Gorgon Gas Development and Jansz Feed Gas Pipeline:

Coastal and Marine Baseline State and Environmental Impact Report Supplement: Area of Coral Assemblages

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Terminology, Definitions and Abbreviation

Terms, definitions and abbreviations used in this document are listed below. These align with the terms, definitions and abbreviations defined in Schedule 2 of the Western Australian Gorgon Gas Development Ministerial Implementation Statement No. 800 (Statement No. 800) and the Commonwealth Gorgon Gas Development Ministerial Approvals (EPBC Reference: 2003/1294, 2008/4178).

ABU	Australasian Business Unit
Bathymetric	Relating to measurements of the depths of oceans or lakes.
Benthic	Living upon or in the seabed.
Benthic Habitats	Areas of the seabed that support living organisms. Examples include, limestone pavement, reefs, sand and soft sediments.
Benthic Primary Producer	Photosynthesising organisms (mangroves, seagrasses, algae) or organisms that harbour photosynthetic symbionts (corals, giant clams).
Biotic	Of or relating to living organisms.
Bombora	Raised, dome-shaped, limestone feature, >1 m high, often formed by coral of the genus *Porites*.
BPPH	Benthic Primary Producer Habitat; benthic habitats that support primary producers.
CDEEP	Construction Dredging Environmental Expert Panel
Confidence Interval	An interval that is likely to contain the true value of a population parameter, but reflects the inherent uncertainty in estimating this parameter from a sample. The level of confidence reflects the likelihood that the constructed interval contains the true parameter value, so a 95% Confidence Interval is an interval which 95% of the time will include the true parameter value. By convention, 95% Confidence Intervals are usually used to define reasonably upper and lower bounds for parameter estimates.
Construction	Construction includes any Proposal-related (or action-related) construction and commissioning activities within the Terrestrial and Marine Disturbance Footprints, excluding investigatory works such as, but not limited to, geotechnical, geophysical, biological and cultural heritage surveys, baseline monitoring surveys and technology trials.
Coral	Marine organisms from the class Anthozoa that exist as small sea-anemone-like polyps, typically in colonies of many identical individuals. Includes 'hard corals' within the order Scleractinia which secrete calcium carbonate to form a hard skeleton and form reefs; and 'Soft corals' within the order Alcyonacea which have no hard skeleton and are not considered reef-building organisms.
Coral Definitions	*Coral Assemblages* are benthic areas (minimum 10 m^2) or raised seabed features over which the average live coral cover is equal to

	or greater than 10%. *The Change in coral mortality* is determined by subtracting the baseline extent of Gross coral mortality from the extent of Gross coral mortality measured on a sampling occasion. *Detectable Net Mortality* is the result of subtracting the Change in coral mortality at the Reference Site(s) from the Change in coral mortality at the Monitoring Site. *Average Net Detectable Mortality* is the result of averaging the net detectable mortality of all monitoring sites within the Zone i.e. the mean of net detectable mortality of any Zone. *Gross coral mortality* at a site is expressed as a percentage of total coral cover at the time of sampling at that monitoring location. In determining the coral loss, measurement uncertainty is to be taken into consideration.
CPCe	Coral Point Count with Excel extensions (software for the determination of coral cover from photographs)
DEC	Western Australian Department of Environment and Conservation
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DoF	Western Australian Department of Fisheries
DoT	Western Australian Department of Transport
Ecological Element	Element listed in listed in Condition 14.2 of Statement No. 800, Condition 12.2 of Statement No. 769 and Condition 11.2 of EPBC Reference: 2003/1294 and 2008/4178.
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development (dated September 2005), as amended or supplemented from time to time.
EPA	Western Australian Environmental Protection Authority
EPBC Reference: 2003/1294	Commonwealth Ministerial Approval (for the Gorgon Gas Development) as amended or replaced from time to time.
EPBC Reference: 2008/4178	Commonwealth Ministerial Approval (for the Revised Gorgon Gas Development) as amended or replaced from time to time.
Estimate	In most ecological studies a complete census is impossible and therefore probability sampling is used to estimate an ecological parameter of interest. Given a sample that can be considered representative of the statistical population of interest, the parameter estimate from the sample is used to infer the actual value of that parameter in the population. However, because the sample is not a complete census, there will always be some (chance-related) sampling error associated with the estimate based on the sample, which should always be reported as part of the estimate.

GDA	Geocentric Data of Australia
GIS	Geographic Information System
Gorgon Gas Development	The Gorgon Gas Development as approved under in Statement No. 800 and EPBC Reference 2003/1294 and 2008/4178, as amended or replaced from time to time.
GPS	Global Positioning System
Ground Truth	To verify the correctness of remote sensing information by use of ancillary information such as field studies.
ha	Hectare
Habitat	The area or areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography) and the biotic factors.
LNG	Liquefied Natural Gas
m	Metre
m^2	Square metre
Macroalgae	Benthic marine plants that are non-flowering and lack roots, stems and vascular tissue. Can be seen without the aid of a magnification; includes large seaweeds.
Marine Disturbance Footprint	The area of the seabed to be disturbed by construction or operations activities associated with the Marine Facilities listed in Condition 14.3 of Statement No. 800 and Condition 11.3 in EPBC Reference: 2003/1294 and 2008/4178 (excepting that area of the seabed to be disturbed by the generation of turbidity and sedimentation from dredging and dredge spoil disposal) and as set out in this Report.
Marine Facilities	In relation to Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178, the Marine Facilities are the: • Materials Offloading Facility (MOF) • LNG Jetty • Dredge Spoil Disposal Ground • Offshore Feed Gas Pipeline System and marine component of the shore crossing • Domestic Gas Pipeline Condition 14.3 of Statement No. 800 relates only to components of the Marine Facilities within State waters (i.e. specifically the Offshore Feed Gas Pipeline System). For the purposes of Statement No. 800 Marine Facilities also include: • Marine upgrade of the existing WAPET landing.
Marine Facilities	The area of seabed associated with the physical footprint of the

Footprint	Marine Facilities, but excluding the area of the seabed disturbed by dredging an dredge spoil disposal, or for example, by anchoring.
Maximum Likelihood (ML) Estimator	A statistical method for estimating population parameters (as the mean and variance) from sample data that selects as estimates those parameter values that maximise the probability of obtaining the observed data.
MGA 50, GDA 94	Map Grid of Australia Zone 50 (WA); projection based on the Geocentric Datum of Australia 1994.
MOF	Materials Offloading Facility
PER	Public Environmental Review for the Gorgon Gas Development Revised and Expanded Proposal dated September 2008, as amended or supplemented from time to time.
Permanent Loss	In relation to Coral assemblages, means loss that does not recover within 30 years of the completion of dredging and spoil disposal.
PGPA	Policy, Government and Public Affairs
QA/QC	Quality Assurance/Quality Control
Quadrat	A rectangle or square measuring area used to sample living things in a given site; can vary in size.
Reference Areas	Specific areas of the environment that are not at risk of being affected by the proposal or existing developments, that can be used to determine the natural state, including natural variability, of environmental attributes such as coral health or water quality.
Regionally Significant Areas	Are the regionally significant areas outside the Zones of High Impact, Moderate Impact and Influence on the eastern margins of the Lowendal Shelf to the southern boundary of the Montebello Islands Marine Park, and Dugong Reef, Batman Reef and Southern Barrow Shoals.
RPS	RPS Australia/SE Asia (a company)
Sessile	Permanently attached directly to the substratum by its base (i.e. immobile), without a stalk or stem.
Spoil Disposal Ground	The area where dredge and excavation material is to be disposed of at sea.
Statement No. 800	Western Australian Ministerial Implementation Statement No. 800 (for the Gorgon Gas Development) as amended from time to time.
Substrate	The surface a plant or animal lives upon. The substrate can include biotic or abiotic materials. For example, encrusting algae that lives on a rock can be substrate for another animal that lives above the algae on the rock.
Taxon (plural: taxa)	A taxon (plural taxa), or taxonomic unit, is a name designating an organism or a group of organisms.

Transect	The path along which a researcher moves, counts and records observations.
Turbidity	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.
WA	Western Australia (or Western Australian)
WAPET	West Australian Petroleum Pty Ltd.
WAPET Landing	Proper name referring to the site of the barge landing existing on the east coast of Barrow Island prior to the date of Statement No. 800.
Waters Surrounding Barrow Island	Refers to the waters of the Barrow Island Marine Park and Barrow Island Marine Management Area (approximately 4169 ha and 114 693 ha respectively), as well as the port of Barrow Island; representing the Pilbara Offshore Marine Bioregion which is dominated by tropical species that are biologically connected to more northern areas by the Leeuwin Current and the Indonesian Throughflow, resulting in a diverse marine biota typical of the Indo–West Pacific flora and fauna.
Zone of High Impact	An area where long-term impacts to corals are predicted to result directly from disturbance during horizontal directional drilling, dredging or construction of infrastructure on the seabed and burial during dredge spoil disposal, or indirectly from smothering due to elevated sedimentation and/or from deterioration in water quality. As set out in Schedule 1 of Statement No. 800 and Schedule 5 of EPBC Reference: 2003/1294 and 2008/4178.
Zone of Influence	This area is predicted to be indirectly influenced by dredging and spoil disposal activities (e.g. marginal increases in turbidity and sedimentation), but at levels that will have no measurable impact on corals. As set out in Schedule 1 of Statement No. 800 and Schedule 5 of EPBC Reference: 2003/1294 and 2008/4178.
Zone of Moderate Impact	An area where short-term moderate impacts (e.g. some partial mortality of corals) is predicted to result indirectly from horizontal directional drilling, dredging, dredge spoil disposal, due to deterioration in water quality and/or an increase in sedimentation rates. Moderate impacts are likely to include some partial mortalities among fast growing, more sensitive coral species (e.g. *Acropora* sp.) but less, if any, mortality of longer living, generally more resilient species (e.g. *Porites* sp., *Turbinaria* sp.). As set out in Schedule 1 of Statement No. 800 and Schedule 5 of EPBC Reference: 2003/1294 and 2008/4178.

1.0 Introduction

The Gorgon Gas Development and Jansz Feed Gas Pipeline Coastal and Marine Baseline State Environmental Impact Report (the Marine Baseline Report) (Chevron Australia 2010) has been developed as required by Condition 14 of Ministerial Implementation Statement No. 800 (Statement No. 800) for the Revised and Expanded Gorgon Gas Development. The Marine Baseline Report for the Materials Offloading Facility (MOF), the LNG Jetty and the Dredge Spoil Disposal Ground is required to be approved by the Director General of the Western Australian Department of Environment and Conservation (DEC). The Marine Baseline Report is also required under Condition 11 of Commonwealth Approval for the Revised and Expanded Gorgon Gas Development (EPBC Reference: 2003/1294 and 2008/4178), and is required to be approved by the Assistant Secretary, Environment Assessment Branch, Department of the Environment, Water, Heritage and the Arts (DEWHA).

The Coastal and Marine Baseline State Environmental Impact Report Supplement: Area of Coral Assemblages (this Supplement) has been prepared to meet the requirements of Condition 14.6.ii of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178, specifically the requirements to calculate the Area of Loss of Coral Assemblages. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the Scope of Works for the Coastal and Marine Baseline State Environmental Impact Report (the Scope of Works) (RPS 2009). The Scope of Works was approved under Condition 14.1 of Statement No. 800 and Condition 11.1 of EPBC Reference 2003/1294 and 2008/4178 on 11 September and 23 September 2009, respectively. This Supplement should be read in conjunction with the Marine Baseline Report, which includes relevant background information on the marine environment in the Barrow Island region, as well as information on the methods implemented to identify, map and classify benthic ecological assemblages, including Coral Assemblages. Note that all other requirements relating to the description and mapping of ecological elements, including hard and soft corals, are addressed within the Marine Baseline Report.

The requirements of this Supplement, as stated in Condition 14.6.ii of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178, are listed in Table 1.1. Table 1.1 also references the specific sections of this Supplement where each requirement is addressed.

