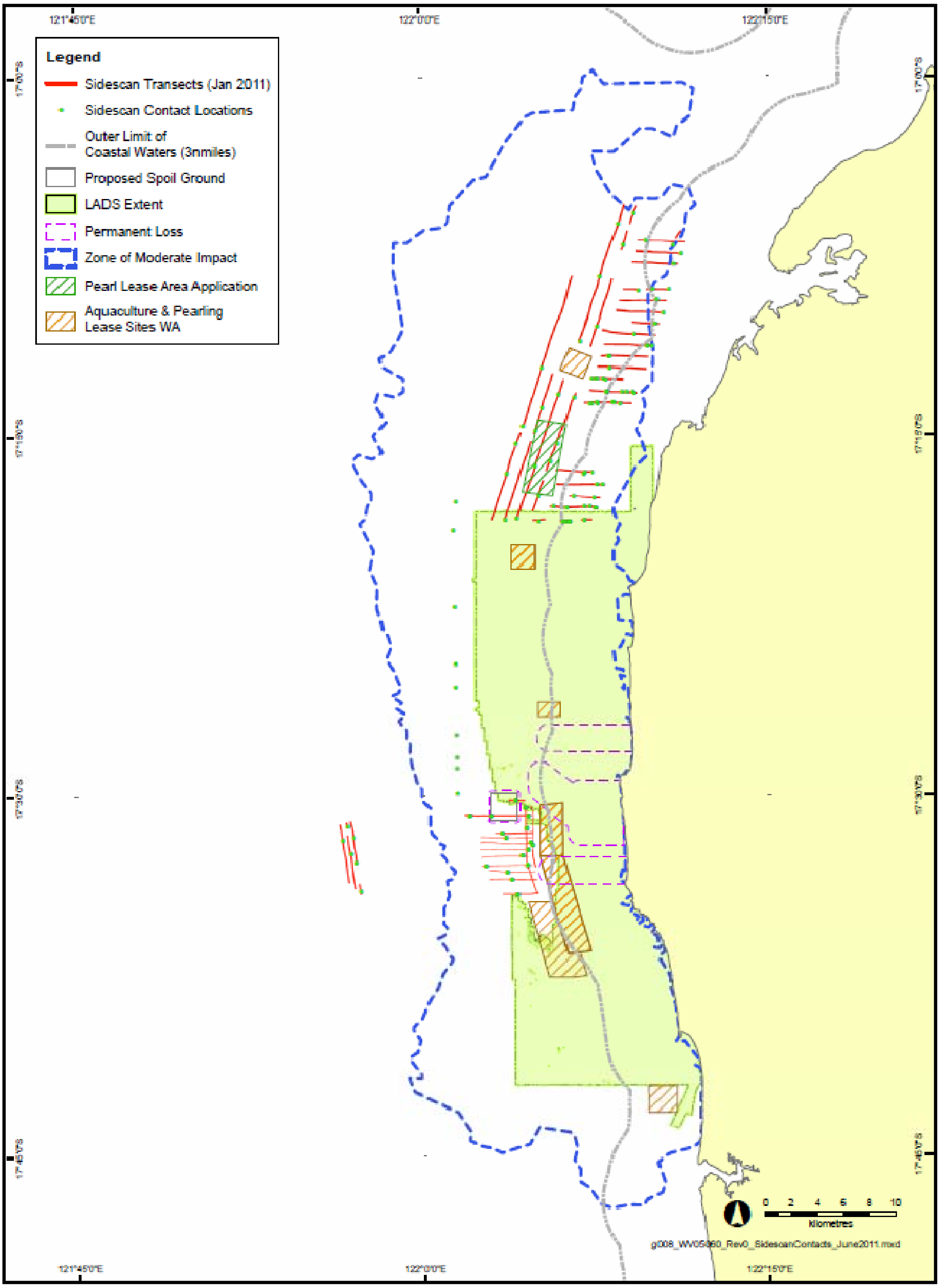
A.1 Description of Sidescan Sonar Contacts

Infill Area	Name	Description
Northern Area	Contact0000	isolated unknown
Northern Area	Contact0001	area of mottled appearance sediment / broken up reef
Northern Area	Contact0002	area showing three distinct types of seabed, probably coarse and fine sediment and low profile reef
Northern Area	Contact0003	isolated object up to 75cm height
Northern Area	Contact0004	higher profile features
Northern Area	Contact0005	higher profile features
Northern Area	Contact0006	target relief
Northern Area	Contact0007	target relief
Northern Area	Contact0008	target relief
Northern Area	Contact0009	target relief
Northern Area	Contact0010	isolated target and diversity of seabed types
Northern Area	Contact0011	notice distinct differences in seabed type from more rugose reef to sediment and low profile reef
Northern Area	Contact0012	low profile reef with gutters of sediment
Northern Area	Contact0013	seabed appears different to other low profile reef
Northern Area	Contact0014	highly defined target reef or manmade object
Northern Area	Contact0015	unusual seabed feature
Northern Area	Contact0016	unusual seabed feature
Northern Area	Contact0017	isolated target
Northern Area	Contact0018	isolated target
Northern Area	Contact0019	isolated target
Northern Area	Contact0020	area of high profile reef and diversity of seabed type
Northern Area	Contact0021	line generally very low profile reef. Shows area of sediment in reef.
Northern Area	Contact0022	all of line similar appearance
Northern Area	Contact0023	All line similar appearance some higher profile features
Northern Area	Contact0024	moderate profile reef area
Northern Area	Contact0025	shows diversity of seabed types
Northern Area	Contact0026	boundary between higher profile reef and mottled looking imagery characteristic of sediment of the area
Northern Area	Contact0027	some potential higher profile reef and patchy sediment
Northern Area	Contact0028	higher profile to sediment
Northern Area	Contact0029	possible low profile reef with heavily rippled sediment
Northern Area	Contact0030	sediment ripples
Northern Area	Contact0031	indistinct low profile reef features
Northern Area	Contact0032	defined slump or boundary in sediment

Northern Area	Contact0033	undulating sedimentary features throughout line with sedimentary features
Northern Area	Contact0034	typical indiscriminate features of this line
Northern Area	Contact0035	ripples amongst typical seabed
Northern Area	Contact0036	typical seabed imagery for line
Northern Area	Contact0037	shows how seabed sediment ripples can be responsible for differences in intensity
Northern Area	Contact0038	typical imagery for this line
Northern Area	Contact0039	typical imagery for this line, changes in sediment type
Northern Area	Contact0040	typical for southern end of line possibly low profile reef
Northern Area	Contact0041	typical sediment features for northern end of line
Northern Area	Contact0042	typical seabed and isolated target
Northern Area	Contact0043	typical sediment features of area
Northern Area	Contact0044	typical sediment features of area
Northern Area	Contact0045	typical seabed features with isolated target
Northern Area	Contact0046	typical seabed features of line
Northern Area	Contact0047	typical sediment features of line
Northern Area	Contact0048	typical sediment features of line
Northern Area	Contact0049	typical sediment features of line showing isolated targets
Northern Area	Feature0000	line low profile reef sediment
Northern Area	Feature0001	line low profile reef sediment
Northern Area	Feature0002	more defined rugosity
Northern Area	Feature0003	line low profile reef sediment
Northern Area	Feature0004	line low profile reef sediment
Northern Area	Feature0005	low profile reef appears more defined
Northern Area	Feature0006	line low profile reef sediment
Northern Area	Feature0007	line low profile reef sediment
Northern Area	Feature0008	line low profile reef sediment
Northern Area	Feature0009	line low profile reef sediment
Northern Area	Feature0010	low profile reef appears more defined
Northern Area	Feature0011	mottled area mixed
Northern Area	Feature0012	low profile reef appears more defined
Northern Area	Feature0013	line low profile reef sediment
Northern Area	Feature0014	line low profile reef sediment
Northern Area	Feature0015	line low profile reef sediment
Northern Area	Feature0016	low profile reef appears more defined
Northern Area	Feature0017	low profile reef appears more defined
Northern Area	Feature0018	line low profile reef sediment
Northern Area	Feature0019	line low profile reef sediment
Northern Area	Feature0020	line low profile reef sediment

