



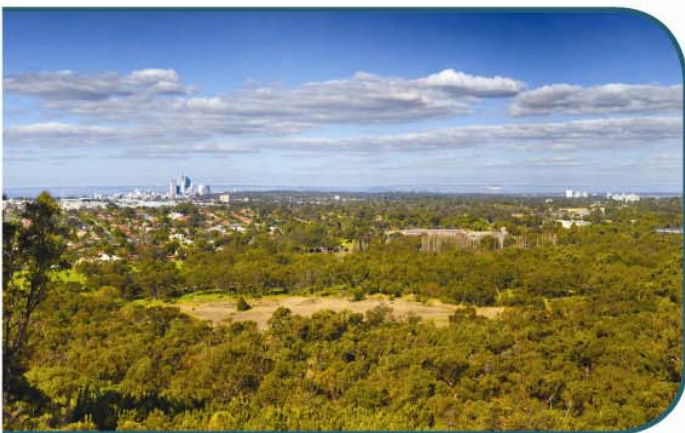
Environmental Protection Authority

# **Environmental Assessment Guidelines**



**No.3**

## **Protection Of Benthic Primary Producer Habitats In Western Australia's Marine Environment**



December 2009

**Western Australia**

---

## FOREWORD

The Environmental Protection Authority (EPA) is an independent statutory authority and is the key provider of independent environmental advice to Government.

The EPA's objectives are to protect the environment and to prevent, control and abate pollution. The EPA aims to achieve some of this through the development of Environmental Assessment Guidelines (EAGs) for the environmental impact assessment (EIA) of proposals or schemes.

This document is one in a series being issued by the EPA to assist proponents, consultants and the public generally and to provide additional information and non-statutory guidance in relation to the EPA's thinking in relation to specific aspects of the EIA process. The series provides the basis for EPA's evaluation of, and advice on, proposals or schemes subject to EIA.

The EPA has developed this Environmental Assessment Guideline in recognition of the fundamental ecological importance of Benthic Primary Producer Habitats (BPPH) and the potential consequences of their loss for marine ecological integrity, and also the fact that almost all marine development proposals will result in some loss of these important habitats. For the purposes of this EAG, Benthic Primary Producer Habitats are defined as seabed communities within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components.

In this Environmental Assessment Guideline the EPA has provided a framework to impart clarity and consistency to the environmental impact of proposals that have potential to result in irreversible loss of, or serious damage to, benthic primary producer habitats in Western Australia's marine environment.

The framework is underpinned by a set of overarching environmental protection principles, which are set out in Section 3.5. The EPA expects all proponents of proposals for which loss of and/or serious damage to benthic primary producer habitat is a relevant factor to demonstrate application of the impact avoidance and minimisation principles as well as how best practice has been incorporated into project formulation and management before any quantitative appraisal of cumulative residual losses are made.

The EPA has also provided a risk-based spatial assessment framework in Section 5 for evaluating cumulative irreversible loss of and/or serious damage to benthic primary producer habitats. The cumulative loss values for the EIA of proposals are the sums of proposed and historic loss/serious damage for each different benthic primary producer habitat within a defined sub-ecosystem scale area termed a 'local assessment unit'. Application of this spatial framework is based around six categories of marine ecological protection and quantitative cumulative loss guidelines for benthic primary producer habitat that apply to each category (see table below). Cumulative Loss Guidelines are percentage values against which the calculated cumulative loss for each different benthic

primary producer habitat are evaluated. The cumulative loss guidelines are intended as tools to help proponents, the EPA and the community to gauge risk to ecological integrity associated with cumulative loss of different benthic primary producer habitats within a defined sub-ecosystem scale area termed a 'local assessment unit'. Cumulative Loss Guidelines are not intended to be hard and fast acceptability criteria.

It could generally be expected that assessments of proposals that are unlikely to cause cumulative loss guidelines to be exceeded would be more straightforward than assessments of loss predicted to significantly exceed the cumulative loss guideline. It should be noted that the acceptability of benthic primary producer habitat damage/loss will, in all cases, be a judgement of the EPA based largely on its consideration of proponents' application of the overarching assessment principles and the overall risk to ecological integrity of the local assessment unit if a proposal were allowed to be implemented.

**Cumulative loss guidelines for benthic primary producer habitat within defined local assessment units for six categories of marine ecological protection that will be applied only after proponents can demonstrate to the EPA that all practicable options to avoid/minimise damage/loss of benthic primary producer habitat have been considered.**

Category	Description	Cumulative loss guideline
A	Extremely special areas	0%
B	High protection areas other than above	1%
C	Other designated areas	2%
D	Non-designated area	5%
E	Development areas	10%
F	Areas where cumulative loss guidelines have been significantly exceeded	No net damage/loss

*\* Defined as a percentage of the original area of BPPH within a defined local assessment unit*

While guidance is provided specifically in relation to the Western Australian *Environmental Protection Act, 1986*, proponents are reminded to ascertain any responsibilities they may have in regard to this issue under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999*.