Table 1.1 Requirements of this Coastal and Marine Baseline State Environmental Impact Report Supplement: Area of Coral Assemblages

Ministerial Document	Condition No.	Requirement	Section Reference in this Supplement
Statement No. 800	14.6.ii	The purposes of this Report are to:... ii. Describe and map the extent and distribution of Coral Assemblages within the Zones of High Impact and the Zones of Moderate Impact which are to be used to calculate the Area of Loss of Coral Assemblages according to the following formula: a = h + (m x 30%) where: a = the area (ha) of loss of Coral Assemblages h = the area (ha) of Coral	Section 3.2.1. *Note that the Methods applied to quantify Coral Assemblages are set out in Section 2.0. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works for the Coastal and Marine Baseline State Environmental Impact Report (RPS 2009).*

Ministerial Document	Condition No.	Requirement	Section Reference in this Supplement
		Assemblages within the Zones of High Impact; and m = the area (ha) of Coral Assemblages within the Zones of Moderate Impact.	
EPBC Reference: 2003/1294 and 2008/4178	11.6.ii	The purposes of this Report are to:... ii. Describe and map the extent and distribution of Coral Assemblages within the Zones of High Impact and the Zones of Moderate Impact which are to be used to calculate the Area of Loss of Coral Assemblages according to the following formula: a = h + (m x 30%) where: a = the area (ha) of loss of Coral Assemblages h = the area (ha) of Coral Assemblages within the Zones of High Impact; and m = the area (ha) of Coral Assemblages within the Zones of Moderate Impact.	Section 3.2.1. *Note that the Methods applied to quantify Coral Assemblages are set out in Section 2.0. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works for the Coastal and Marine Baseline State Environmental Impact Report (RPS 2009).*

Following approval, this Supplement will be considered to be approved as part of the Marine Baseline Report, but will be maintained as a stand-alone document. Where relevant, amendments made to the Marine Baseline Report will also be considered amendments to this Supplement. Any matters or requirements in this Supplement that are taken from the Marine Baseline Report (rather than Statement No. 800 or EPBC Reference: 2003/1294 and 2008/4178) may be amended from time to time in accordance with amendments to the Marine Baseline Report. Amendments to this Supplement may also be made directly in accordance with Section 1.5.8 of the Marine Baseline Report and Section 4.0 of this Supplement.

1.1 Area of Loss of Coral

The initial calculations of the extent of coral in the Zones of High and Moderate Impact associated with the generation of turbidity and sediment deposition from dredging and dredge spoil disposal required for the MOF, LNG Jetty and Dredge Spoil Disposal Ground was a total mapped area of coral of 33 ha (Chevron Australia 2005, 2006, 2008). This figure was based on the broad-scale assessment and mapping of marine benthic habitats in the area potentially impacted by marine infrastructure, dredging and dredge spoil disposal activities. The figure formed the basis for the Benthic Primary Producer Habitat (BPPH) loss calculations in accordance with the Western Australian Environmental Protection Authority (EPA) Guidance Statement No. 29 (EPA 2004) (note now superseded by the EPA Environmental Assessment Guideline No. 3 for Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment [EPA 2009]). Note that, in recognition of the intrinsic uncertainties in qualitative descriptions of coral cover, these calculations were highly conservative. Areas where coral cover was estimated to be representative of a coral community (nominally >10%,

although this was not directly measured at this scale) and the underlying and surrounding benthic substrate where corals were likely to be able to grow were mapped as 'Coral Habitat'. Note, however, that only those areas that had been mapped as coral were included in this assessment. Any small, indistinct areas of coral interspersed within other major habitats but which were too small to map individually were not included in calculations because, by definition, there are no measures of their areas. As in previous calculations (Chevron Australia 2005, 2006, 2008), any such small areas of unmapped coral are not considered further in the calculation of the area of Loss of Coral Assemblages documented in this Supplement. The predicted loss of coral from dredging, dredge spoil disposal and construction activities associated with the construction of the MOF and LNG Jetty for the Revised Proposal was approximately 22.06 ha (Chevron Australia 2008; see also Chevron Australia 2005, 2006). This value takes into account the complete loss of coral from within the Zones of High Impact and the 30% loss of coral from within the Zones of Moderate Impact.

Within areas mapped as coral, the total area of Coral Assemblage present is likely to be over-estimated for two reasons. Firstly, the baseline habitat maps used in the calculations of coral loss for the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Proposed Gorgon Development (Chevron Australia 2005, 2006) and the Public Environmental Review (PER) for the Gorgon Gas Development Revised and Expanded Proposal (Chevron Australia 2008), were relatively broad-scale and based on information available at that time. Subsequently, additional quantitative mapping focused on the zones of impact and monitoring sites has been undertaken during the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1). Secondly, the calculation conservatively assumed that all areas mapped as Coral Habitat were 100% covered with Coral Assemblage.

In reality, at least some proportion of the reef areas mapped as coral are likely to be dominated by macroalgal assemblage, or to be soft sediment in between areas of coral, resulting in an over-estimate of the actual amount of Coral Assemblage within the mapped areas. Note that this may also be true for the updated maps produced as part of the Marine Baseline Program. The actual area of Coral Assemblage, as defined in Schedule 2 of Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178, thus needs to be determined by summing the total area mapped as coral in the Zones of High and Moderate Impact, scaled by the proportion of those areas that is actually Coral Assemblage. The latter can only be determined by quantitatively sampling the mapped coral within the Zones of High and Moderate Impact. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works.

This Supplement presents an assessment of the extent and distribution of Coral Assemblages within areas mapped as coral in the Zones of High and Moderate Impact. The extent and distribution of Coral Assemblages has been assessed for four main reasons:

- Coral Assemblages are not static, thus the extent and distribution of Coral Assemblages may have changed from the time initial assessments for the EIS/ERMP (Chevron Australia 2005, 2006) and PER (Chevron Australia 2008) were made, to the sampling undertaken for this Supplement
- qualitative descriptions of Coral Assemblages do not support auditable quantification of the actual loss of the Coral Assemblages. It is therefore important to provide a quantified measure of the extent and distribution of Coral Assemblages as close as possible to the commencement of dredging, spoil disposal and construction activities. The methods to quantify Coral Assemblages have been prescribed in Section 4.1.2.7 of the approved Scope of Works.
- Schedule 2 in Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178 includes a quantitative definition of Coral Assemblages (Section 2.1)
- improved and additional imagery has become available since the time the coral mapping commenced (Marine Baseline Report, Section 5, Section 6.3.2.1 and Section 6.4.1).

1.2 Objectives

Condition 18.1.ii of Statement No. 800 states that the implementation of the marine works associated with construction, dredging and dredge spoil disposal activities for the MOF, the LNG Jetty and the marine component of the WAPET Landing upgrade, shall not result in the Permanent Loss of Coral Assemblage within the Zones of High and Moderate Impact in excess of 22 ha or the Area of Loss of Coral Assemblages calculated under Condition 14.6.ii, whichever is less. Condition 14.6.ii of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178, set out the requirement to:

> Describe and map the extent and distribution of Coral Assemblages within the Zones of High Impact and the Zones of Moderate Impact, which are to be used to calculate the Area of Loss of Coral Assemblages according to the following formula:
>
> a = h + (m x 30%)
>
> where:
>
> a = the area (ha) of loss of Coral Assemblages
>
> h = the area (ha) of Coral Assemblages within the Zones of High Impact; and
>
> m = the area (ha) of Coral Assemblages within the Zones of Moderate Impact.

The actual area of Coral Assemblage, as defined in Schedule 2 of Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178, is determined by summing the total area mapped as coral in the Zones of High and Moderate Impact, scaled by the proportion of those areas that is actually Coral Assemblage. The latter can only be determined by quantitatively sampling the mapped coral within the Zones of High and Moderate Impact. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works.

The key objectives of this Supplement are:

- to determine the appropriate scaling factor based on quantitative surveys
- to calculate the area of Coral Assemblage at risk within the Zones of High and Moderate Impact, based on the quantitative survey results and updated mapping of the extent and distribution of coral in the Zones of High and Moderate Impact
- to document the pre-dredging, dredge spoil disposal and construction activities baseline proportions of Coral Assemblages within areas mapped as potential Coral Assemblage at a suite of Reference Areas and Regionally Significant Areas outside the Zones of Influence. The proportion of Coral Assemblages at these sites will be monitored prior to and after dredging, spoil disposal and construction activities, to provide a measure of natural changes in Coral Assemblages in the Barrow Island region. This will provide the information required to assess the Net Loss of Coral Assemblage within the Zones of High and Moderate Impact that is attributable to dredging, spoil disposal and construction activities (refer to Section 4.1.2.7 of the approved Scope of Works).

The methods employed to calculate the total area of Coral Assemblages within the Zones of High and Moderate Impact associated with dredging, dredge spoil disposal and construction activities for the MOF and LNG Jetty are presented in Section 2.0. The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works. Results of the field surveys to provide a quantitative measure of the Area of Loss of Coral Assemblages are presented in Section 3.0.

1.3 Stakeholder Consultation

Under Condition 14.5 of Statement No. 800 and Condition 11.5 of EPBC Reference: 2003/1294 and 2008/4178, consultation with the Construction Dredging Environmental Expert Panel (CDEEP), the Western Australian Department of Environment and Conservation (DEC),

Department of Transport (DoT) and Department of Fisheries (DoF) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) is required during the development of the Marine Baseline Report.

This Supplement to the Marine Baseline Report has been prepared with input from:

- The Department of Environment and Conservation: The DEC has reviewed and provided comment on the Draft Supplement
- The Department of Environment, Water, Heritage and the Arts: The DEWHA was provided with the Draft Supplement for their review
- The Department of Transport: The DoT was provided with the Draft Supplement for their review
- The Department of Fisheries: The DoF was provided with the Draft Supplement for their review
- The Construction Dredging Environmental Expert Panel was provided with a briefing on the proposed methodology at the Panel meeting convened on 12 August 2009 and provided with an update on progress with the field surveys at the Panel meeting on 10 December 2009.

2.0 Methods

2.1 Defining/Quantifying Coral Assemblages and Choice of Sampling Units

Schedule 2 of Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178, define Coral Assemblages as *"benthic areas (minimum 10 m^2) or raised seabed features over which the average live coral cover is equal to or greater than 10%."* The methods to quantify Coral Assemblages are required to be those prescribed in Section 4.1.2.7 of the approved Scope of Works.

To determine the proportion of the areas mapped as coral that would be classified quantitatively as Coral Assemblage, the cover of live coral was measured in a representative, randomly selected sample of areas. Across areas mapped as coral, circular areas (15.9 m^2) were sampled using a transect line of five (0.5 x 0.5 m; i.e. 0.25 m^2) photo-quadrats located at 1 m intervals across one diameter (Figure 2.1). The locations of each of these 15.9 m^2 circular areas were determined by the randomly selected starting points and randomly pre-determined transect directions.

Areas were sampled using 0.5 x 0.5 m photo-quadrats because these were considered to be sufficiently large units to provide a reasonable sample of substratum within each photograph (reducing the overall number required to achieve a reasonable coverage of the area), yet small enough that the cameras and frames could be efficiently deployed in the field and with a sufficiently short focal distance that photographs could be taken under a range of water clarity conditions. Prior analyses based on the data from the Marine Baseline Program also found that differences in the size of photo-quadrats commonly used to sample coral had no detectable effect on the precision of samples; i.e. no difference in residual variance components was detected between surveys, which used 1.0 x 1.0 m or 0.5 x 0.5 m quadrats. Photo-quadrats were systematically arranged along the transect to ensure coverage across a diameter of the circular area being sampled and spaced to avoid overlapping photographs which might lead to double counting of any corals/bare areas. While, theoretically, there can be serial autocorrelation issues associated with the systematic spatial arrangement of sampling units, in practice such arrangements can help to ensure an even coverage of sampling across areas and are used regularly in ecology (Krebs 1999).