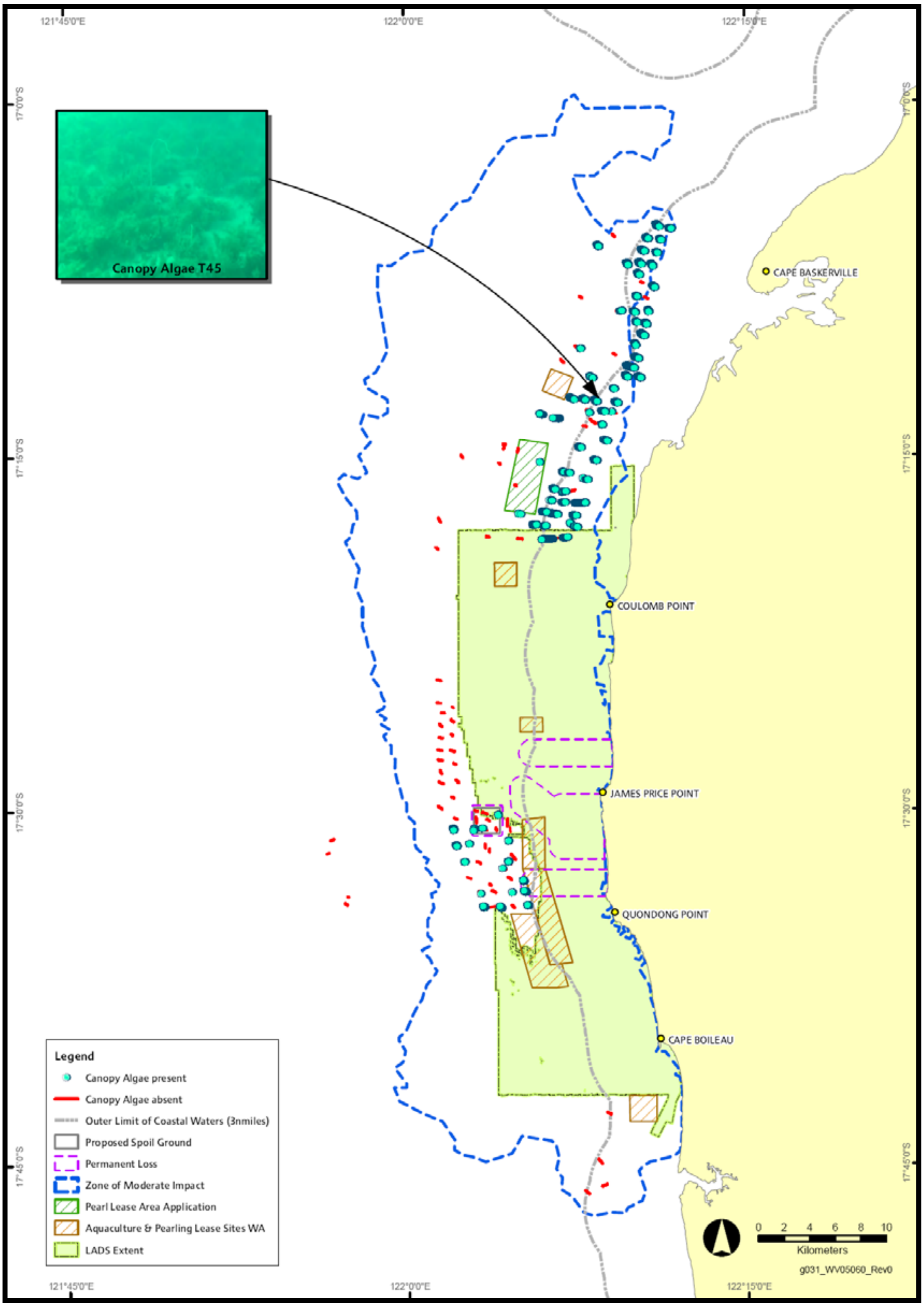
Northern Area	Feature0021	line low profile reef sediment
Northern Area	Feature0022	line low profile reef sediment
Northern Area	Feature0023	line low profile reef sediment
Northern Area	Feature0024	line low profile reef sediment
Western Area	Contact0000	rippled sediment amongst flatter sediment
Western Area	Contact0001	rippled and smoother sediment patterns
Western Area	Contact0002	rippled and smooth sediment patterns
Western Area	Contact0003	patterns of different sediment morphology rippled smooth
Western Area	Contact0004	patterns of differing sediment morphology / texture
Western Area	Contact0005	appears generally to be patterns of sediment morphology
Western Area	Contact0006	appears to be patterns in sediment morphology.
Western Area	Contact0007	appears to be patterns of sediment
Western Area	Contact0008	Possibly differing patterns in sediment morphology.
Western Area	Contact0010	Likely to be patterns in sediment morphology
Western Area	Contact0011	Likely to represent patterns in sediment morphology.
Western Area	Contact0012	likely to be patterns of sediment morphology with possible some relief
Western Area	Contact0013	patterns in sediment type
Western Area	Contact0014	patterns in sediment type or morphology, possible light relief
Western Area	Contact0015	patterns in sediment type, possible light relief
Western Area	Contact0016	patterns in sediment morphology, possible light relief
Peanut	Contact0000	appears featureless sediment
Peanut	Contact0001	possible changes in sediment morphology
Peanut	Contact0002	shows how water column features can appear as seabed features
Peanut	Contact0003	unclear or indiscriminate sediment morphology
Peanut	Contact0004	flat featureless seabed
Peanut	Contact0005	probably featureless sediment