This document has the status of “Final” which means it has been reviewed by stakeholders and the public. The process for developing EAGs is set out in Appendix 1.

I am pleased to release this document which now supersedes Guidance Statement No.29 (June 2004) and previous draft revised versions of that document.

A handwritten signature in blue ink, appearing to read 'P. Vogel', is written over a horizontal line that extends across the page.

**Dr Paul Vogel**  
CHAIRMAN  
ENVIRONMENTAL PROTECTION AUTHORITY  
1 December 2009



## Table of Contents

1	PURPOSE .....	1
2	CONTEXT AND SCIENTIFIC BACKGROUND.....	2
3	POLICY AND LEGISLATIVE CONTEXT .....	5
4	METHODOLOGY .....	7
5	RISK-BASED ASSESSMENT GUIDELINES.....	13
6	RESPONSIBILITIES .....	21
7	DEFINITIONS.....	21
8	GLOSSARY OF TERMS .....	22
8	LIMITATIONS.....	23
9	REFERENCES .....	23
<b>Appendix 1:</b> Generic Flow Diagram for the Environmental Assessment Guidelines Process.....		26
<b>Appendix 2:</b> Example Applications of Environmental Assessment Guideline No.3.....		27
<b>Appendix 3:</b> Contextual Information .....		35
<b>Appendix 4:</b> Submitting Proposal Boundaries and Benthic Habitat Information as Spatial Data for Environmental Impact Assessment.....		41



---

## **Environmental Assessment Guideline No. 3**

### **Environmental Assessment Guidelines for Protection of Benthic Primary Producer Habitat in Western Australia's Marine Environment**

---

**Key Words:** Environmental Impact Assessment, primary producers, benthic habitat, ecological integrity, cumulative impact, protection, guideline

#### **1 PURPOSE**

Environmental Assessment Guidelines (EAGs) are developed by the Environmental Protection Authority (EPA) to provide non-statutory advice to proponents, consultants and the public generally about specific procedures, methodologies and the minimum requirements for environmental impact assessment (EIA) and management which the EPA would expect to be met by proposals or schemes it considers during the EIA process. The generic process for developing Environmental Assessment Guidelines is set out in Appendix 1.

This EAG specifically addresses protection and maintenance of ecological integrity and biodiversity through a framework for assessment of cumulative irreversible loss of, and serious damage to, benthic primary producer habitats (BPPH) in Western Australia's marine environment. Benthic Primary Producer Habitats are seabed communities within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components. Benthic Primary Producer Habitats also include areas of seabed that can support these communities. Expanded contextual information regarding this definition is set out in Section 2.

This Environmental Assessment Guideline No.3 supersedes Guidance Statement No.29 (June 2004) and previous draft revised versions of that document and sets out:

- (a) the EPA's contemporary thinking on its approach to assessment of activities which, on their own or in the context of existing and approved developments, may directly or indirectly contribute to cumulative irreversible loss of, or serious damage to, benthic primary producer habitat;
- (b) overarching environmental protection principles and the expectations for their application;
- (c) a risk-based assessment framework for considering cumulative loss of benthic primary producer habitat and the potential consequences for marine ecological integrity that recognises different ecological, conservation and social values of the marine environment and aims to preferentially steer development proposals away from 'vegetated' benthic primary producer habitat; and
- (d) the EPA's expectations for minimum standards of information to be supplied by proponents for EIA.

This Environmental Assessment Guideline specifically applies to *development proposals* that are predicted to result in *irreversible loss of, or serious damage to*, benthic primary producer habitats.

The terms 'loss' and 'serious damage' used in the definition above warrant some clarification. Loss refers to direct removal or destruction of benthic primary producer habitat. Loss of benthic primary producer habitat would commonly be associated with activities such as excavation or burial. In almost all cases these activities directly modify benthic primary producer habitat so significantly that the impacted benthic primary producer habitat would not be expected to recover to the pre-impact state and therefore the loss is considered irreversible. 'Serious damage' is also intended to apply to damage to benthic primary producer habitat that is effectively irreversible or where recovery, if that can be reasonably predicted at all, would not occur for at least 5 years. Serious damage is most often associated with indirect effects of development activities which have adverse consequences for benthic primary producer habitat such as alteration of natural groundwater hydrology (leading to changes in salinity and pH of intertidal sediments) and acutely (or chronically) elevated concentrations of particles suspended in the water column (causing light deprivation).