Given the decision to use 0.25 m^2 photo-quadrats spaced at 1 m intervals, the length of transects was then fixed at 5 m in order to sample the diameter of an appropriately sized circular area. The edge of the first photo-quadrat located at 0 m and the furthest edge of the last photo-quadrat at 4.5 m forms a diameter of a circular area of seabed with an area of 15.9 m^2 (Figure 2.1). This area is of approximately the correct spatial scale under the definition of Coral Assemblages in Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178. The five photo-quadrats are considered a representative sample of coral cover within the circular area because anywhere within the circle could have been sampled by a similar, but differently orientated, transect of five photo-quadrats. Sampling fewer photo-quadrats (e.g. four photo-quadrats at 1 m intervals) would sample a smaller circular area (diameter = 3.5 m, and an area of 9.6 m^2) which is less than the minimum required based on the definition of Coral Assemblages.

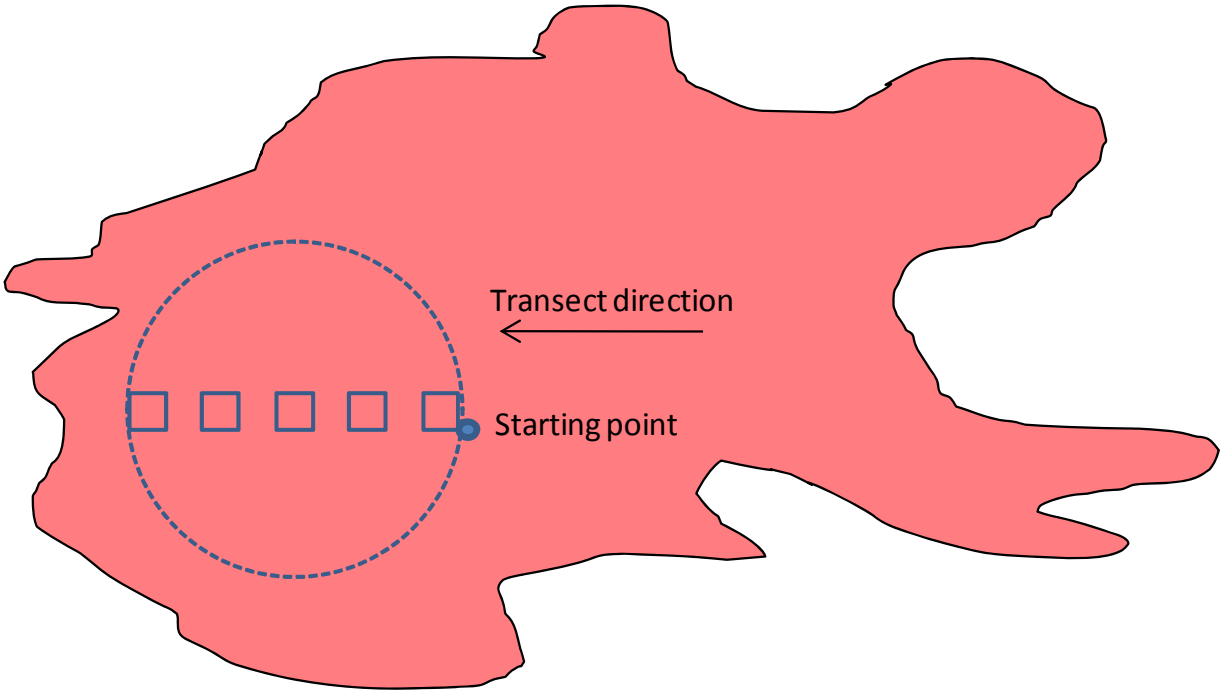

Figure 2.1 Five 0.5 m x 0.5 m Quadrats, Located at 0, 1, 2, 3 and 4 m along a 5 m long Transect. The Area of the Circle is 15.9 m^2 with an Approximate Diameter of 4.5 m

Each photo-quadrat along a transect was treated as an independent measure of cover within the circular area determined by the starting point and direction of that transect (Figure 2.1). Live cover of corals was thus averaged across the five photo-quadrats per transect to obtain a measure of the average cover within each area. However, because that measure is based on a sample of cover across the area (and thus subject to sampling error), the upper 95% Confidence Interval estimate was used to determine the greatest coverage of coral that might be present in the area. This upper 95% Confidence Interval estimate was then used to classify each area as Coral Assemblage (≥10% live coral cover) or not. Thus, a conservative approach has been used to classify each sampled area; areas were classified as Coral Assemblage unless there was evidence that the average live cover of corals was almost certainly not 10% or greater.

2.2 Calculating the Area of Coral Assemblage

The rationale behind the methods and estimation of the area of Coral Assemblages is detailed in Section 4.1.2.7 in the approved Scope of Works. The rationale is outlined in Figure 2.2.

Specifically, the steps taken to assess the total area of Coral Assemblages in the Zones of High and Moderate Impact (and at Reference Areas and Regionally Significant Areas) were:

1. Areas mapped as coral during in the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1) were identified, as well as discrete community types within these areas that might allow for stratified sampling (see Section 2.3 for details of the specific strata sampled).
2. The locations of sites at which coral cover would be measured were pre-determined within each of the strata using a Geographic Information System (GIS). Using a stratified sampling approach, sites were randomly located within each stratum. Sampling locations at the five Reference Areas and Regionally Significant Areas were similarly pre-determined.
3. The minimum number of transects (n = 25 in each Zone) that were required to obtain a relatively precise sample of area of Coral Assemblage across the Zones of High and Moderate Impact were calculated prior to the survey.
4. Geographic coordinates generated by the GIS were entered into the Global Positioning System (GPS) to enable precise site location in the field. On commencement of the surveys at each site, a weighted buoy was deployed to mark the centre of the site.
5. The size of the seabed features influenced the number of transects sampled at each site (Figure 2.2). On smaller bombora (15–50 m in diameter), single transects were laid. On larger reef areas, four transects were laid radiating outwards from starting points at 5–20 m from the centre of the site. The transect starting points and the direction of the transects were randomly selected prior to the survey to avoid any potential diver-bias in the placement of transects in the field. Random transects that would have extended beyond the stratum being sampled were replaced. Mapped bombora <15 m in diameter, as well as bombora 15–50 m in diameter in the LNG Jetty area, were not sampled (Section 2.3.1); however, for Coral Assemblage calculations these areas were conservatively assumed to have 100% coral cover.
6. Coral cover was assessed by photographing 0.25 m^2 quadrats at 1 m intervals along each transect (Section 2.1).
7. Photo-quadrats from each transect were analysed using Coral Point Count with Excel extensions (CPCe) (Kohler and Gill 2006) to determine the average cover (± standard error) of live coral across each transect (Section 2.6). This was then used to classify each transect as either ‘Coral Assemblage’ (upper 95% Confidence Interval of live cover ≥10%; n = 5) or ‘Not Coral Assemblage’ (upper 95% Confidence Interval of live cover <10%; n = 5). Information about the substrates and other biotic assemblages along the transects was also recorded.
8. The proportion of transects classified as Coral Assemblage was then calculated for each stratum, within each Zone and Reference Area and Regionally Significant Area, using weightings according to the relative area of each stratum. Because samples were used to infer the proportion of Coral Assemblage in the overall mapped area, Maximum Likelihood estimators and 95% Confidence Intervals for proportions were calculated to represent the variation associated with sampling error at the area scale.
9. The area of Coral Assemblages in each Zone and at each Reference Area and Regionally Significant Area was calculated as the area of coral mapped in the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1), scaled by the proportion of transects in each that were classified as Coral Assemblage.

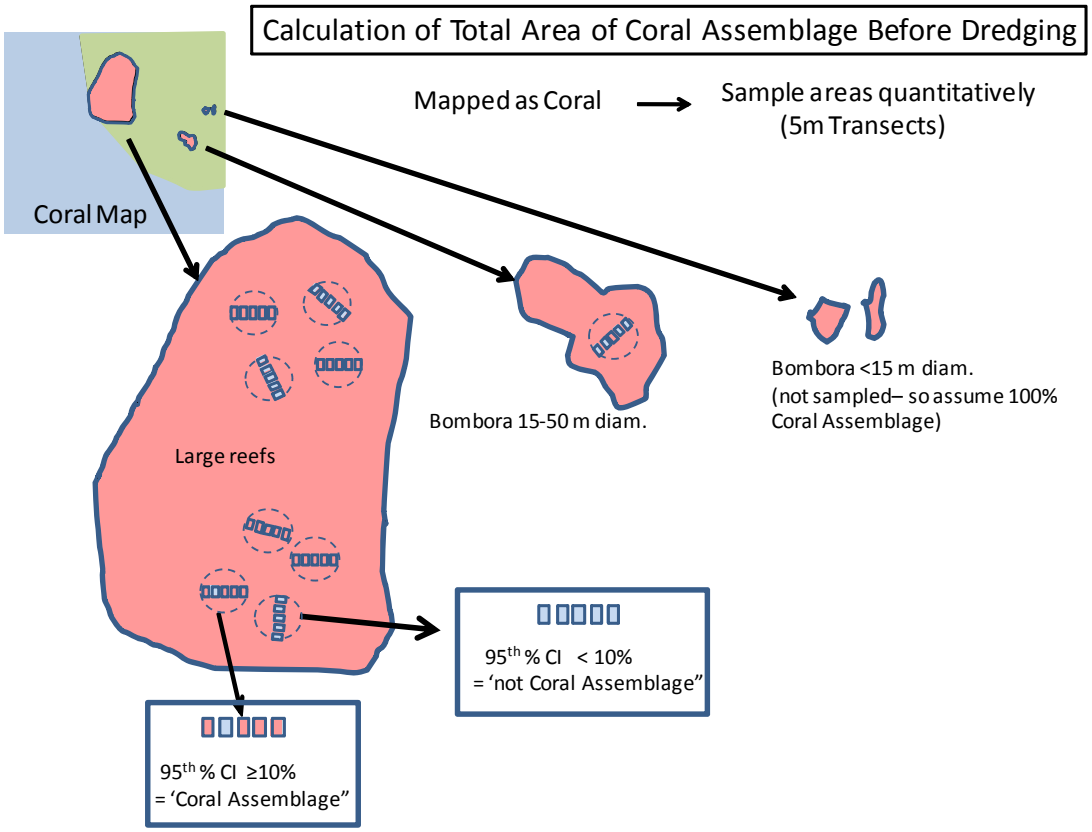

Figure 2.2 Diagrammatic Overview of the Calculation of the Area of Coral Assemblages

2.3 Identification of Areas/Strata Mapped as Coral

Areas of coral (i.e. potential Coral Assemblage) were identified from GIS-based habitat maps of:

i. Zones of High Impact

ii. Zones of Moderate Impact

iii. Reference Areas (including some Regionally Significant Areas):

- Ah Chong Reef
- LNG3
- Batman Reef (Regionally Significant Area)
- Dugong Reef (Regionally Significant Area)
- Southern Barrow Shoals (Regionally Significant Area).

The location, area and composition of coral within these areas were based on the maps produced during the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1).

To ensure adequate geographic spread, coverage of different types of Coral Assemblage and to potentially increase the precision of sampling, areas were then stratified by different-sized features and coral communities. Areas around the Marine Facilities within the Zones of High and Moderate Impact were classified into six strata, based on the size of features (bombora <15 m diameter, bombora 15–50 m, and larger reefs) and distance offshore (inshore and offshore):

- MOF (inshore) – large reefs
- MOF (inshore) – bombora (15–50 m diameter)

- MOF (inshore) – bombora (<15 m diameter)
- LNG Jetty (offshore) – large reefs
- LNG Jetty (offshore) – bombora (15–50 m diameter)
- LNG Jetty (offshore) – bombora (<15 m diameter).

The area of reef inside the Zone of Moderate Impact at Lone Reef was treated as an additional stratum to ensure coverage of Coral Assemblage surrounding the Dredge Spoil Disposal Ground. No potential Coral Assemblages were identified in the Zone of High Impact at the Dredge Spoil Disposal Ground (Chevron Australia 2010).