A.2 Location of Sidescan Sonar Transects and Contacts

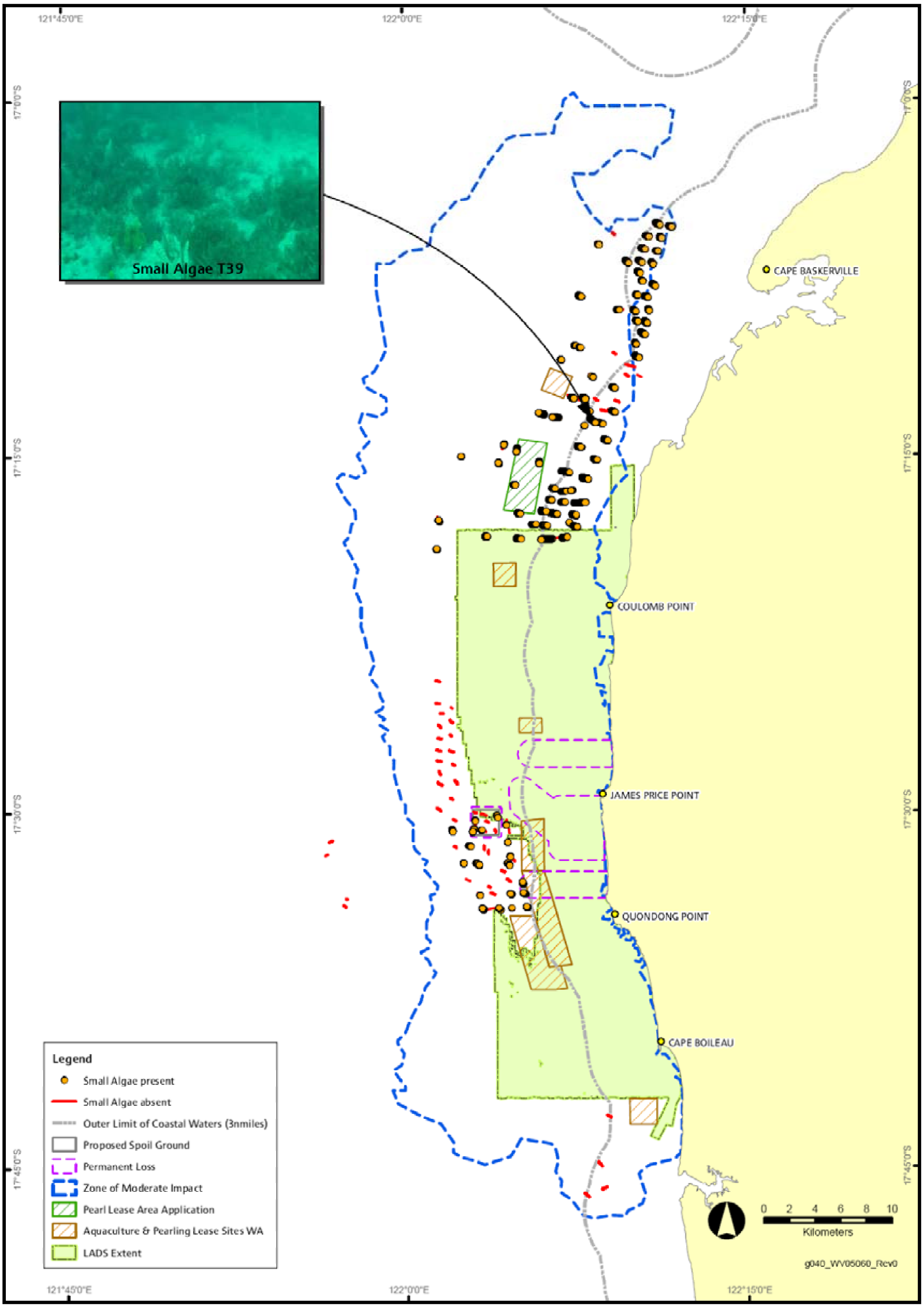


Appendix B Distribution of the Main Biota Types Along Video Transects

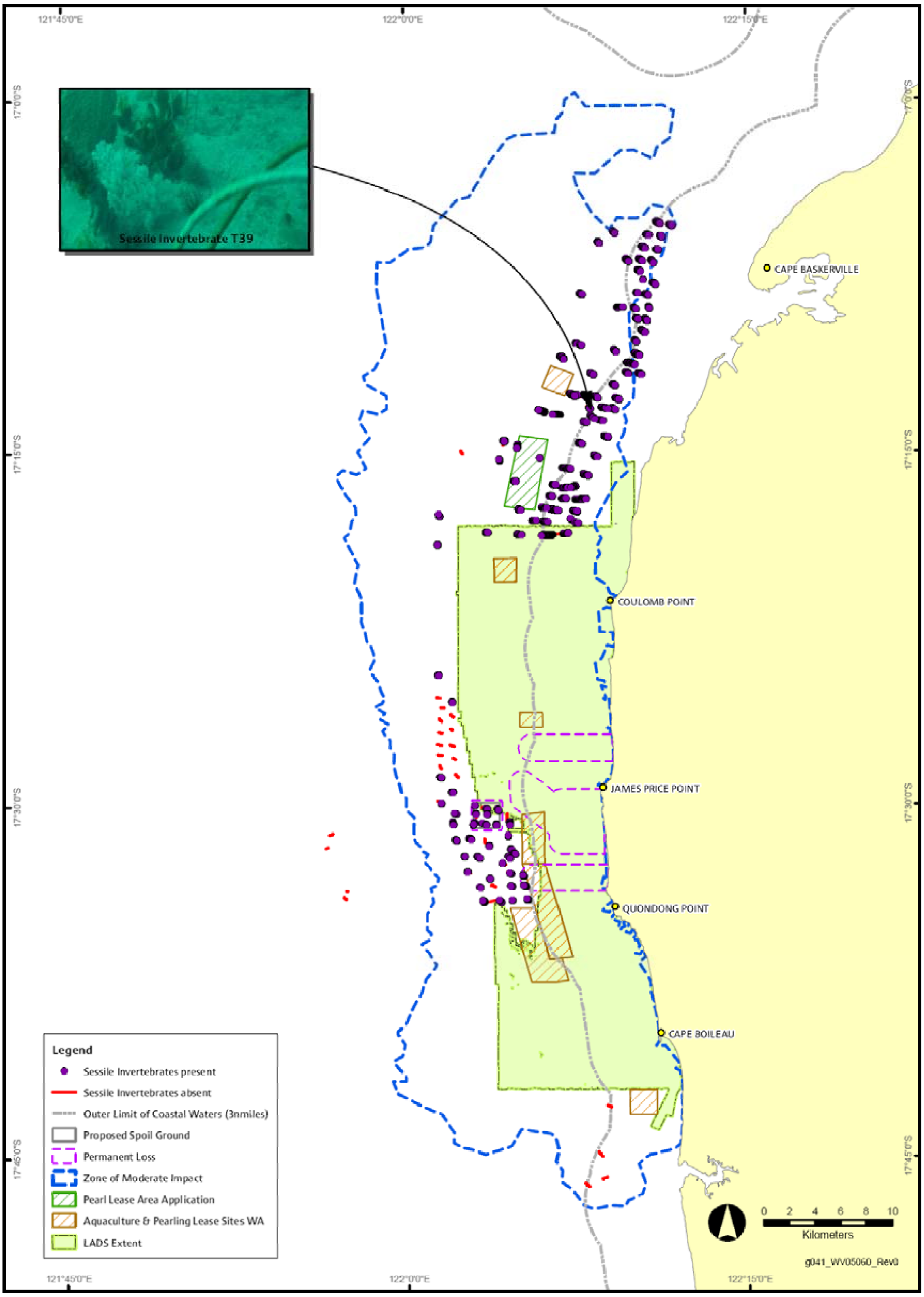
B.1 Canopy Algae



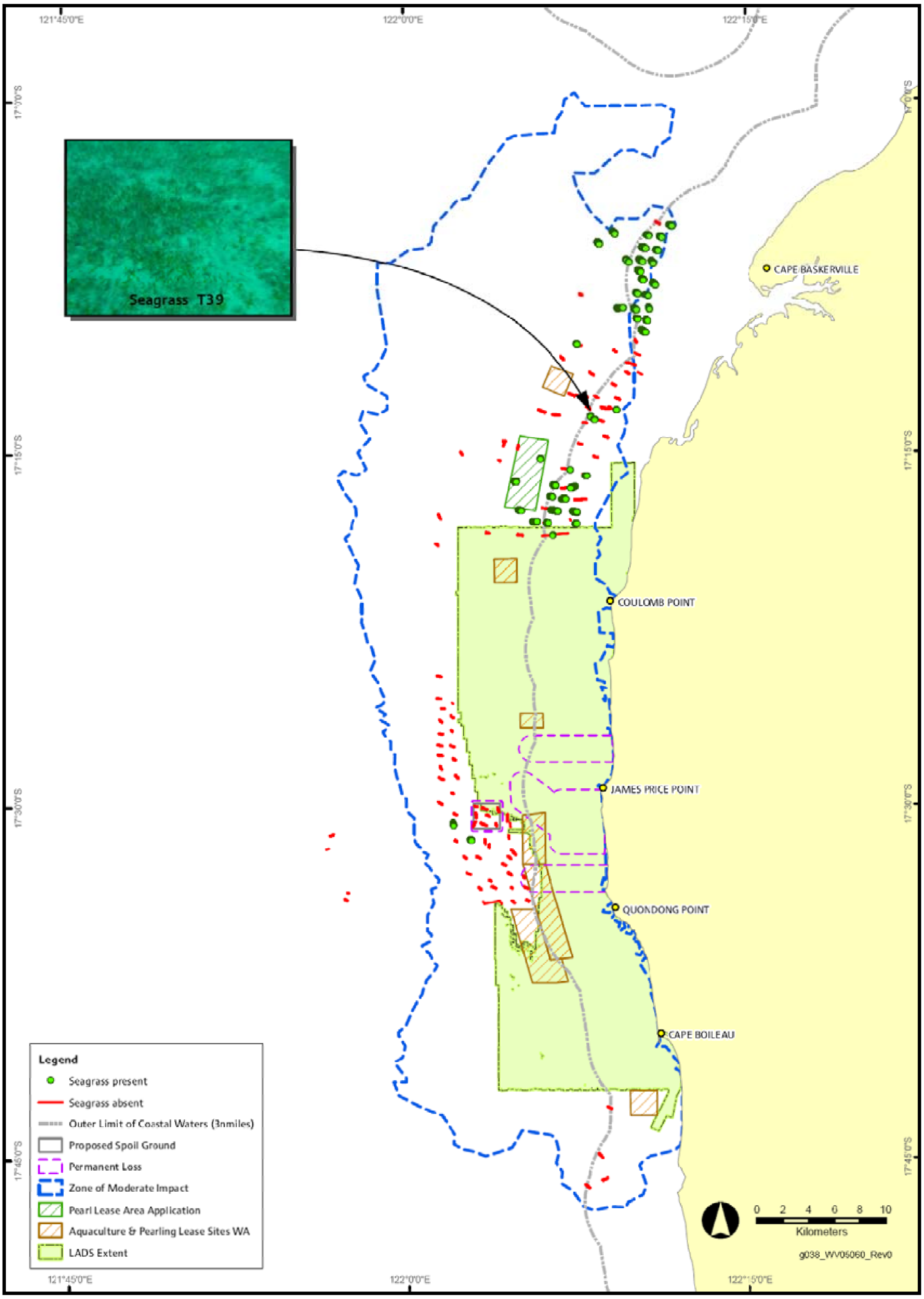
B.2 Small Algae



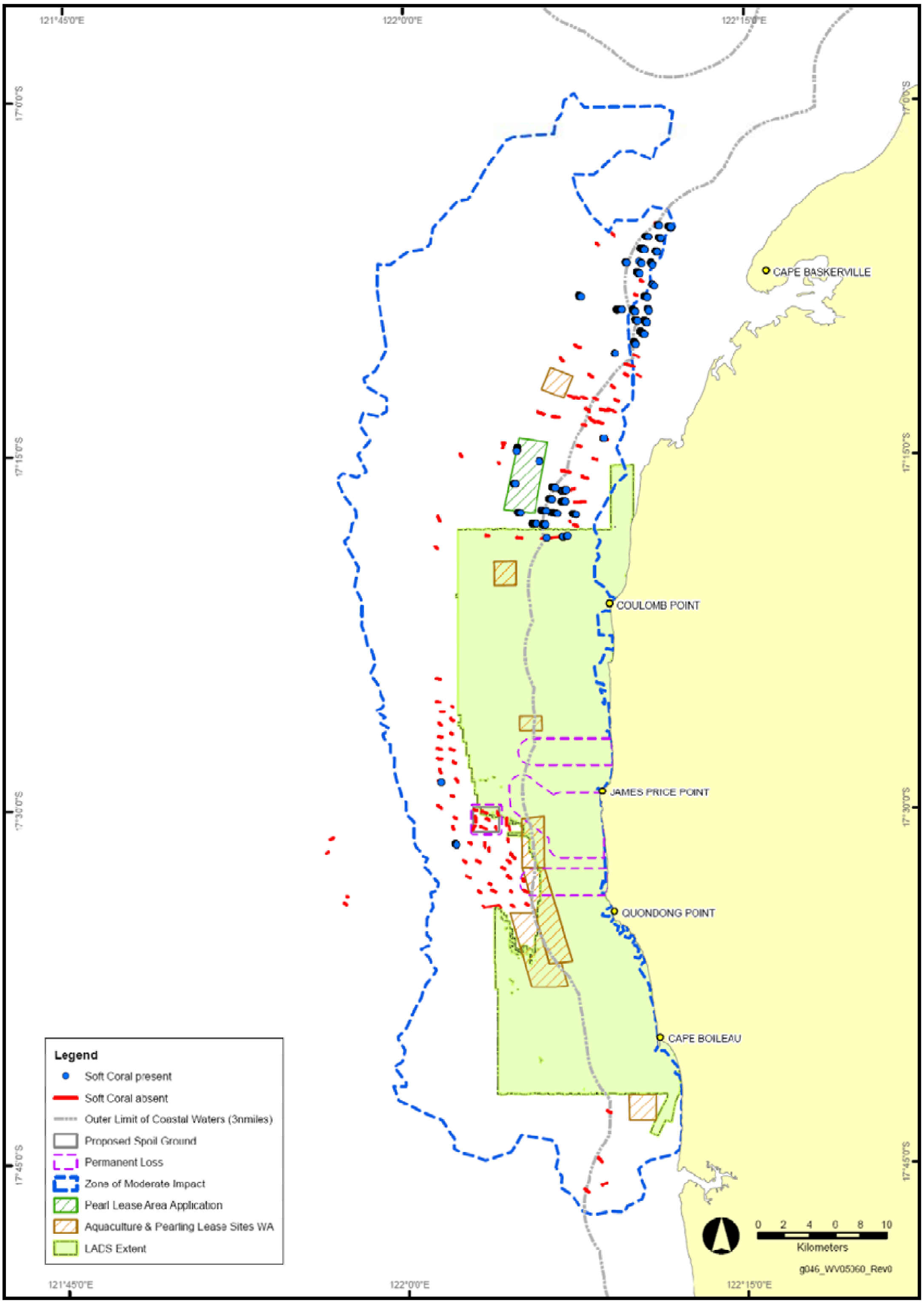
B.3 Sessile Invertebrates



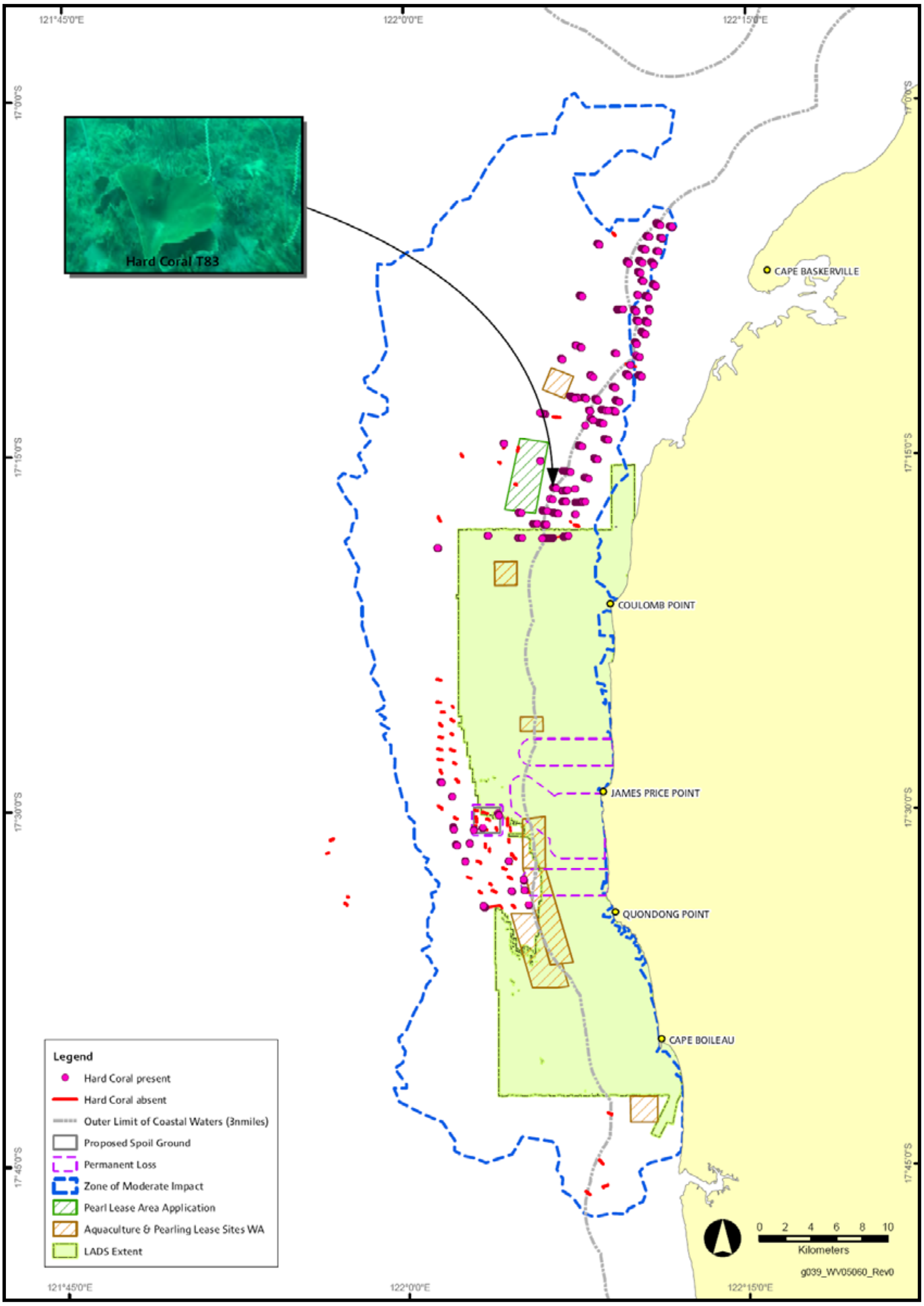
B.4 Seagrass


121°45'0"E
122°0'0"E
122°15'0"E
17°0'0"S
17°15'0"S
17°30'0"S
17°45'0"S
Seagrass T39
CAPE BASKERVILLE
COULOMB POINT
JAMES PRICE POINT
QUONDONG POINT
CAPE BOILEAU
Legend
Seagrass present
Seagrass absent
Outer Limit of Coastal Waters (3nmiles)
Proposed Spoil Ground
Permanent Loss
Zone of Moderate Impact