The geographic scope of this EAG covers all coastal waters of Western Australia, from the highest water mark of the intertidal zone associated with the mainland, islands and emergent reefs to the depth maxima for benthic primary producer habitats in the subtidal zone of these waters.

## 2 CONTEXT AND SCIENTIFIC BACKGROUND

Human disturbance to habitats is a significant threat to the structural and functional integrity of whole ecosystems, on land and in the sea (Biodiversity Working Party 1991). The Western Australian *State of the Environment Report* (EPA 2007) identifies degradation of marine environments (including marine habitats) as a high priority issue and notes a trend toward further deterioration, mainly around existing development centres. Similar fundamental concerns about impacts of human activities on marine habitats such as seagrass (Waycott *et al.* 2009), mangroves (FAOUN 2007) and corals (Wilkinson 2004) have been reiterated more recently in scientific and broader literature.

The EPA has developed this EAG recognising the fundamental ecological importance of Benthic Primary Producer Habitats (BPPH) and the potential consequences of their loss for marine ecological integrity and resilience, and also that almost all marine and coastal development proposals will result in some loss of benthic habitat. While there is a focus here on benthic primary producer habitat, it is important to recognise that this EAG is not intended to downplay the ecological importance or the contribution to biodiversity made by other benthic habitats, communities and individual species. As would be the case for any assessment, EPA will still expect proponents to predict, evaluate and demonstrate manageability of all relevant environmental impacts of their proposals. This EAG establishes the framework within which the EPA expects cumulative loss of, and serious damage to, benthic primary producer habitat should be couched.

Benthic primary producer habitats play important roles in maintaining the integrity of marine ecosystems and the supply of ecological services. There is strong evidence that the presence of benthic primary producer habitat is important for the maintenance of biodiversity through provision of structurally complex and diverse habitat, provision of refuge, and increased food supply. The direct and indirect services benthic primary producer habitats provide to humans are also significant. Benthic primary producer habitats form the foundation of many marine food webs which in turn support productive and economically-important fisheries. They also attenuate wave and current energy which helps protect our shorelines and coastal infrastructure. Maintaining healthy and viable benthic primary producer habitat may also bolster the resilience of other marine habitats, associated flora and fauna, some important fisheries and maintain our use of the coasts in the face of increasing demand for marine resources to support expanding human populations and challenges associated with climate change.

The EPA is mindful that climate change-related effects (e.g. increased sea surface temperature, sea level rise and increased frequency and intensity of storms) may act in complex and synergistic ways with the effects of local development-related habitat loss to amplify impacts of those losses on ecosystems. This is among the reasons why the EPA has prepared guidance for avoiding, minimising, managing and evaluating cumulative extent of local, 'more-controllable' impacts associated with development proposals. It is not the EPA's intention for this EAG to specifically address implications of global climate change.

Benthic Primary Producer Habitats are functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components. Benthic Primary Producer Habitats also include areas of seabed that can support these communities.

The intent of the latter part of the definition above is to afford protection to areas of seabed which for example may have been subject to the effects of a natural perturbation and do not support benthic primary producers at the time of the assessment but which are most likely to support those biota again in the future following a period of recovery. Examples where this part of the definition would apply include:

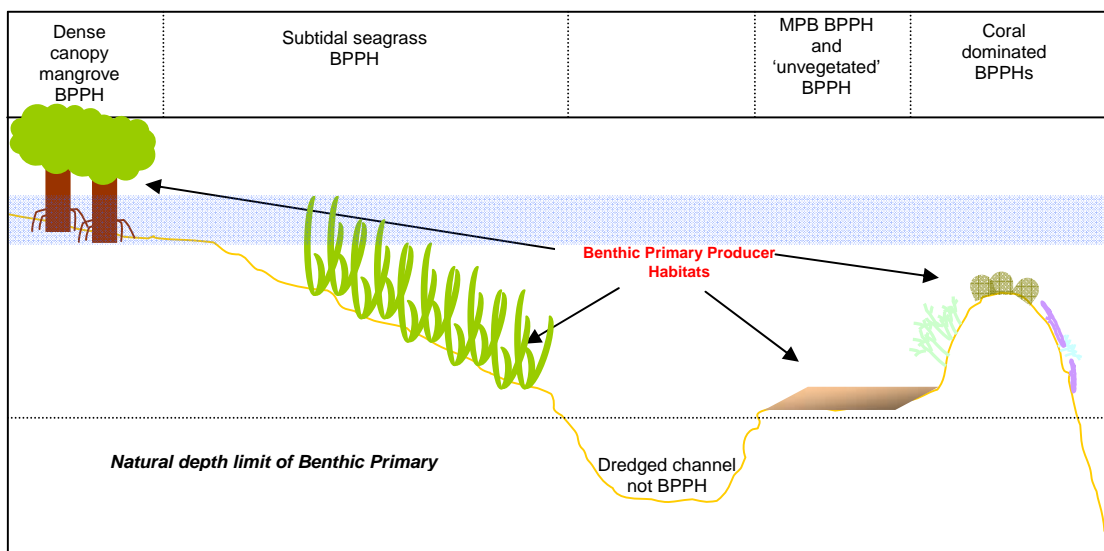
- areas of coral reefs which have suffered high mortality of live coral due to impacts of a tropical cyclone or thermal bleaching event;
- areas of seabed known to support ephemeral seagrass communities or seagrass that are known to show measurable spatial variability in their meadows over several years to decades; and
- areas where the EPA has stated the importance of maintaining opportunities for recovery of benthic primary producer habitat.