Reference Areas and Regionally Significant Areas were stratified by the different coral communities that were mapped in the Marine Baseline Program (Marine Baseline Report, Section 6.4.1). Maps showing the strata within the Zones of High and Moderate Impact and at Reference Areas and Regionally Significant Areas, as well as the location of sites within strata, are included in Appendix 1.

2.3.1 Strata not Sampled

A minimum diameter of 15 m was set as the size of coral areas mapped in the Marine Baseline Program, which could be confidently sampled. This reflects the difficulties in placing transects in the field in exactly the place corresponding to a small mapped feature. At fine spatial scales, sampling accuracy in the field is affected by the limits of resolution of the GPS, as well as potential inaccuracies in marking locations. For example, in strong currents, site markers may drift slightly before reaching the seabed and it may be difficult for the divers to maintain a precise bearing across the seabed. In addition, if a transect is located near the edge of a mapped area, which is not marked by an obvious change in seabed terrain, it is difficult to be certain whether sampling is being undertaken within or outside the mapped feature. Alternatively, allowing transects to be located on areas of coral that are assumed to be the mapped feature, introduces a significant risk of diver-bias, towards or away from areas perceived as Coral Assemblage. This may lead to potential errors between survey times if conditions change, or, for example, if the diver approaches the site from a different direction.

Some strata were not found, or were very uncommon in some areas and were thus not sampled (see also Section 2.4). For example, there was only a very small area of large reefs in the inshore MOF area and no 15–50 m diameter bombora in the LNG Jetty area Zone of Moderate Impact. Not sampling these areas made little difference to the overall calculation of the area of Coral Assemblage.

2.4 Sampling Effort and Allocation of Sites/Transects among Strata

For smaller features (bombora 15–50 m in diameter) each transect was uniquely located (i.e. there was only one transect per site). This allowed independence among transects within the ‘small bombora’ strata. However, for larger areas of reef an additional layer of nesting was implemented (transects within sites) by surveying four transects at each site. This was undertaken to increase the area sampled within these strata, given the constraints of diving using surface-supplied breathing apparatus (e.g. restrictions arising as a consequence of the lengths of divers’ hoses; requirements for visual contact to be maintained) and the relatively large amounts of time taken to move to a new site and re-anchor the vessel.

A consequence of this partially nested design was that while each site within a stratum was an independent, randomly chosen sampling unit, each of the four transects within a site was not necessarily an independent measure of the proportion of Coral Assemblage within a stratum (even though where transects were started relative to the central site location was randomly determined). For the sake of simplicity, the method illustrated in Figure 2.2 was applied, treating each transect as if it were an independent measure in a stratum. The non-independence of the transects nested within sites was ignored and the design treated as a simple stratified program. This avoided unnecessarily complicating the calculation of overall

proportions and, in particular, calculations of Confidence Intervals. Note that the calculation of Confidence Intervals is an unresolved statistical problem, even for many straightforward stratified or nested designs (Duffy and Santner 1987; Gross and Frankel 1991; Agresti and Coull 1998).

Pre-survey calculations were undertaken using Excel/Visual Basic to assess allocation of numbers of sites among strata and determine the likely size of standard errors produced by stratified sampling in the Zones of High and Moderate Impact, assessing a range of numbers of transects and likely proportions of the area that might be classified as Coral Assemblage. These calculations indicated that 20 to 25 transects per Zone of High and Moderate Impact should provide relatively narrow Confidence Intervals for the overall calculations of Coral Assemblage and that there would be marginal increases in precision with additional transects. Nevertheless, because these calculations were based on preliminary calculations before data had been collected, more than 25 transects were sampled in each Zone in order to ensure reasonably high precision (Figure 2.3).

The Neyman allocation of effort among strata was also determined. This is the optimal allocation among strata that provides the most precise sample for a given effort; if there are large differences among strata in the variable of interest, then the Neyman allocation can sometimes make a large difference to precision (Cochran 1977). Thus, the optimal allocations of transects among strata were also calculated. Here, because the larger reef areas near the LNG Jetty accounted for most of the area of mapped coral across the Zones of High and Moderate Impact, most effort was required in determining the proportion of Coral Assemblage in these strata, rather than in the smaller 15–50 m diameter bombora strata. In particular, the preliminary calculations suggested that measuring in the very small area of bombora 15–50 m in diameter around the LNG Jetty area made almost no difference to the overall calculation or precision and so consequently no transects were placed in that stratum (see Section 2.7 for how this was addressed in the calculations). However, some effort was made to ensure that a reasonable number of transects were placed in each of the other strata, where practicable. Thus, although mathematically the optimal strategy would have been to place virtually all effort into the large reef areas associated with the LNG Jetty area (and this survey did bias effort towards these areas); this was not done to the complete exclusion of other strata such as Lone Reef or bombora near the MOF, as it was considered important to have at least some measurement of what was in these areas. Despite this, the precision attained from the survey was still quite close to the optimal that could have been achieved for the amount of survey effort (Figure 2.3). Further survey effort, however allocated, would not have lead to a great increase in precision.

Figure 2.3 Predicted Precision of Samples for Total Area of Coral Assemblage across Zones of High and Moderate Impact, using the Neyman Allocation of Transects among Strata

Note: The graph illustrates the decrease in the range of the 95% Confidence Intervals with an increase in the number of transects (error bars are the 95% Confidence Intervals). The datum highlighted in yellow is the 95% Confidence Interval achieved with the actual sampling program (74 transects sampled).

2.5 Timing of Field Survey

The field survey was undertaken over the period 7–13 November 2009. This was approximately four months prior to the commencement of dredging, spoil disposal and construction activities.

2.6 Coral Point Extension (CPCe) Analysis

Digital images of the 0.25 m^2 photo-quadrats were analysed by randomly distributing 30 points over each image and then classifying the benthos under each point. Thirty points per photo-quadrat was selected because previous studies have found that, while there is a substantial increase in precision from 5 to 10 points per frame, and from 10 to 25 points per frame, the increase in precision from 25 to 50 points per frame becomes marginal (Stoddart *et al.* 2005). Additionally, as a general rule for determining how effort should be allocated across different levels of sampling, more samples at the highest hierarchical level, possibly at the cost of fewer sub-samples per sample, will almost always be the most efficient/powerful sampling strategy, unless the costs of sub-sampling are extremely low (Quinn and Keough 2002). Consequently, a conscious decision was made to concentrate on increasing numbers of transects per strata, at the trade-off of fewer (but still sufficient) photo-quadrats per transect and points scored per photo-quadrat. The software program Coral Point Count with Excel extensions (CPCe) was used to automate the random point count analysis process (Kohler and Gill 2006).

Although not strictly required to determine the overall coverage, corals were also classified to family level. Other biota were classified to higher levels consistent with the Marine Baseline Program. In addition, classification of corals to family level also facilitated the effective quality assurance/quality control (QA/QC) of the CPCe scores.

2.7 Quantifying Coral Assemblages and Calculation of Allowable Loss of Coral Assemblage

The proportion of transects within each stratum that were classified as Coral Assemblages, was determined. Proportions were then averaged, weighting each stratum according to the relative area of the stratum (note that although results are presented to a few significant figures, calculations were undertaken throughout with double integer level precision before final rounding). This generated an overall measure of the proportion of potential Coral Assemblages that were actually Coral Assemblages, within each of the Zones of High and Moderate Impact and Reference Areas and Regionally Significant Areas. Because small bombora <15 m in diameter, bombora 15–50 m in diameter in the LNG Jetty area and large reefs in the MOF area were not sampled, a conservative assumption was made that all these mapped areas were Coral Assemblages. While this is unlikely to be true, there was no information with which to set a more realistic proportion of Coral Assemblages. In any case, the strata accounted for a very small proportion of the overall area of mapped coral and made very little difference to the overall calculation (Section 2.4). Similarly, as well as Maximum Likelihood estimates, 95% Confidence Interval estimates for the proportions were calculated on the basis of normal approximation for binomial sampling (Cochran 1977) and a Yates' correction for continuity applied to account for the finite nature of the data (Zar 1984).

The areas of Coral Assemblages were calculated separately for the Zones of High and Moderate Impact. The total area of Coral Assemblage within each Zone of High and Moderate Impact, Reference Area and Regionally Significant Area was calculated as the Maximum Likelihood estimate (± 95% Confidence Interval) of the proportions of the survey areas that were confirmed to be Coral Assemblages multiplied by the total mapped area of potential Coral Assemblage, within that Zone, Reference Area or Regionally Significant Area. The 95% Confidence Intervals were also generated for each calculation.

Condition 18.1.ii of Statement No. 800 stipulates that the Permanent Loss of Coral Assemblages within the Zones of High Impact and Zones of Moderate Impact is not to exceed 22 hectares, or the Area of Loss of Coral Assemblages calculated under Condition 14.6.ii, whichever is less. Condition 14.6.ii of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178, prescribe the formula to calculate the Area of Loss of Coral Assemblage:

$$a = h + (m \times 30\%)$$

where:

a = the area (ha) of loss of Coral Assemblages

h = the area (ha) of Coral Assemblages within the Zones of High Impact; and

m = the area (ha) of Coral Assemblages within the Zones of Moderate Impact.

Areas 'h' and 'm' were based on Maximum Likelihood estimates for proportions of Coral Assemblage in each Zone.

2.8 QA/QC Procedures

Quality Assurance and Quality Control procedures were developed to ensure the consistent and accurate collection, storage and processing of data and report production. These procedures are outlined in Appendix 2.

3.0 Results

3.1 Assessments of the Area of Mapped Coral and Coral Loss in the Zones of High and Moderate Impact

The revised assessment of the extent of coral within the Zones of High and Moderate Impact was a total mapped area of coral of 14.68 ha across the Zones of High (8.79 ha) and Moderate (5.89 ha) Impact. This area, based on the refined mapping undertaken for the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1), is substantially lower than had been predicted previously in the EIS/ERMP (Chevron Australia 2005, 2006) and the PER (Chevron Australia 2008). Many areas that had been identified as potentially being coral in qualitative maps or bathymetry/aerial photography, were found through field surveys not to be Coral Assemblage, but were areas dominated by macroalgae with sparse sessile taxa. Where such areas had been identified by ground-truthing during the Marine Baseline Program as not being Coral Assemblage, they were removed as coral areas from the maps. In particular, raised seabed features in inshore areas around the MOF were often found to be covered in macroalgae rather than actually being coral as (conservatively) originally assumed from the information available. This was also found to be the case in the quantitative surveys of the remaining areas of mapped coral undertaken as part of this study. A large proportion of bombora (10–50 m in diameter) in the inshore MOF areas were covered in macroalgae rather than Coral Assemblage. In reality, the field surveys have indicated that there is relatively little Coral Assemblage in the Zones of High and Moderate Impact, especially in the inshore MOF area. While the greater mapping effort resulted in more accurate maps of places where Coral Assemblages were likely, it also resulted in a reduction in total area of mapped coral—note, however, that it could have lead to greater areas had there actually been more coral than previously predicted. Consequently, even if the cover of Coral Assemblages in the mapped coral areas had been uniformly very high (e.g. 100% cover), the overall calculation of total area of Coral Assemblage would still have been much less than 22 ha.

Based on this revised information, the predicted loss of coral from dredging, dredge spoil disposal and construction activities associated with the construction of the MOF and LNG Jetty for the Gorgon Gas Development Revised and Expanded Proposal is thus approximately 10.56 ha. This value takes into account the complete loss of coral from within the Zones of High Impact and the 30% loss of coral from within the Zones of Moderate Impact. This value ignores any differences in live coral cover of the different areas of coral, assuming 100% cover of Coral Assemblage in all of the mapped coral areas. Note, however, that only areas that had been mapped as coral were included in this assessment. Any small, indistinct areas of coral interspersed within other major habitats, but that were too small to map individually, were never included in calculations because, by definition, there are no measures of their areas. As in previous calculations (Chevron Australia 2005, 2006, 2008), any such small areas of unmapped coral are not considered further in the calculation of the area of Loss of Coral Assemblages documented in this Supplement.