Pearl Lease Area Application
Aquaculture & Pearling Lease Sites WA
LADS Extent
0 2 4 6 8 10
Kilometers
g038_WV05060_Rev0

B.5 Soft Coral



B.6 Hard coral



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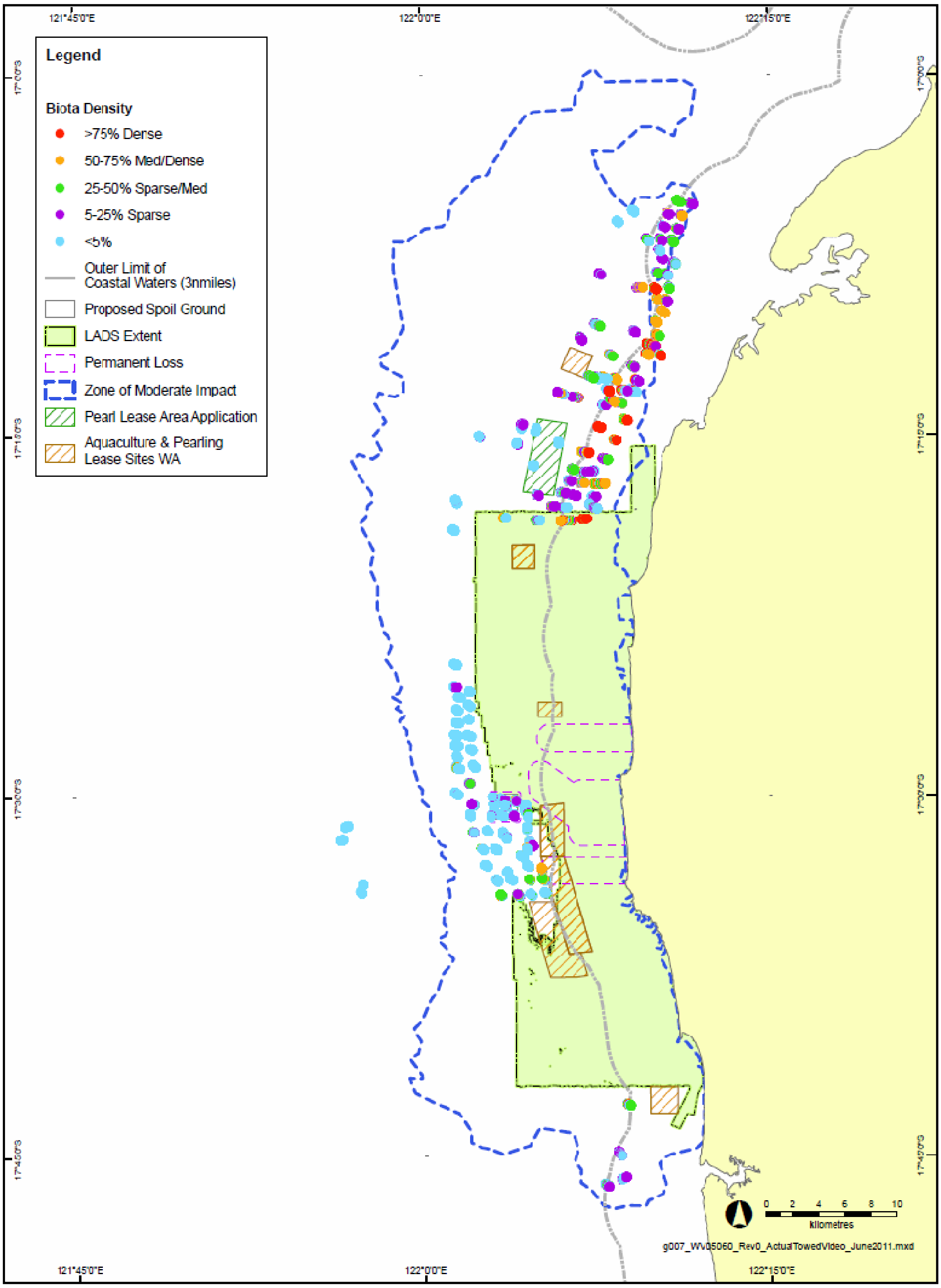
Appendix C Combined Biota Density


121°45'0"E
122°0'0"E
122°15'0"E
17°0'0"S
17°15'0"S
17°30'0"S
17°45'0"S
Legend
Biota Density
>75% Dense
50-75% Med/Dense
25-50% Sparse/Med
5-25% Sparse
<5%
Outer Limit of Coastal Waters (3nmiles)
Proposed Spoil Ground
LADS Extent
Permanent Loss
Zone of Moderate Impact
Pearl Lease Area Application
Aquaculture & Pearling Lease Sites WA
0 2 4 6 8 10
kilometres
g007_WV05060_Rev0_ActualTowedVideo_June2011.mxd