The above points are examples of how the EPA will apply the latter part of its definition of benthic primary producer habitat and it will also judge the applicability of the definition to other situations on a case by case basis.

The term ‘seabed’, when used in the context of the benthic primary producer habitat definition above, includes seabed substrates in the intertidal and subtidal zones of WA’s coastal waters and also encompasses substrates on which epiphytic communities grow.

General *examples* of benthic primary producer habitats include coral reefs, algal-dominated biogenic reefs, algal-dominated rocky reefs, seagrass meadows, mangrove forests, intertidal mud flats that support mangroves, intertidal algal mat communities, intertidal saltmarshes, and areas of seabed where macroalgae, coral, mangrove or seagrass communities have grown and could grow. A schematic representation of different general examples of benthic primary producer habitat is shown in Figure 1.

The ecological determinants, structural and functional aspects, and ecological services associated with different benthic primary producer habitat vary. Accordingly, it may be possible to define different specific benthic primary producer habitat at different scales. At the coarsest scale are the general examples of benthic primary producer habitat outlined above. However at finer scales, any one of the general examples of benthic primary producer habitat could include a number of different more specific benthic primary producer habitats definable by local arrangements of species. These different benthic primary producer habitats are often linked to the physical characteristics of the area. For example, different mangrove benthic primary producer habitats are distinguishable by different community composition and canopy cover and these are often linked to factors such as the degree and frequency of tidal inundation. Similarly, areas of different coral reef benthic primary producer habitat may be differentiated by their characteristic local arrangements of prominent coral species or functional groups (e.g. thickets dominated by branching corals in more sheltered areas and massive or encrusting corals in more exposed higher-energy areas).



**Figure 1: A conceptual diagram showing different general types of benthic primary producer habitats. The dashed line represents the natural depth limit of benthic primary producer habitats.**

It is recognised that functional ecological value of benthic primary producer habitat varies. It varies depending on factors such as what species are present/dominant, geographic location, temporal patterns of abundance, structural complexity, productivity, nutritional value and recovery potential. In effect, as this EAG addresses loss of area of benthic primary producer habitat, it would treat the loss of 5 hectares of two different coral BPPH, each with live coral cover of 5% and 80% respectively, in the same way. This is a reasonable approach, particularly if cumulative losses of benthic primary producer habitat do not exceed the cumulative loss guidelines provided in Section 5. This guidance allows proponents to argue on a case-by-case basis for consideration of differing functional ecological values of different benthic primary producer habitat (e.g. BPPHs with differing cover) after initially describing the overall context and magnitude of impact in spatial terms. However, this approach would only really be warranted if the relevant cumulative loss guideline had been exceeded.

While not included among the general examples above, it is important to recognise the roles and functional importance of subtidal sandy seabed areas that support benthic microalgae or microphytobenthos (MPB, micro-algae which live amongst or on sediment particles). Not only is MPB habitat a significant contributor to overall benthic primary productivity, but these areas can provide habitat for short range endemic fauna and in places have been shown to form a foundation for the functioning of entire ecosystems (e.g. Murrell *et al.* 2009). In general, MPB BPPHs exhibit considerably greater potential for recovery from disturbance (generally in the order of days to weeks) than benthic primary producer habitat predominated by macrophytes and hard corals. In view of this and the overarching intent of the guidance to steer development away from areas of ‘vegetated’ benthic primary producer habitat where possible, the EPA will still expect proponents to understand the extent of impacts of their proposals on sandy MPB-dominated habitat, however it does not expect impacts on these BPP communities to be a significant consideration for most assessments.

Additional context and scientific background information can be found in Appendix 3.