3.2 Proportions of Mapped Areas that were Coral Assemblages in the Zones of High and Moderate Impact

Most of the coral mapped during the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1) was present as relatively small features in inshore areas and as larger reefs in offshore areas. There were almost no larger areas of reef in the Zones of High or Moderate Impact surrounding the MOF. The majority of mapped coral that may be affected by dredging, spoil disposal and construction activities was in the larger reefs within the Zones of High and Moderate Impact surrounding the LNG Jetty (Table 3.1, Table 3.2). Approximately 80% of the total area mapped as coral across the Zones of High and Moderate Impact were around the LNG Jetty. Consequently, the proportion of these strata that were classified as Coral Assemblage was critical to the overall calculation of the area of Coral Assemblage. Small bombora <15 m in diameter, bombora 15–50 m diameter in the LNG Jetty

area and large reefs in the MOF area accounted for <10% of the overall mapped area of coral, so assuming these were 100% covered with Coral Assemblage made little difference to the overall calculations.

Inshore areas (MOF strata), in particular, had low proportions of Coral Assemblage; none of the areas sampled on 16 bombora were classified as Coral Assemblage. However, a much higher proportion of the large reefs in the LNG Jetty area were classified as Coral Assemblage and all eight transects at Lone Reef were classified as Coral Assemblage (Table 3.1, Table 3.2).

Table 3.1 Proportion of Transects Classified as Coral Assemblage within the Zones of High Impact

Stratum	Area (ha)	No. Transects Surveyed	Proportion Coral Assemblage within Stratum	Area of Coral Assemblage (ha)
MOF – Large Reefs	0.13	Not surveyed	Assume 1.0	0.13
MOF – bombora (15–50 m diameter)	0.52	6	0.17	0.09
MOF – bombora (<15 m diameter)	0.31	Not surveyed	Assume 1.0	0.31
LNG Jetty – Large Reefs	7.58	26	0.62	4.66
LNG Jetty – bombora (15–50 m diameter)	0.06	Not surveyed	Assume 1.0	0.06
LNG Jetty – bombora (<15 m diameter)	0.19	Not surveyed	Assume 1.0	0.19
Total (95% Confidence Interval)	**8.79**	**32**	**0.62**	**5.44 (3.68, 7.20)**

Table 3.2 Proportion of Transects Classified as Coral Assemblage within the Zones of Moderate Impact

Stratum	Area (ha)	No. Transects Surveyed	Proportion Coral Assemblage within Stratum	Area of Coral Assemblage (ha)
MOF – Large Reefs	0.30	Not surveyed	Assume 1.0	0.30
MOF – bombora (15–50 m diameter)	1.34	16	0	0
MOF – bombora (<15 m diameter)	0.38	Not surveyed	Assume 1.0	0.38
LNG Jetty – Large Reefs	3.19	18	0.61	1.95
LNG Jetty – bombora (15–50 m diameter)	0.00	No mapped features	-	0
LNG Jetty – bombora (<15 m diameter)	0.00	No mapped features	-	0
Lone Reef (Dredge Spoil Disposal Ground)	0.68	8	1.0	0.68
Total (95% Confidence Interval)	**5.89**	**42**	**0.56**	**3.31 (2.38, 4.24)**

3.2.1 Overall Calculation of Coral Assemblages and Area of Loss of Coral Assemblages

The overall calculations of the estimate of the total area of Coral Assemblage within the Zones of High and Moderate Impact were 7.20 ha (Zones of High Impact; Table 3.1) and 4.24 ha (Zones of Moderate Impact; Table 3.2), which gives a total of 11.44 ha for both areas summed. Note that this calculation includes a (conservative) assumption that where proportions could not be measured on strata, the proportion of Coral Assemblage was assumed to be one. However, even if all those strata had not contained any Coral Assemblage at all, the calculation of total area of Coral Assemblage would still have been 10.07 ha. Thus, the overall calculation was not very sensitive to not having measured proportions of Coral Assemblage in some of the smaller strata.

The total area of Coral Assemblage within the Zones of High Impact plus 30% of the area of Coral Assemblage within the Zones of Moderate Impact, as calculated using the formula in Condition 14.6.ii of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178, was:

Area of Loss of Coral Assemblages (a) = 7.20 + (4.24 x 30%) = 8.47 ha

As outlined in Section 4.1.2.7 of the approved Scope of Works, this calculation is based on the upper 95% Confidence Interval estimates of the area of Coral Assemblages in each Zone and is consistent with Schedule 2 of Statement No. 800 and Condition 11.6.ii of EPBC Reference: 2003/1294 and 2008/4178. Schedule 2 states that *"In determining the coral loss, measurement uncertainty is to be taken into consideration"*.

3.3 Proportions of Mapped Areas that were Coral Assemblages at Reference Areas and Regionally Significant Areas

Coral cover was relatively high at most Reference Areas and Regionally Significant Areas and the proportions of strata that were Coral Assemblage were large, at least in those strata in which cover had been visually determined as part of the mapping undertaken for the Marine Baseline Program (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1) (Table 3.3). Coverage of Coral Assemblage was low only in strata where visual assessment had not been undertaken.

Table 3.3 Proportion of Transects Classified as Coral Assemblage within Reference Areas and Regionally Significant Areas

Reference Area/ Regionally Significant Area	Stratum	Area (ha)	No. Transects Surveyed	Proportion Coral Assemblage within Stratum	Area of Coral Assemblage (ha)
Ah Chong	Unconfirmed Coral	244.99	16	0.56	137.80
	Porites Bombora (51–75% cover)	0.57	Not Surveyed	Assume as for Unconfirmed Coral stratum	0.32
Total (95% Confidence Interval)		**245.56**	**16**	**0.56**	**138.12 (60.00, 216.25)**
Batman Reef	*Porites* Bombora (10–50% cover)	20.20	4	0.50	10.10
	Mixed Coral Assemblage (10–50% cover)	39.74	16	0.88	34.78
	Mixed Coral Assemblage	0.50	4	1.0	0.50

Reference Area/ Regionally Significant Area	Stratum	Area (ha)	No. Transects Surveyed	Proportion Coral Assemblage within Stratum	Area of Coral Assemblage (ha)
	(51–75% cover)				
	Unconfirmed Coral	262.05	16	0.31	81.89
Total (95% Confidence Interval)		**322.49**	**40**	**0.39**	**127.27 (48.83, 205.70)**
LNG3	Unquantified Coral	19.84	20	0.70	13.89
	Porites Bombora (10–50% cover)	0.43	0	Assume as for Unquantified Coral stratum	0.30
Total (95% Confidence Interval)		**20.27**	**20**	**0.70**	**14.19 (9.11, 19.26)**
Dugong Reef	Unquantified Coral	51.37	8	1.0	51.37
	Mixed Coral Assemblage (10–50% cover)	35.16	7	1.0	35.16
	Mixed Coral Assemblage (51–75% cover)	96.03	8	1.0	96.03
	Unconfirmed Coral	88.18	12	1.0	88.18
Total (95% Confidence Interval)		**270.74**	**35**	**1.0**	**270.74 (no Confidence Interval)**
Southern Barrow Shoals	Mixed Coral Assemblage (10–50% cover)	32.10	4	1.0	32.10
	Mixed Coral Assemblage (10–50% cover) and Mixed Phaeophyceae (25–75% cover)	696.39	12	0.75	522.29
	Unconfirmed Coral	704.23	16	0.44	308.10
Total (95% Confidence Interval)		**1432.72**	**32**	**0.60**	**862.49 (555.39, 1169.60)**

Overall proportions (± standard error) of area mapped as coral that is Coral Assemblage ranged from 0.39 (± 0.10) at Batman Reef to 1.0 at Dugong Reef (Table 3.3). There was no standard error or Confidence Interval calculation for Dugong Reef because all 35 transects surveyed were classified as Coral Assemblage. The relatively lower overall proportion of Coral Assemblage at Batman Reef was mainly because of the inclusion of a large area of 'Unconfirmed Coral' from the Department of Environment and Conservation (DEC) maps (Department of Conservation and Land Management 2004; DEC 2007) into the Marine Baseline Program maps (Marine Baseline Report, Section 5.0, Section 6.3.2.1 and Section 6.4.1). These were found to have only a relatively small proportion (0.31) actually Coral Assemblage. Similarly, the large area of 'Unconfirmed Coral' at Southern Barrow Shoals was also found to have a relatively low proportion of the area (0.44) that was actually Coral Assemblage. Proportions of area that were Coral Assemblage at the other Reference Areas and Regionally Significant Areas were: Ah Chong = 0.56 (± 0.13), LNG3 = 0.70 (± 0.10) and Southern Barrow Shoals 0.60 (± 0.09).

3.4 Accounting for Temporal Variation with Future Measurements of Coral Assemblages

Coral Assemblages are well known as naturally very dynamic systems, even over relatively short time scales (e.g. Connell and Keough 1985; Connell *et al.* 1997). Indeed, quite large variations in coral cover and composition were apparent across just a few months at a number of monitoring sites during the Marine Baseline Program. For example, coral cover at Ant Point Reef decreased markedly over the period of the Marine Baseline Program (Marine Baseline Report, Section 6.4.4.3.1). Whilst such variation is natural, it also means that any calculation of the cover of Coral Assemblages at one point in time, such as was undertaken for the present assessment, is simply a 'snapshot' and not a measure across the period before the commencement of dredging and spoil disposal activities. Measurements at a single time are a measure of the cover of Coral Assemblages at one time and so do not necessarily reflect what cover of Coral Assemblages there might have been if measurements had been made a few months earlier or later.

4.0 Review of this Supplement

Chevron Australia is committed to conducting activities in an environmentally responsible manner and aims to implement best practice environmental management as part of a program of continuous improvement. This commitment to continuous improvement means Chevron Australia will review this Supplement as required (e.g. in response to new information).

Reviews will address matters such as the overall design and effectiveness of the Supplement, progress in environmental performance, changes in environmental risks, changes in business conditions, and any relevant emerging environmental issues.

If the Supplement no longer meets the aims, objectives or requirements of the Supplement, if works are not appropriately covered by the Supplement, or measures are identified to improve the Supplement, Chevron Australia may submit an amendment or addendum to the Supplement to the Minister for approval under Condition 36 of Statement No. 800.

If Chevron Australia wishes to carry out an activity otherwise than in accordance with the Supplement, Chevron Australia will update the Supplement and submit it for approval by the Minister in accordance with Condition 25 of EPBC Reference: 2003/1294 and 2008/4178.

The Commonwealth Minister may also direct Chevron Australia to revise the Supplement under Condition 26 of EPBC Reference: 2003/1294 and 2008/4178.

5.0 Conclusion

Ministerial Implementation Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178 for the Gorgon Gas Development Revised and Expanded Proposal require an assessment of the area of Coral Assemblage that might be lost as a consequence of construction, dredging and spoil disposal activities on the east coast of Barrow Island. Schedule 2 of Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178 provide that, in determining coral loss, measurement uncertainty is to be taken into consideration. The results from the field sampling program undertaken in November 2009 thus indicate that the revised Area of Allowable Loss of Coral Assemblages equals 8.47 ha (based on the upper 95% Confidence Interval estimate of the area of Coral Assemblage in each Zone).