Appendix D Interpolation of Biota Boundaries in the Western Area

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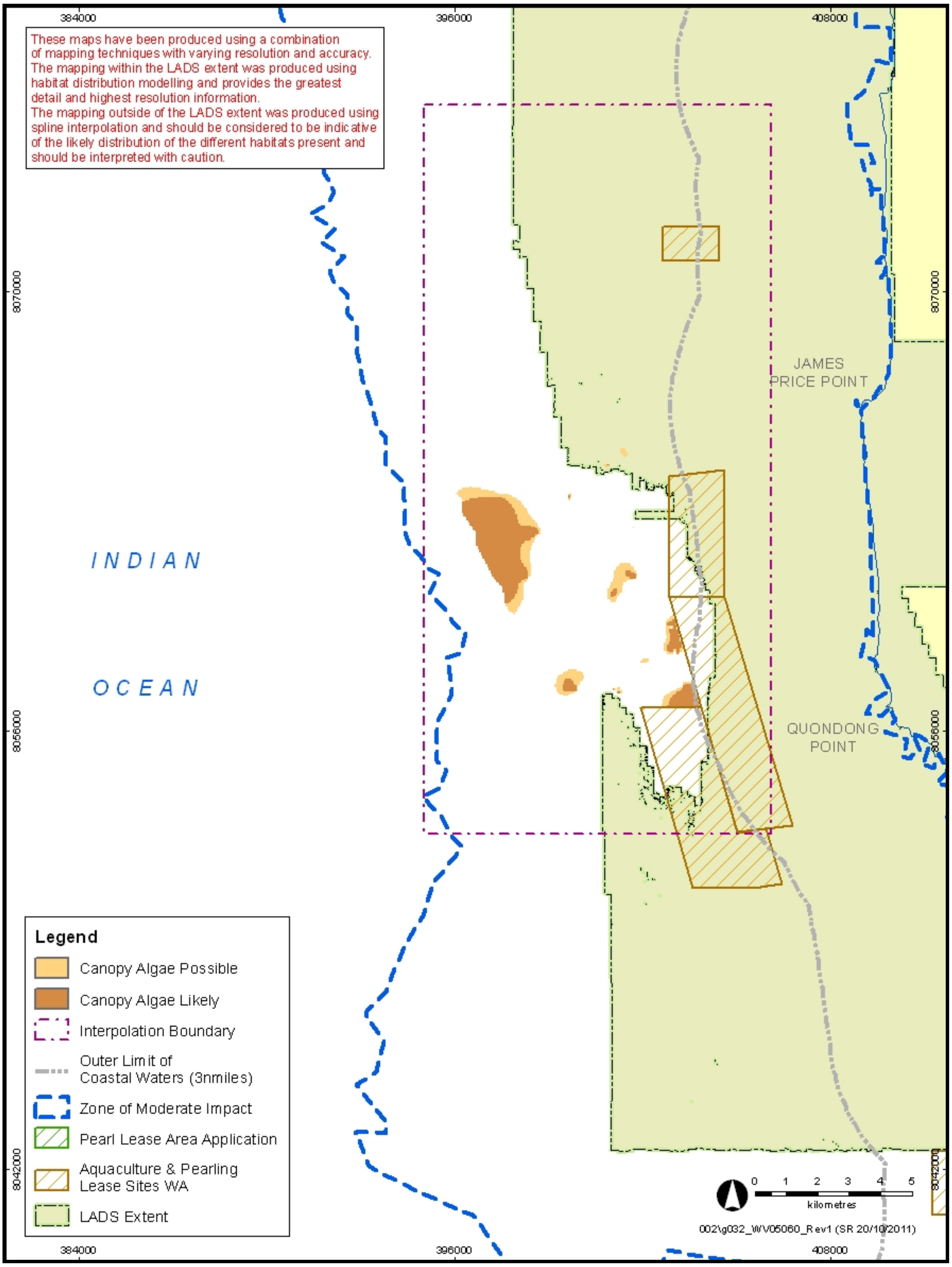
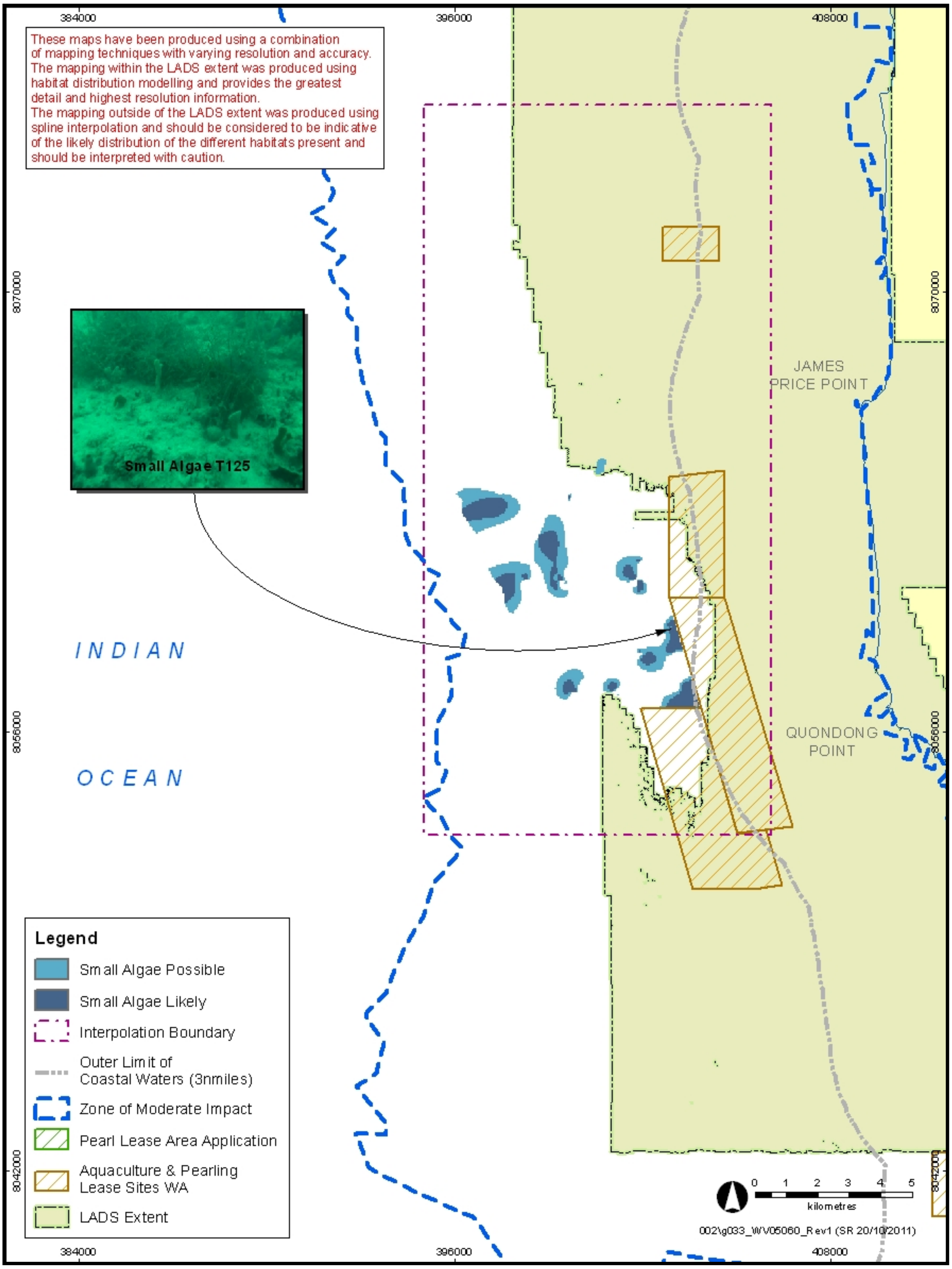
Canopy Algae – Interpolated boundaries of possible and likely distribution in western area

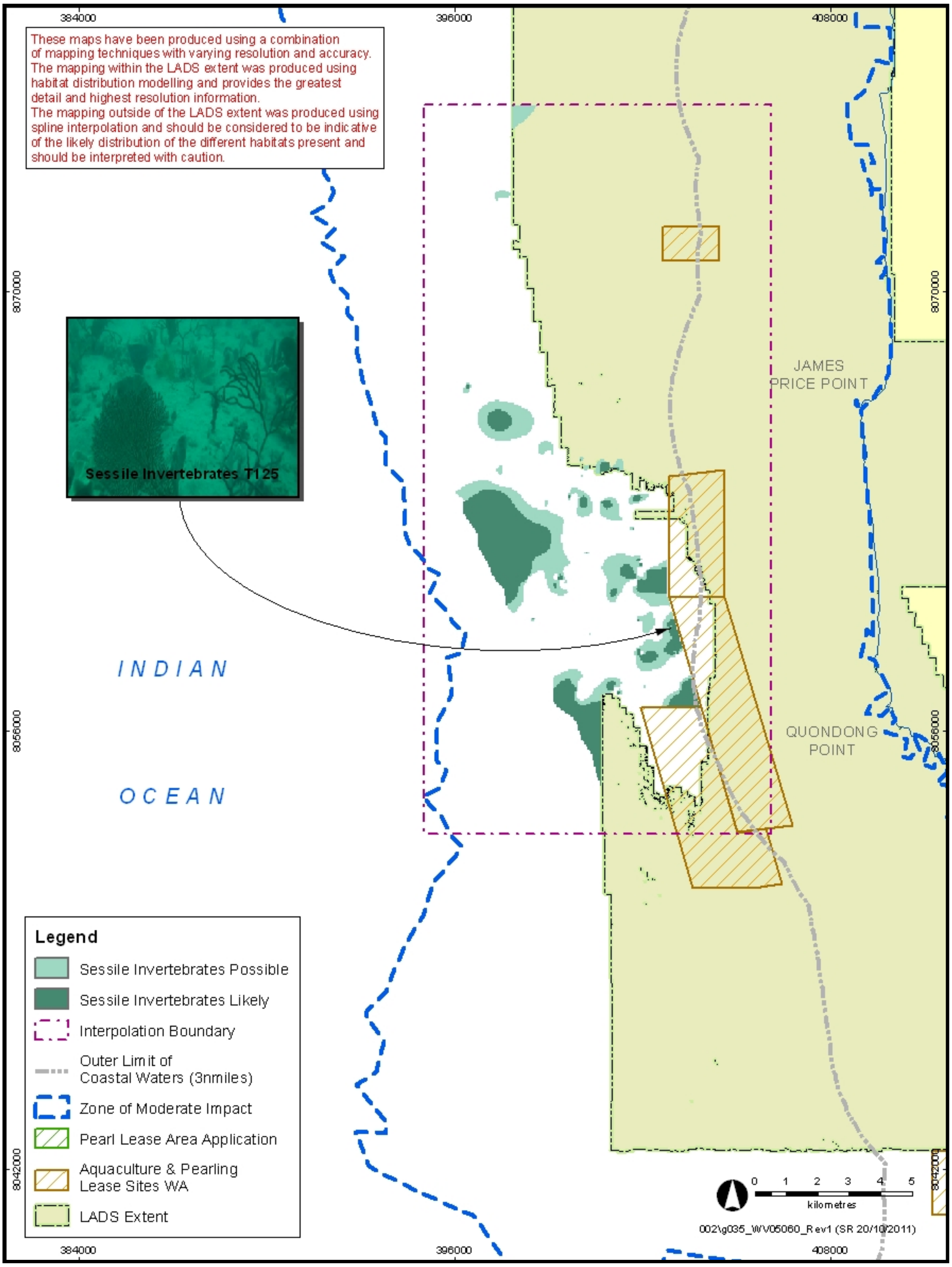


D.1 Small Algae - Interpolated boundaries of possible and likely distribution in western area