### **3 POLICY AND LEGISLATIVE CONTEXT**

#### **3.1 Guidance Statement No. 1 - *Protection of tropical arid zone mangroves along the Pilbara coast (EPA 2001).***

This EAG complements the EPA’s Guidance Statement No. 1, which sets out the EPA’s advice on the protection of mangroves along the Pilbara coast, having particular regard for their conservation significance. Proposals with potential for overlap between this EAG and Guidance Statement No.1 will be assessed in the context of guidance provided in both documents. Specific guidance on linkages between this EAG and Guidance Statement No.1 is provided in Section 5.

#### **3.2 Environmental Quality Management**

In Western Australia, the effects of pollution, waste discharges and deposits on environmental quality are considered and addressed in the context of an Environmental Quality Management Framework (EQMF) which is outlined in the *State Water Quality Management Strategy Document No.6* (Govt. of WA 2004). Proposals that include waste

discharges and/or deposits which are predicted to result in irreversible losses of, or serious damage to, benthic primary producer habitat should be assessed in the context of this EAG as well as the EQMF.

At the time this document was being prepared, the EPA was preparing guidance on the application of the EQMF for all State waters and proponents will be expected to give attention to that guidance when it is released. In the interim, proponents should refer to *State Water Quality Management Strategy Document No.6, Perth's Coastal Waters, Environmental Values and Objectives* (EPA 2000) and the EPA's (2002) *Revised Environmental Quality Criteria Reference Document (Cockburn Sound)* and its updates.

### **3.3 Marine Conservation**

Marine Protected Areas (MPAs) are important tools for the conservation of Western Australia's marine biodiversity. There are a number of different types of State-administered marine conservation reserves that have been, or can be, created under Western Australian legislation. Section 5 of this EAG describes the application of the guidance in various parts of the marine environment, including MPAs. The guidance set out here is designed to complement management frameworks that apply to benthic primary producer habitat in MPAs and other specially-protected areas (e.g. management objectives, and long- and short-term targets in MPA Management Plans).

### **3.4 Reversible /recoverable impacts on benthic habitats**

Currently there is no specific EPA guidance for considering short-term reversible impacts on benthic primary producer habitat and other categories of benthic habitat (e.g. filter feeder communities). This gap will largely be addressed through the development of guidance for the EIA of dredging proposals. When completed, this guidance will establish principles and a framework within which proponents should couch all predicted impacts on benthic habitats (i.e. sublethal reversible impacts as well as irreversible impacts to benthic primary producer habitat as well as other benthic habitat types). It is expected that the principles and framework established for EIA of dredging proposals will be generally transferable to other development activities.

### **3.5 Overarching Environmental Protection Principles**

The EPA has developed general principles aimed at protecting benthic primary producer habitats. The EPA expects that proponent's EIA documentation will demonstrate how principles 1-3 below in particular have been applied in advance of any assessments of cumulative benthic primary producer habitat loss.

The EPA expects the following hierarchy of principles to be addressed by all proponents applying this EAG and the EPA will apply these to its consideration of proposals that could cause damage/loss of benthic primary producer habitats:

1. All proponents should demonstrate consideration of options to avoid damage/loss of benthic primary producer habitats, by providing the rationale for selection of the preferred site and broad project design for example.

2. Where avoidance of benthic primary producer habitats is not possible, then design should aim to minimise damage/loss of benthic primary producer habitats (e.g. through iterative design and demonstrable application of Principle 3 below). Proponents will be required to justify that design in terms of operational needs and environmental constraints of the site.
3. Proponents will need to demonstrate 'best practicable' design, construction methods and environmental management aimed at minimising further damage/loss of benthic primary producer habitats through indirect impacts and minimising potential for recovery.
4. The EPA's judgement on environmental acceptability with respect to damage/loss of benthic primary producer habitats and the risk to ecological integrity will be based primarily on its consideration of the proponent's application of principles 1 to 3 and calculations of cumulative loss of each benthic primary producer habitat type within a defined local assessment unit (the most 'realistic' scenario), together with supporting ecological information, and expert advice, as required.

## 4 METHODOLOGY

### 4.1 General Approach

This section outlines the preferred general approach to be taken by proponents to avoid, minimise, manage and evaluate the cumulative residual loss of, or serious damage to, benthic primary producer habitat (BPPH) that may arise as a result of their development proposals.

Before proponents apply the risk-based assessment framework detailed in Section 5 of this EAG they must first demonstrate to the EPA how the first three of the Overarching Environmental Protection Principles detailed in Section 3 above have been addressed. Indeed, the cumulative *residual* losses of each different benthic primary producer habitat can only be calculated and expressed as a percentage of that benthic primary producer habitat originally present before European habitation after the first three of the Overarching Environmental Protection Principles detailed in Section 3 have been demonstrably addressed. The calculated percentage loss figure(s) is then evaluated against the relevant percentage-based cumulative loss guideline set out in Section 5.