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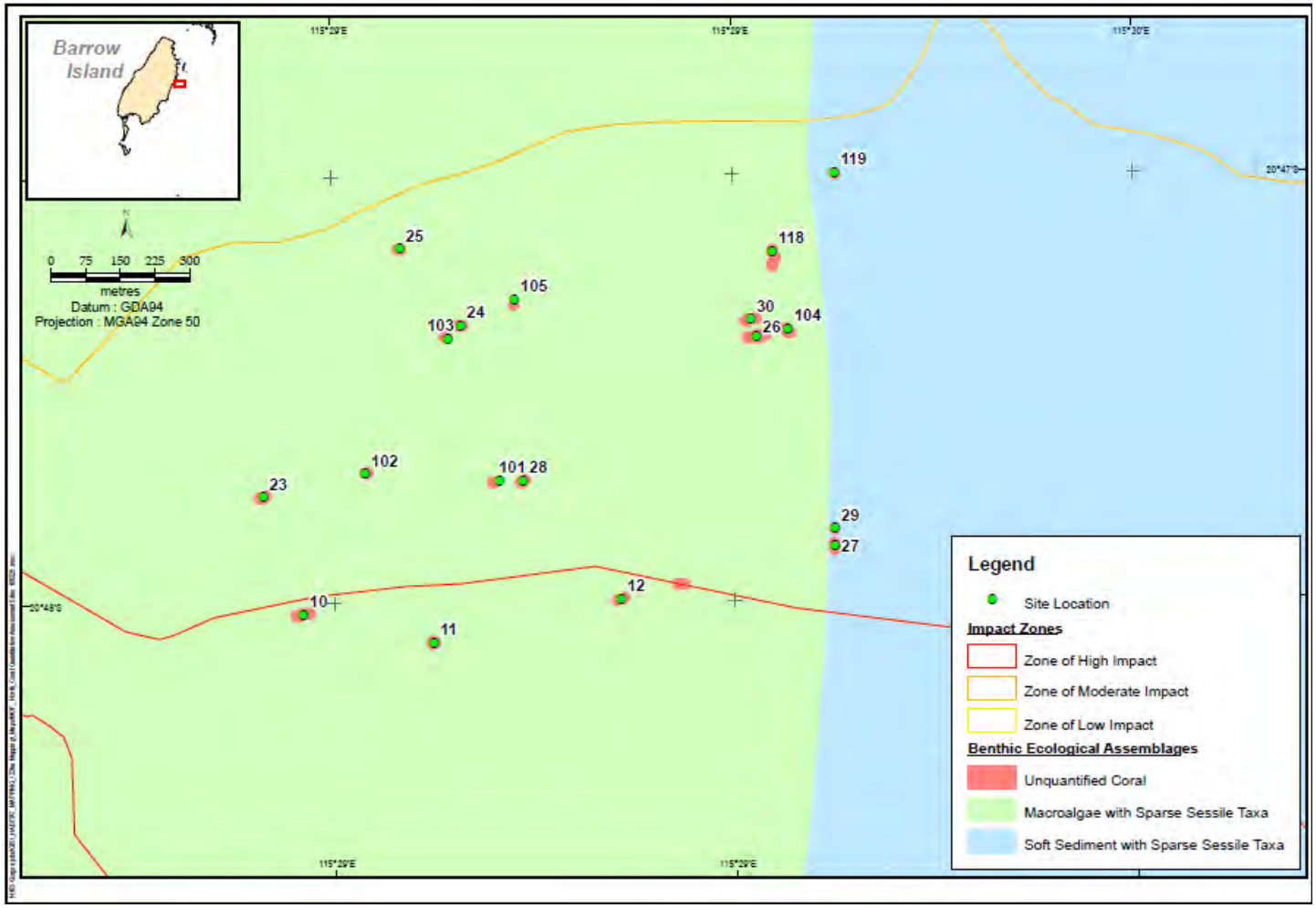
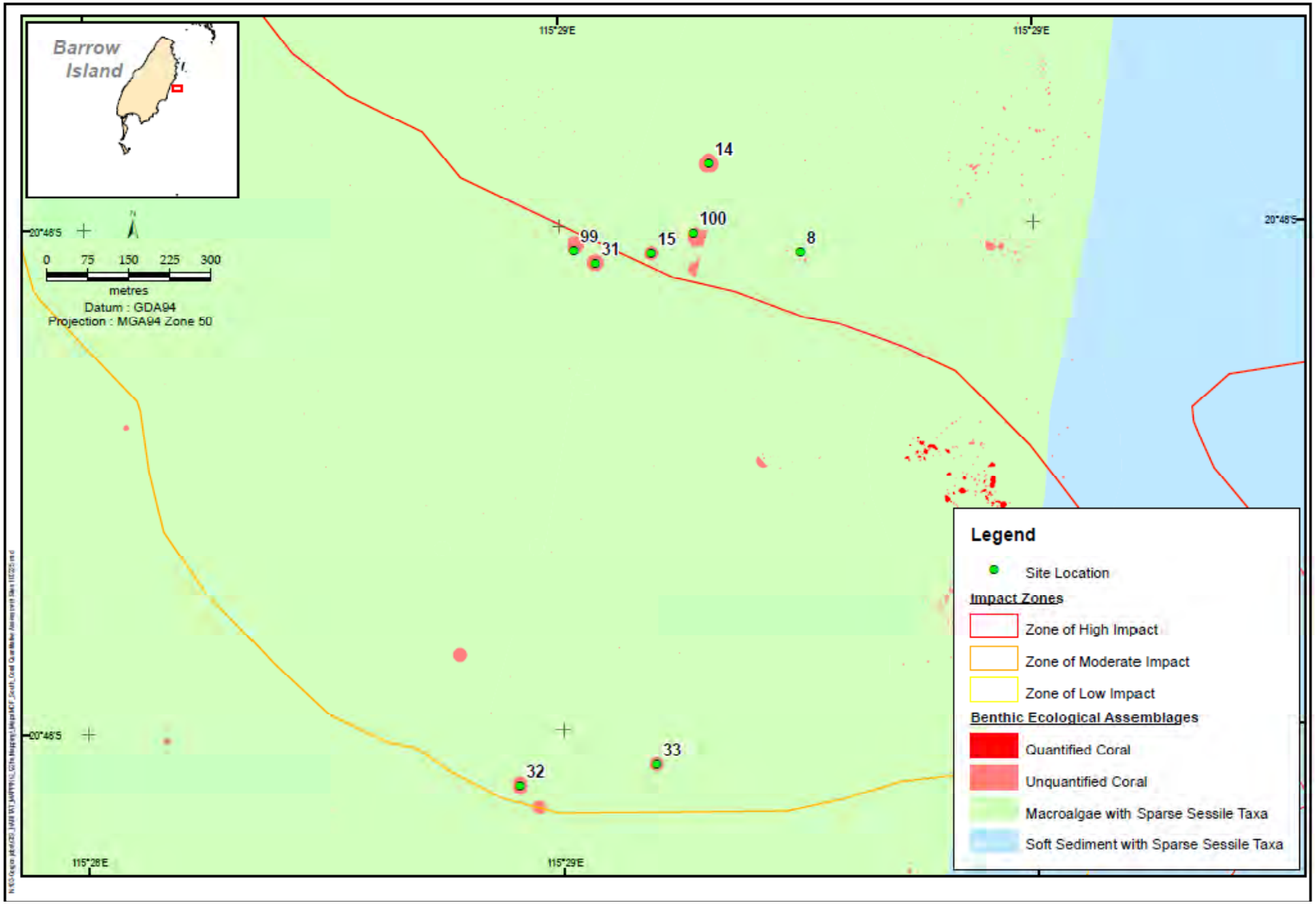
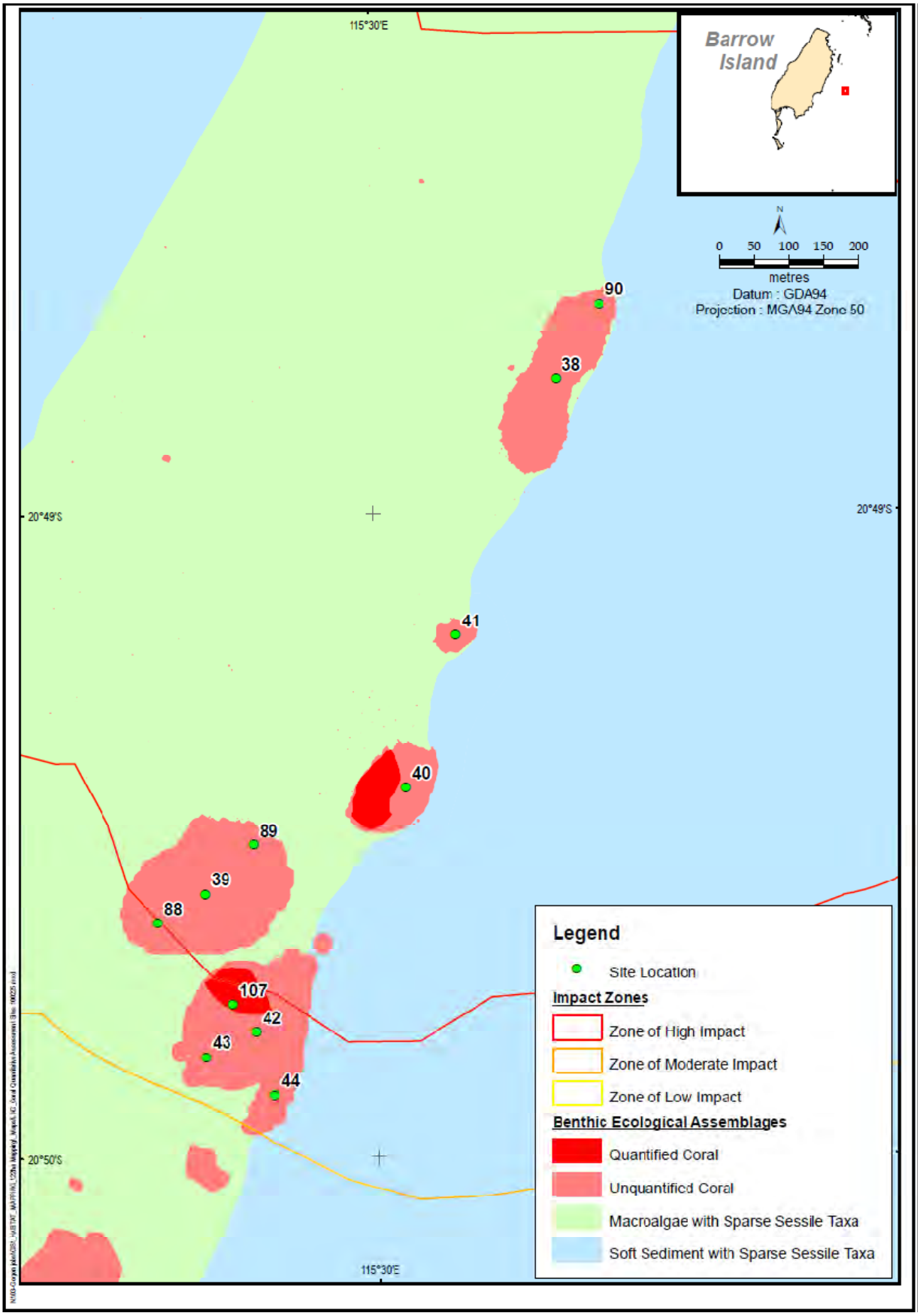
Appendix 1 Site Maps