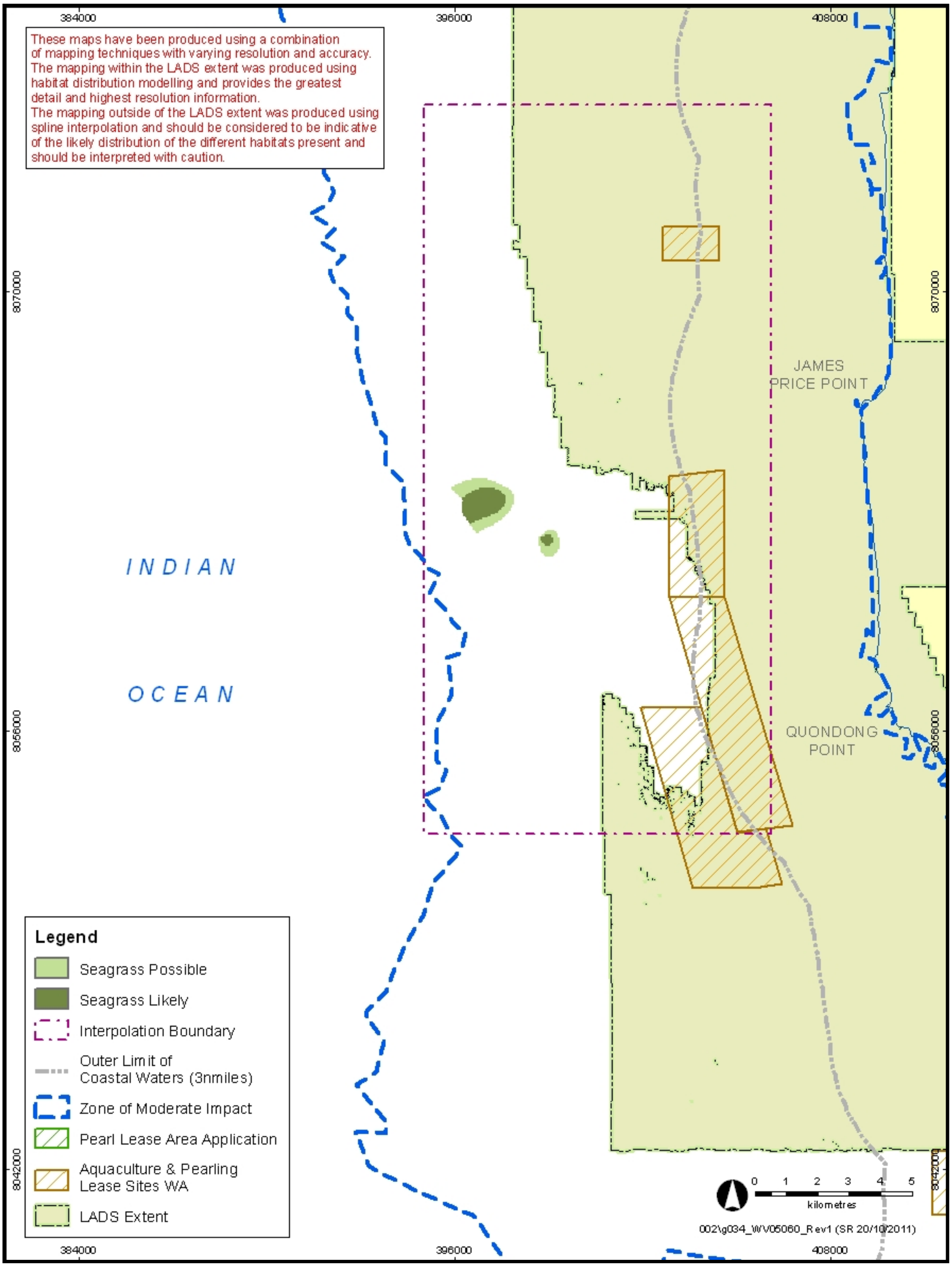


SINCLAIR KNIGHT MERZ SKM

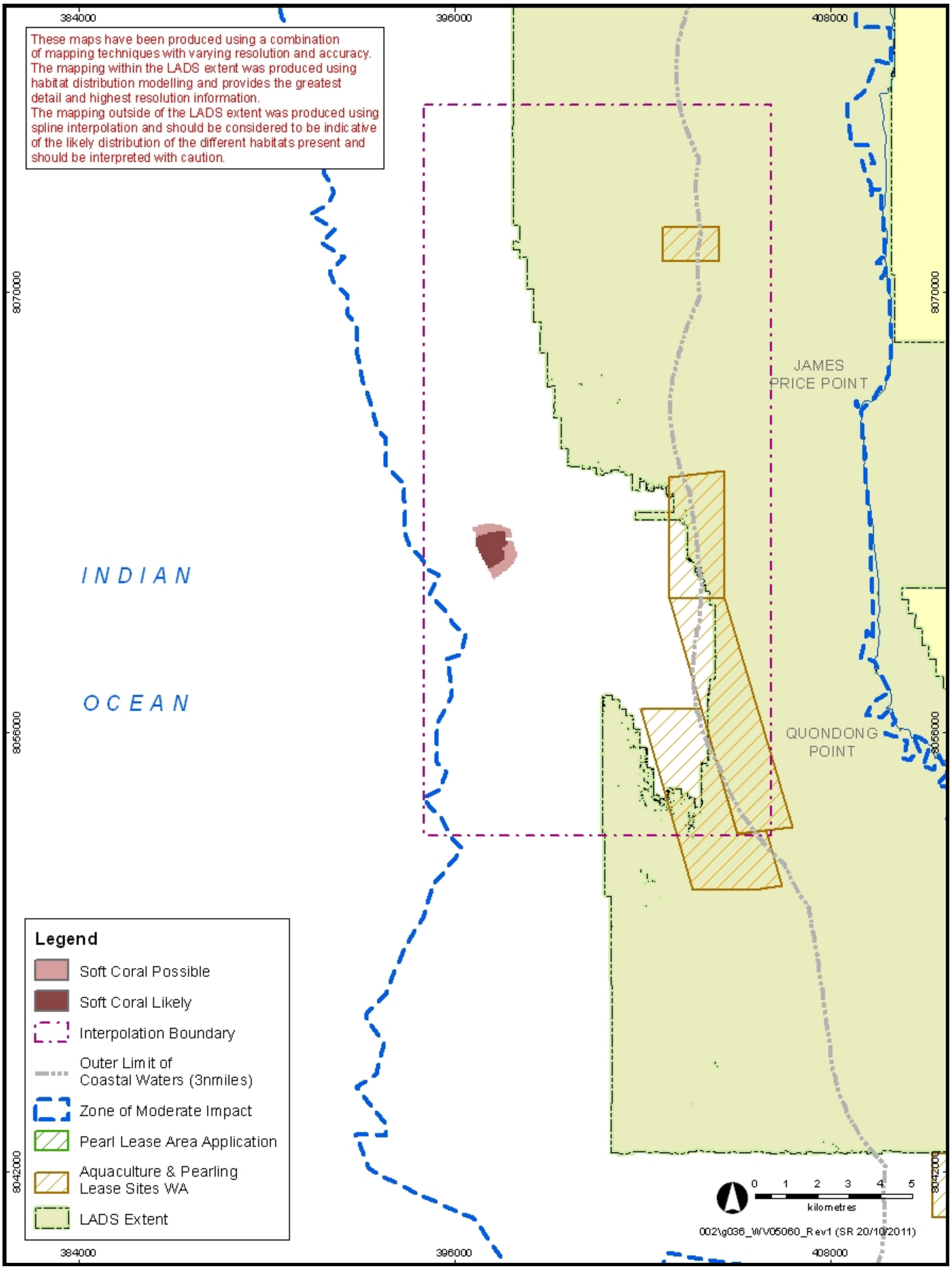
D.2 Sessile Invertebrates - Interpolated boundaries of possible and likely distribution in western area



D.3 Seagrass - Interpolated boundaries of possible and likely distribution in western area

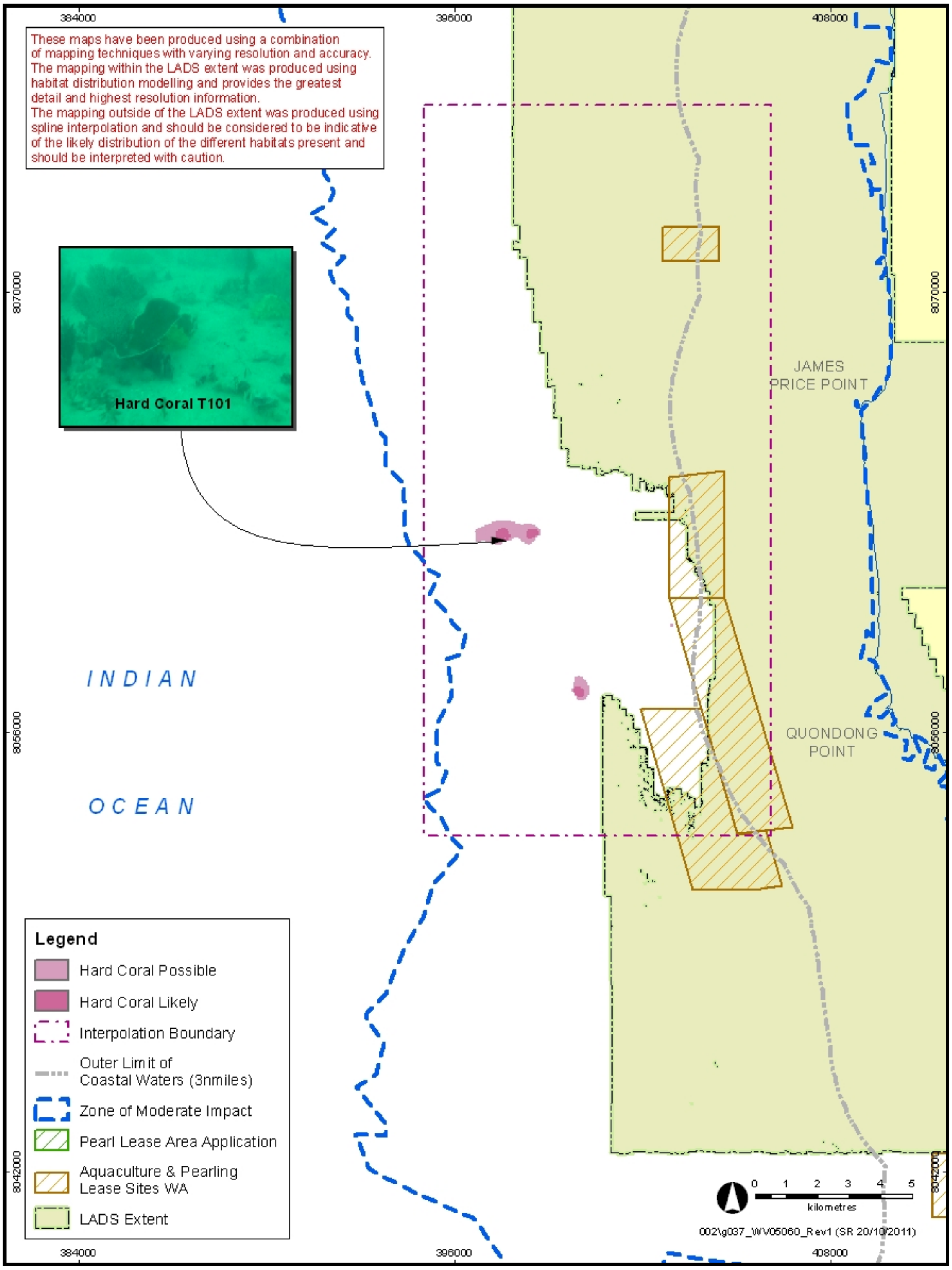


D.4 Soft coral - Interpolated boundaries of possible and likely distribution in western area