For the purpose of this EAG, cumulative impact is defined as the sum of all irreversible loss of, and serious damage to, benthic primary producer habitat caused by human activities since European habitation of Western Australia (approximately 200 years Before Present). Cumulative impacts in this context do not include changes to benthic primary producer habitat caused by natural disturbances such as severe storms or effects of freshwater inundation from river flow, or climate change.

This guidance is spatially-based, meaning that its operation is based on evaluation of *areas* of benthic primary producer habitats which have been lost historically, are currently present and proposed to be lost within defined areas. The EPA has termed the areas within which to calculate cumulative losses Local Assessment Units (LAUs). The EPA is of a view that local assessment units should normally be approximately 50 km<sup>2</sup> (e.g. a rectangular area defined by a 10 km stretch of coastline extending 5 km offshore). The

EPA considers that, based on contemporary local science, areas of this size broadly capture the length scales of key functional ecological processes such as trophic connectivity and significant proportions of larval dispersion in some corals.

The EPA will consider larger or smaller local assessment units if well justified. Furthermore, for some large proposals or proposals predicted to cause extensive impacts that are discontinuous with infrastructure footprints, it may be necessary to define more than one local assessment unit.

Local assessment units used for calculating cumulative losses should be configured to take into account aspects of the local marine environment such as bathymetry and position of offshore reefs/islands, substrate type, water circulation patterns, exposure to waves and current and biological attributes such as habitat types. It is recommended that wherever possible, other variables related to the functional ecology of the system in question should be considered. Also, when defining local assessment units, information such as administrative (e.g. zoning schemes within marine conservation reserves) and jurisdictional (e.g. State coastal waters) boundaries should be taken into account.

In all cases, proponents are expected to determine the cumulative loss of, and/or serious damage to, each different benthic primary producer habitat within each of the local assessment. This approach provides a basis for considering the degree to which the natural proportionality of the different benthic primary producer habitats in the local assessment unit will be maintained.

Proponents of proposals within, or with potential to impact, existing or proposed marine conservation reserves should also consult Department of Environment and Conservation (DEC) staff responsible for reserve planning and the DEC Marine Science Program at an early stage. In some cases, DEC staff may suggest that early discussion with the Marine Parks and Reserves Authority may be warranted. The Department of Fisheries (DoF) should be consulted on proposals that may impact benthic primary producer habitats within or adjacent to areas managed by that Department.

Proponents are strongly encouraged to seek the advice of relevant Government agencies on the appropriateness of the proposed local assessment unit boundaries and, where necessary, discuss compatibility of proposals with marine conservation reserve management objectives/targets *as early as possible in the design of proposals*.

Once the local assessment unit(s) has been defined (and preferably discussed with relevant agency staff), it establishes the spatial context for the calculation and assessment of cumulative impacts. Calculating cumulative impact relies on three fundamental pieces of information – 1) estimates of the areas of benthic primary producer habitats present before European habitation, 2) estimates of the extent of historic losses and 3) predictions of the additional losses associated with the current proposal. A benthic habitat map is an essential tool for addressing each of these requirements. Where different benthic primary producer habitats (including different BPPH of the same general type) can be distinguished for the purposes of producing a benthic habitat map, then the different habitat types should be mapped separately to allow the cumulative loss of each to be calculated separately.

When preparing benthic habitat maps, proponents are encouraged to utilise rectified aerial photography or other remote sensing techniques coupled with targeted field work to ground-truth the interpretation of remote sensing to produce full-coverage benthic habitat maps. Where there are demonstrable inherent difficulties in using remote sensing techniques (e.g. due to deeper or very turbid water) and proponents are able to demonstrate to the EPA that there is an adequate level of knowledge about local biophysical conditions required to support various types of benthic primary producer habitat, the use of surrogates such as geomorphic features, sediment type, degree of exposure to waves/currents and water depth may be considered to infer the locations and estimate the original areas of benthic primary producer habitat within local assessment units. Similarly, where there are existing ground truthed benthic habitat mapping data these could be used along with other biophysical/geographic/geomorphological information (e.g. degree of exposure to wave/current energy) and knowledge of the biology of benthic primary producers to help predict the likely presence and distribution of habitat beyond the surveyed areas in a defined local assessment unit. Proponents should be aware that the EPA is likely to apply a precautionary approach to its assessment of benthic primary producer habitat loss in cases where surrogates and gross or multiple untested assumptions are applied, particularly where, in the view of the EPA, there are likely to be high levels of residual uncertainty associated with application of those assumptions/surrogates and where risks of serious off-site damage to benthic primary producer habitat are evident through the assessment.