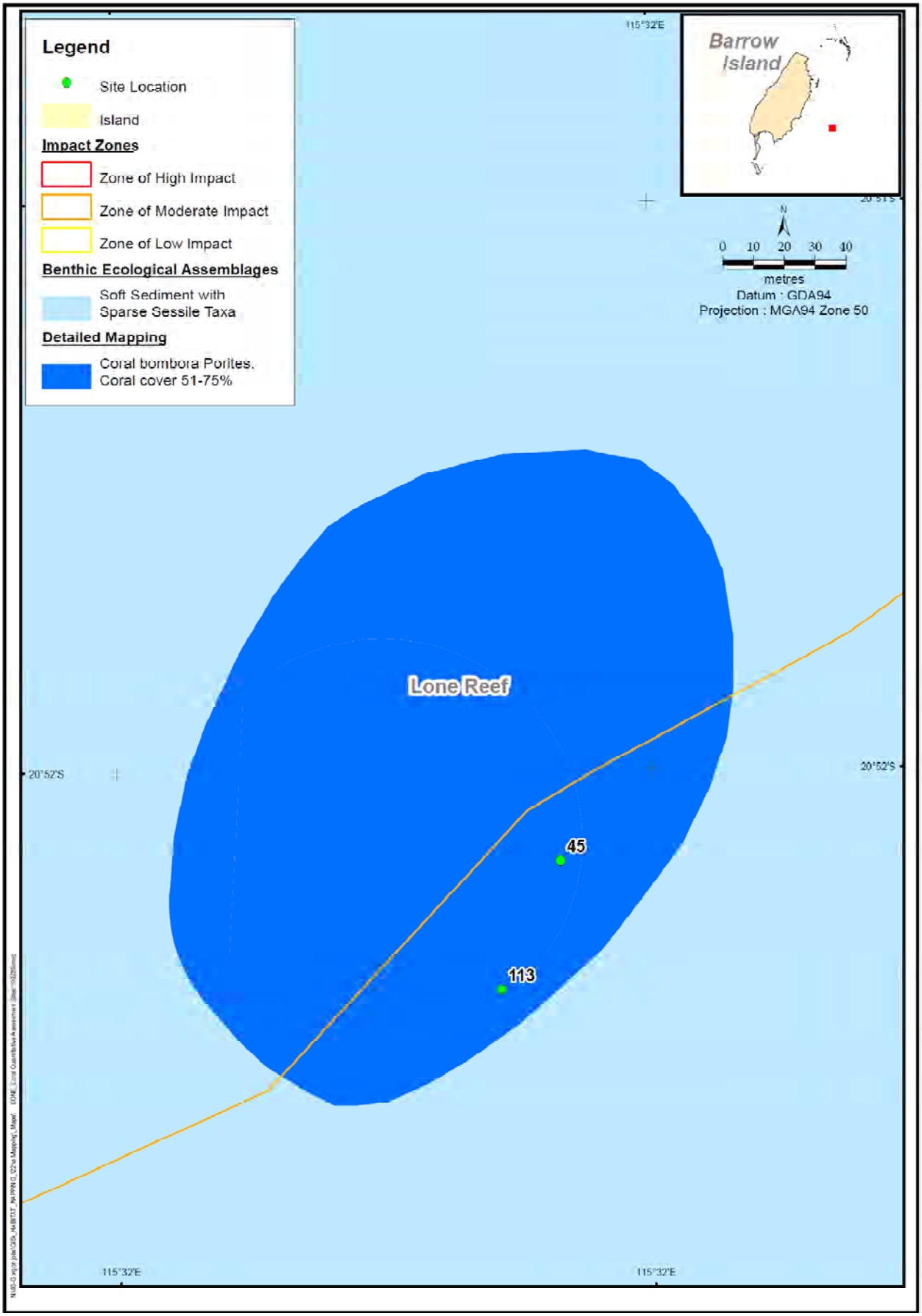
Survey Sites North of the Materials Offloading Facility



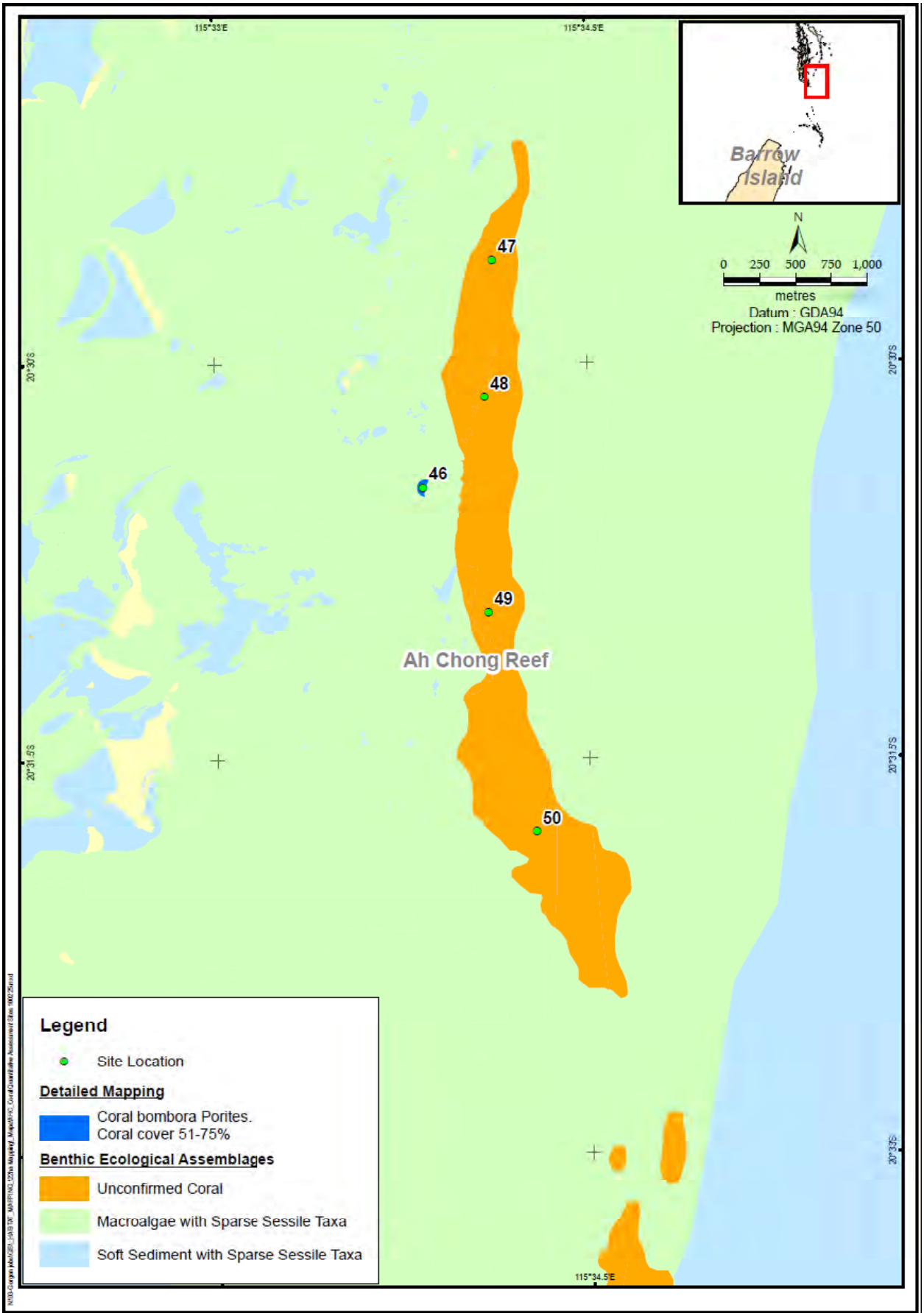
Survey Sites South of the Materials Offloading Facility