SKM SINCLAIR KNIGHT MERZ

D.5 Hard Coral - Interpolated boundaries of possible and likely distribution in western area



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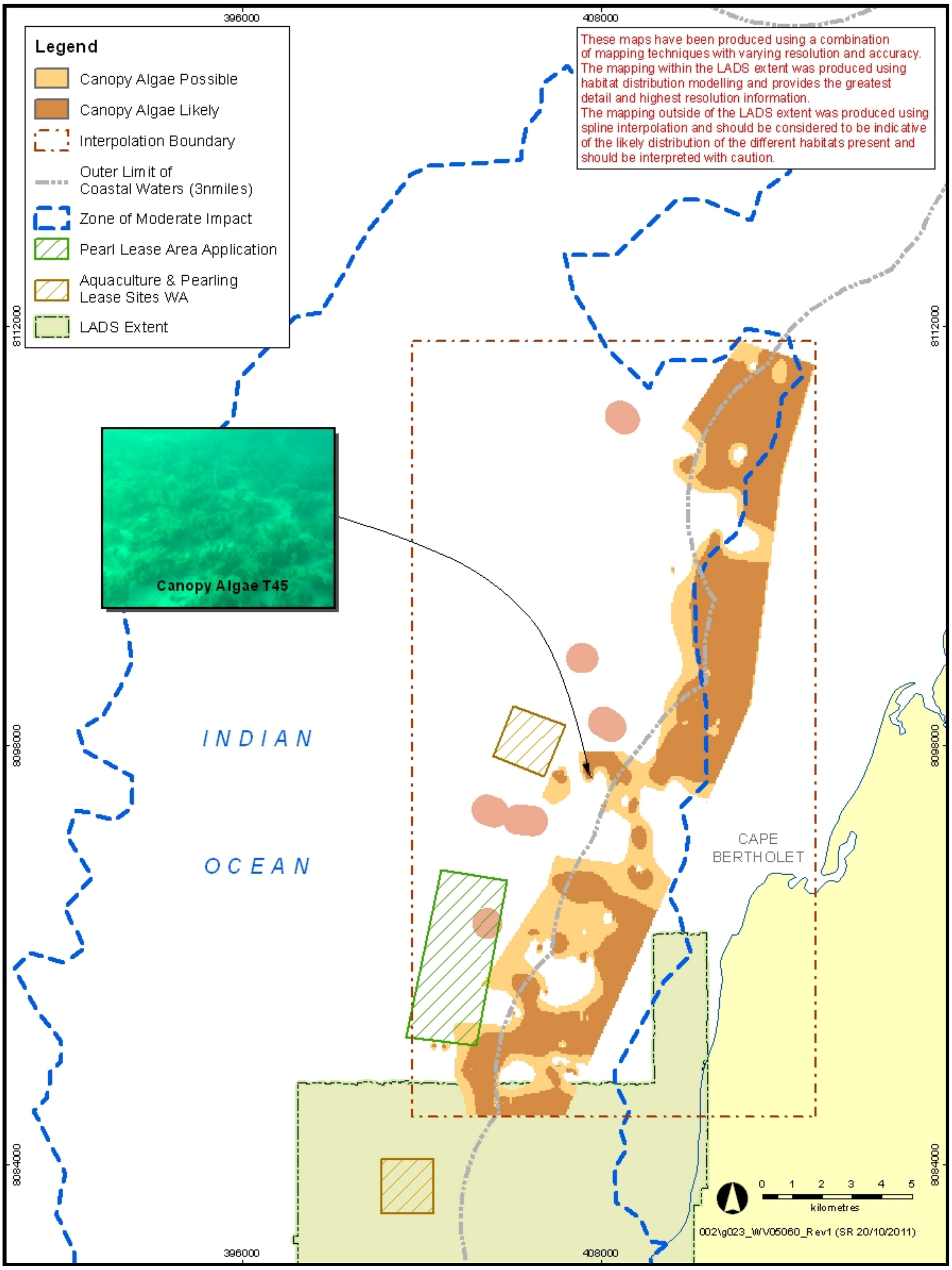
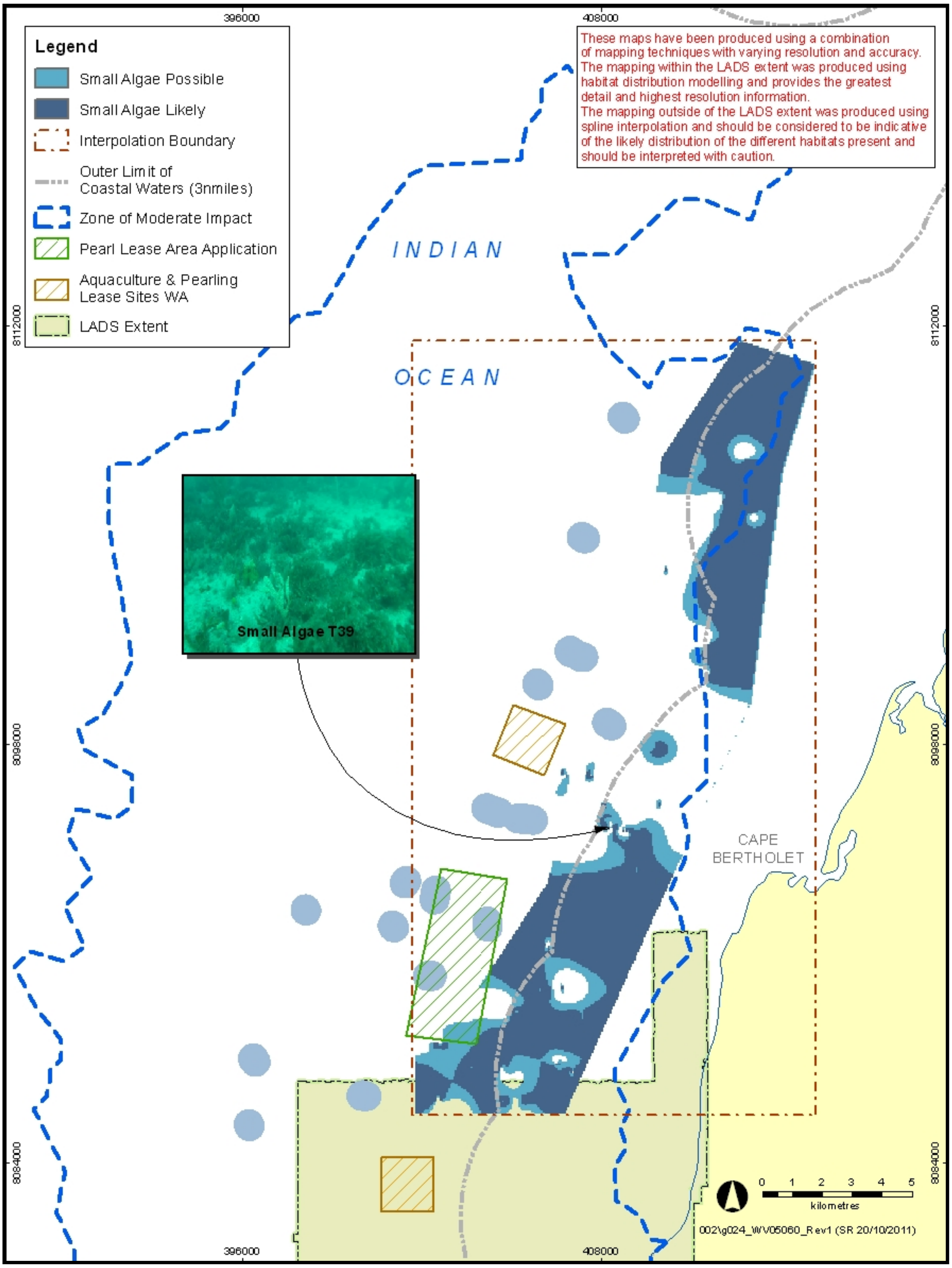
Appendix E Interpolation Mapping of Biota Boundaries in the Northern Area

E.1 Canopy Algae - Interpolated boundaries of possible and likely distribution in northern area