Like all ecological systems, benthic primary producer habitats can vary with respect to extent and composition in space and time. Wherever practicable, natural variation should be accounted for when estimating cumulative impact. However it should be recognised that in general in the absence of human perturbation or catastrophic natural events (e.g. tropical cyclones) areas of habitat are relatively static over time compared with the temporal and spatial variability that is sometime observed in the abundance of benthic primary producer organisms. Where change in the area of habitat does occur in the absence of these disturbances, it generally takes place over longer timeframes than similar magnitude changes in areas of communities, which can vary, sometimes significantly, over seasonal and inter-annual timeframes depending on the species in question. The EPA recognises that some proponents are now working to improve understanding of losses and gains in areas of benthic primary producers and also their habitats. Proponent's who intend to use this understanding to interpret habitat dynamics for the purpose of applying this guidance, are encouraged to clearly differentiate between areas 'vegetated' by benthic primary producers and the areas of their habitat, and proceed with some caution particularly where understanding of the disturbance regimes and community dynamics (e.g. successional phases) has been developed from relatively short term time-series data.

To ease the burden of data collection during the EIA process, operators of existing marine facilities that have, or are likely to have, plans for expansion in the future are strongly encouraged to invest in strategic environmental data acquisition. For example, over a period of time, proponents could implement staged survey programs targeted towards providing high-quality data on the current extent and temporal variability in abundance (e.g. to capture seasonality of ephemeral species such as some tropical seagrasses) of the different benthic primary producer habitats in local assessment units or broader areas of

interest, as well as studies to improve estimates of any losses that have occurred and the reasons for those losses.

The EPA understands that quantifying all of the changes in the extent of the different benthic primary producer habitats may not be a simple task. However proponents that can provide the EPA with a high degree of confidence that proposals will not cause the cumulative loss guideline to be exceeded can, in most cases, anticipate a relatively straightforward assessment of cumulative benthic primary producer habitat loss as an environmental factor. Generally in such cases this guidance would afford some benefit to proponents in that the overall effort required to address this factor would be significantly less than that required if losses were significantly above the cumulative loss guideline or if there was no guidance for the assessment of this factor.

To provide the EPA with the necessary level of confidence in predictions of cumulative loss, proponents will need to clearly describe how estimates of the original extent and cumulative losses of benthic primary producer habitat within defined local assessment units have been determined. The information supplied should include technical documentation and spatial data sets<sup>1</sup> relating to analysis of remote sensing data (e.g. aerial photography), benthic habitat mapping and infrastructure footprints, and explicit articulation of all assumptions made for the assessment of benthic primary producer habitat loss/serious damage.

Proponents who can provide the EPA with a high degree of confidence that proposals will not cause the cumulative loss guideline to be exceeded can, in most cases<sup>2</sup>, anticipate a relatively straightforward assessment of cumulative benthic primary producer habitat loss as an environmental factor.

As a guide, the proponent's level of understanding about the role and importance of benthic primary producer habitat for the maintenance of ecological integrity and the detail of survey work required will be risk-based. In essence, this means that knowledge should increase as losses approach the relevant cumulative loss guideline and/or where the risk of widespread severe impacts is evident through the assessment.

In general, the level of understanding about the role and importance of benthic primary producer habitat, and the potential consequences of their loss for maintenance of ecological integrity within the local assessment unit, should increase as the relevant cumulative loss guideline is approached.

Some proposals will be predicted to cause a combination of irreversible loss and serious damage to benthic primary producer habitats. Some habitats exhibit natural resilience to certain stressors such that recovery can be expected to occur if the stressor is removed and environmental conditions return to, and are maintained in, the pre-impact state. In such cases, it may be reasonable for proponents to examine (using technically sound methods) the predicted serious damage to assess the recoverability of those impacts. If recovery is

<sup>1</sup> The preferred format for spatial data supplied to the EPA is described in Appendix 4

<sup>2</sup> The environmental acceptability of loss of, or serious damage to, BPPH will, in all cases, be a judgement of the EPA.

predicted within a timeframe of 5 years or less<sup>3</sup> and the EPA is sufficiently confident in the predictions, those 'recoverable' impacts do not need to be accounted for in the context of this EAG.

Recoverability from impacts may be considered if proponents can reasonably demonstrate that full recovery of the impacted benthic primary producer habitat would be expected within a timeframe of 5 years or less.

Proponents should be mindful that even if a benthic primary producer habitat is known to exhibit a strong potential for recovery from an impact in the short term (i.e. < 5 years), in places where there are multiple consecutive or coincident development-related disturbances or other external threats to recovery, the EPA will take these factors into account when assessing recovery rates.

As a general rule, all predicted irreversible or 'non-recoverable' losses should be couched in the context of the guidelines set out in Section 5 below.