Survey Sites in the LNG Jetty area

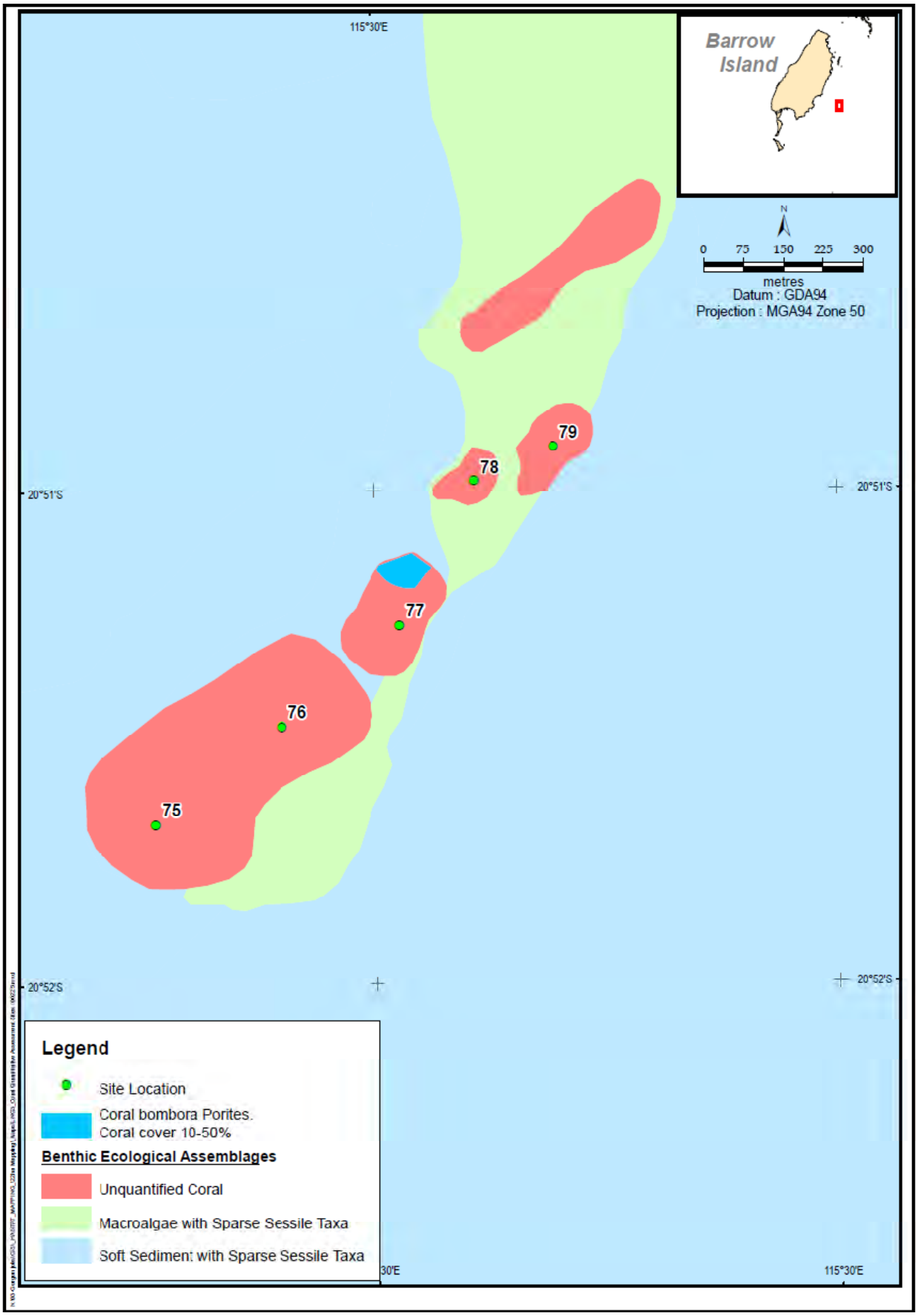


Survey Sites at Lone Reef

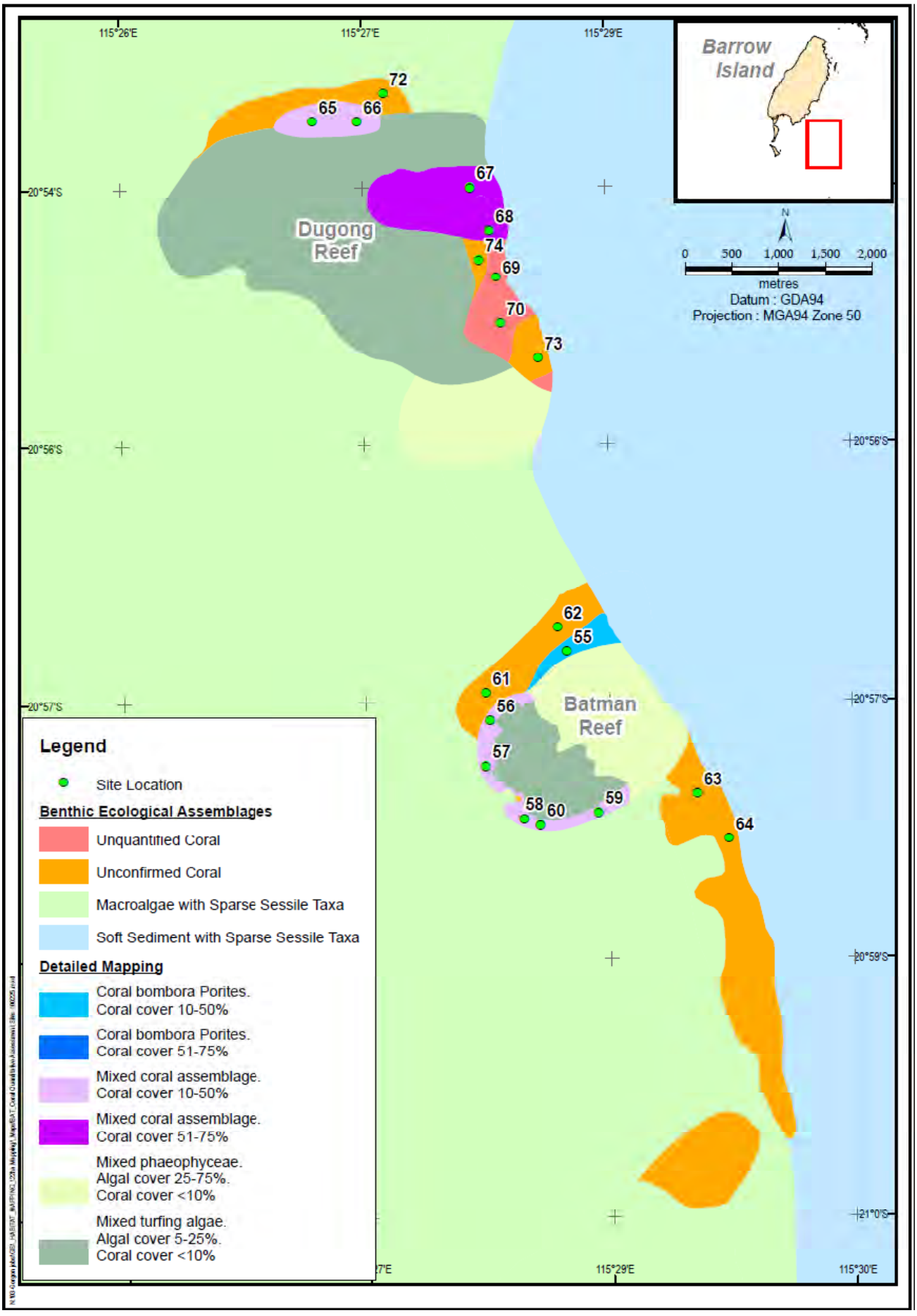


Survey Sites at the Ah Chong Reef (Reference Area)

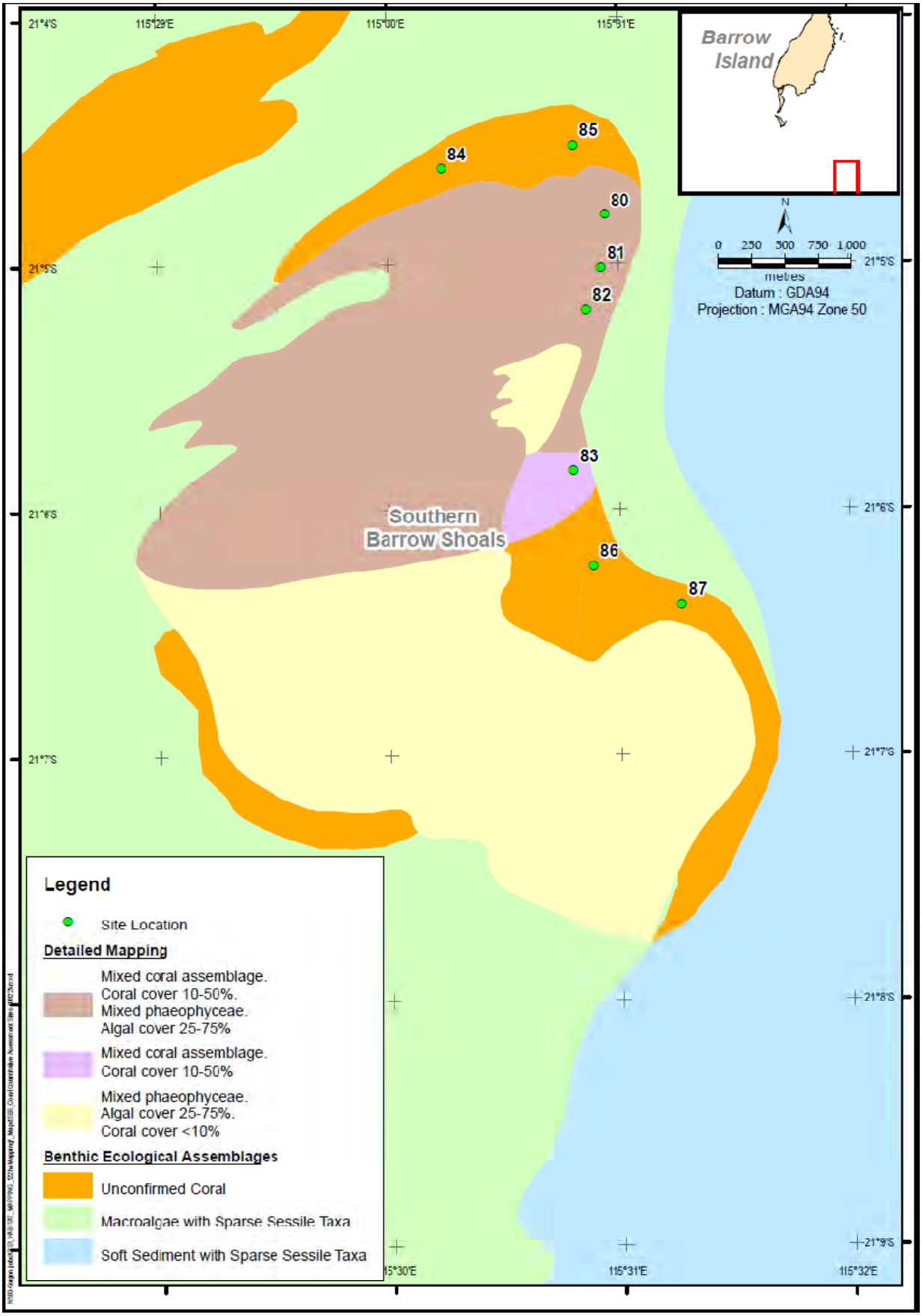
Public



Survey Sites the LNG3 (Reference Area)



Survey Sites at the Dugong Reef and Batman Reef (Regionally Significant Areas)



Survey Sites at the Southern Barrow Shoals (Regionally Significant Area)

Appendix 2 Quality Assurance and Quality Control Procedures

Field Survey Data Collection

- Prior to entering the water at the survey sites, the divers were inducted on the procedures for establishment of transects and taking photographs. The same team of divers were used to photograph all transects.
- Photographs were taken with a camera mounted on a frame attached to the quadrat to ensure that a standard area was photographed at a standard height and angle. All photographs were taken using a Canon digital IXUS 110 IS camera on a wide-angle setting. Photographs were taken at every 1 m along each transect. Tape measures were used to delineate transects and to avoid the possibility of diver bias in positioning quadrats. Divers reviewed each photograph as it was taken to ensure that the quadrat was visible (i.e. to ensure a standard area was photographed and analysed) and that the photo was focused/appropriately exposed.
- Photographs were downloaded to a laptop computer immediately after each dive and each photo was electronically labelled with the site name, transect number, quadrat number and date. A protocol was developed for photo labelling and processing as follows:

  Photo labelling protocol

  Zone_Date(yymm)_Time_Date(dd-mm-yy)_ReefStrataCode_SiteNumberTransectNumber_ Quadrat Number

  e.g. HIG_0911_0_18-11-09_MF_02_351_01

  Strata Codes

  Zone:

  HIG = Zone of High Impact

  MOD = Zone of Moderate Impact

  REF = Reference Area/Regionally Significant Area

  Reef:

  MF = MOF

  JT = Jetty

  LO = Lone Reef

  L3 = LNG3

  BT = Batman Reef

  AC = Ah Chong

  DG = Dugong Reef

  SB = Southern Barrow Shoals

  Strata:

  Coral Bombora >15 m diameter and ≤50 m diameter (Unquantified Coral) = 01

  Coral Reef >50 m diameter (Unquantified Coral) = 02

  Coral Bombora *Porites* 10–50% = 03

  Coral Bombora *Porites* 51–75% = 04

Mixed Coral Assemblage 10–50% = 05

Mixed Coral Assemblage 51–75% = 06

Mixed Coral Assemblage 10–50%, Mixed Phaeophyceae 25–75% = 07

Unconfirmed Coral = 08

Possible combinations for strata at each Zone and Reef are shown below.

Zone	Reef	Strata	Code
HIG	MF, JT	Coral Bombora >15 m diameter and ≤50 m diameter (Unquantified Coral)	01
HIG	MF, JT	Coral Reef >50 m diameter (Unquantified Coral)	02
MOD	MF, JT	Coral Bombora >15 m diameter and ≤50 m diameter (Unquantified Coral)	01
MOD	MF, JT, LO	Coral Reef >50 m diameter (Unquantified Coral)	02
REF	L3, DG	Coral Reef >50 m diameter (Unquantified Coral)	02
REF	L3, BT	Coral Bombora *Porites* 10–50%	03
REF	AC	Coral Bombora *Porites* 51–75%	04
REF	BT, DG, SB	Mixed Coral Assemblage 10–50%	05
REF	BT, DG	Mixed Coral Assemblage 51–75%	06
REF	SB	Mixed Coral Assemblage 10-50%, Mixed Phaeophyceae 25–75%	07
REF	BT, DG, SB, AC	Unconfirmed Coral	08

- All photographs were copied onto the field laptop computer and backed up to an independent hard drive at the end of each survey day. On return to the office, photographs were immediately transferred to the RPS network, which is backed up daily.

Data Management

Photographs were analysed using the program CPCe (see below) and the CPCe files were converted to Microsoft Excel® files. Consequently, there were several files and folders for each site including:

- photos
- CPCe analysis files
- CPCe analyses uploaded to Excel
- master database of CPCe-processed data in Excel
- Excel working sheets used for statistical calculations.

In each folder, data/files were labelled with the site name, transect number, quadrat number and date. The master database of CPCe-processed data in Excel retains all the file names so that all data can be traced to the original photograph and CPCe file.

CPCe Analysis

A training program was developed for CPCe analysis of coral transects, including formalised definitions and reference photographs of each of the CPCe categories. Each scorer was

required to complete the training course and achieve a high level of accuracy in an assessment prior to analysing any routine images. A maximum 10% difference in classification for all benthos pooled (i.e. 90% identical) and no more than one point misclassified for all coral categories is allowed per photo; the reason for the difference is that sometimes discerning bare rock versus low turfing algae etc. can be more subjective than scoring coral families. Misclassification rates are determined by periodically comparing scores from an image analysed by both the senior CPCe scorer and the individual scorer being tested (approximately every 50 images processed). If misclassification rates are greater than the criteria, the scorer is retrained and retested before being allowed to continuing scoring. All images sampled by this scorer since they were last tested are rescored by another recently tested scorer. This discrepancy between scorers is also communicated to all scorers to ensure ongoing scorer consistency.

Data Analysis, Interpretation and Reporting

- CPCe outputs were converted to Excel files using the CPCe program. A macro embedded in the Excel program was then used to compile the data into a master data sheet suitable for summaries and statistical analyses. The add-in contains several checks to ensure that all data points are uploaded from CPCe and none are uploaded more than once.
- Manual checks were also done to ensure that all data were included in the files used in the statistical analyses, including checking off each row of data in the master against corresponding photo and CPCe files.
- Once checked, the master Excel database was changed to ‘read only’ and password-protected. All subsequent analyses involving potential changes to spreadsheets were done with copies of the original file.
- Checked data was analysed by an experienced statistician using custom-built worksheets in Excel/Visual Basic to create averages of coral percentage cover and proportions of transects in each zone/reef/strata that are classified as ‘Coral Assemblage’. A diary of analyses was maintained.