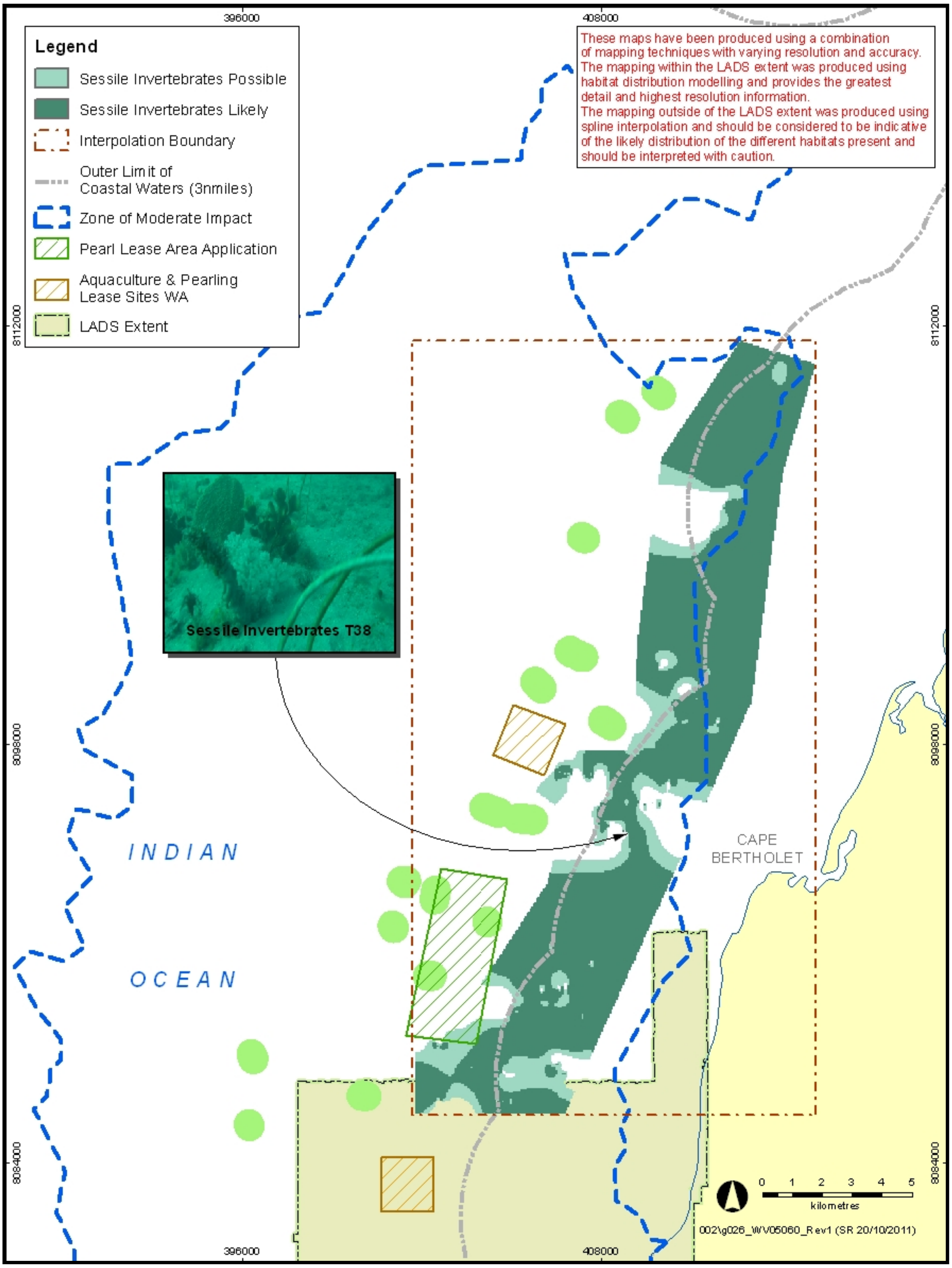


E.2 Small Algae - Interpolated boundaries of possible and likely distribution in northern area

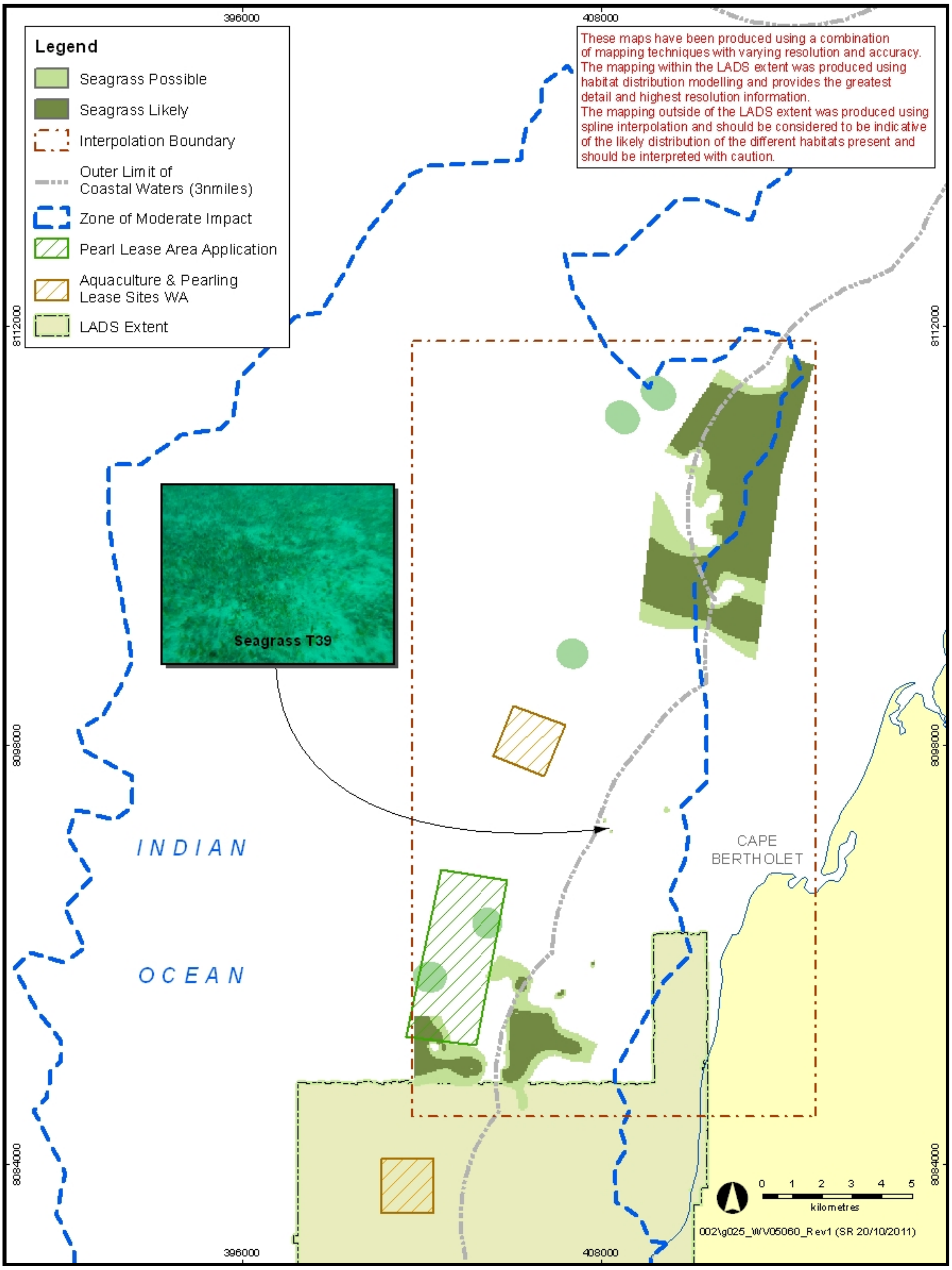


SINCLAIR KNIGHT MERZ SKM

E.3 Sessile Invertebrates - Interpolated boundaries of possible and likely distribution in northern area



E.4 Seagrass - Interpolated boundaries of possible and likely distribution in northern area



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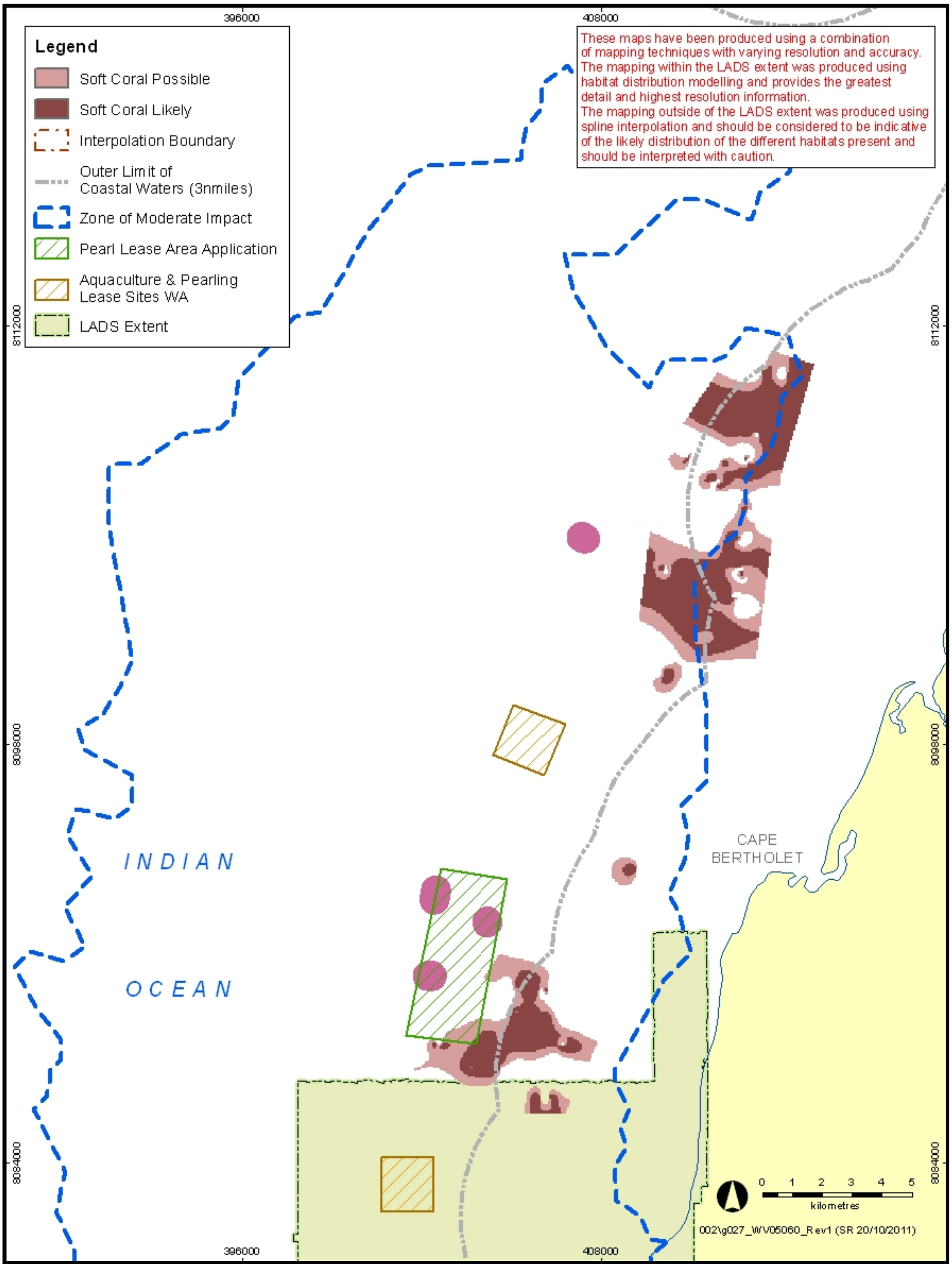
SKM

E.5 Soft Coral - Interpolated boundaries of possible and likely distribution in northern area



SINCLAIR KNIGHT MERZ
SKM

E.6 Hard Coral - Interpolated boundaries of possible and likely distribution in northern area