Proposals which, in the judgement of the EPA, pose an unacceptable risk to ecological integrity within a local assessment unit will be presumed to be unable to meet the EPA's objective(s) for this factor and therefore be judged environmentally unacceptable.

#### **4.2 Generic guidance for determining cumulative impact on key benthic primary producer habitat**

The following evaluation scheme should be applied for assessing the ecological implications of a proposal that may result in the direct or indirect loss of benthic primary producer habitat.

The evaluation scheme is based on cumulative changes within a defined local assessment unit and includes determining the spatial extent of benthic primary producer habitat:

- prior to all human-induced disturbance;
- existing at the time of the proposal; and
- remaining after implementation of the proposal.

Steps 1-6 outlined below and Figure 2 are designed to provide summaries of the information required to assess the proposal against the cumulative loss guidelines set out in Table 1, which is shown in Section 5.

#### **4.3 Evaluation scheme**

Steps in the acquisition of information required for assessment are:

1. What is the 'local assessment unit'?

Define an appropriate local assessment unit (LAU) boundary, taking into account key physical and biological ecosystem attributes such as bathymetry and position of

---

<sup>3</sup> The EPA may also consider predicted recovery timeframes of greater than 5-years, but these will need to be supported by technically robust data relevant to the region in question.

offshore reefs/islands, water circulation patterns, habitat/substrate types and energy/material flows. A local assessment unit is generally geomorphologically determined and the area will be of the order of 50 km<sup>2</sup> defined considering local biophysical and geomorphic features for example.

2. What is there now? What is the current area of each BPPH within the LAU?

Determine the current spatial extent of each of the benthic primary producer habitats in the local assessment unit. This can generally be achieved through analysis of suitable aerial photographs or remotely sensed data with an appropriate level of ground-truthing of habitat types.

3. What area of each BPPH was originally present within the LAU? (i.e. pre-existing conditions)

It is necessary to establish a realistic estimate of the spatial extent of each benthic primary producer habitat that existed in the local assessment unit prior to European habitation to set the baseline for assessing cumulative loss. Historical aerial photography may be available in some cases to assist in these determinations but where this is not available, or the losses pre-date aerial photography, it may be necessary to use alternative means. In many cases, the majority of historical irreversible loss will have been caused by excavating and/or burying benthic primary producer habitat or modifying key sustaining processes such as water flow regimes on which benthic primary producer habitat depend for their growth, survival and reproduction. Hence, in such cases it would be reasonable to equate areas of benthic primary producer habitat loss to areas occupied by infrastructure footprints and accounting for any 'halo' effects around infrastructure perimeters and considering the environmental tolerances of the relevant benthic primary producer habitat. By adding areas of loss determined using this type of approach to the currently mapped areas of different benthic primary producer habitats, and by applying clearly articulated assumptions as necessary, proponents can generate reasonable estimates of areas of benthic primary producer habitats that are likely to have been present in the local assessment unit prior to development. Of course, there will be situations where considering only infrastructure footprints and their 'halos' to evaluate loss will not be sufficiently accurate or appropriate. Locations where benthic primary producer habitats have been lost due to indirect impacts of poor water quality are examples.

Proponents may also need to assess the spatial extent of benthic primary producer habitat that is currently unvegetated by taking into account knowledge of environmental requirements as well as the knowledge gained through establishing the current spatial extent of benthic primary producer habitat (in 2 above). This approach will be particularly useful where habitats are subject to episodic but severe natural disturbance (e.g. coral reefs in the Pilbara) or where the distribution is naturally dynamic and changes may be gradual but significant (e.g. *Posidonia coriacea* seagrass meadows on Success Bank).

4. What percentage of the original area of each BPPH is present now?

Express the current spatial extent of each benthic primary producer habitat (considering areas that do, once did, or can support the dominant BPP communities) in the local assessment unit (from 2 above), as a percentage of pre-existing conditions (from 3 above) and not including the current proposal.

5. How much more will be lost?

Determine the area of each benthic primary producer habitat type in the local assessment unit that would be directly and indirectly damaged/lost as a result of the proposal and express as a percentage of pre-existing conditions (from 3 above).

6. How much would be lost in total if proposal proceeds?

Re-determine the potential cumulative loss in aerial extent of each benthic primary producer habitat in the local assessment unit to include the direct and indirect impacts of the current proposal and express as a percentage of pre-existing conditions (from 3 above). Note that this is an additive approach and provides a way of viewing the proposal from a cumulative impact perspective.

7. Comparison against the cumulative loss guideline

The total cumulative percentage loss value calculated for each different BPPH in 6. above is compared against the cumulative loss guideline relevant to the LAU set out in Section 5.

In summary, proponents and their consultants are advised to include in their EIA documentation:

- a suggested boundary for the local assessment unit and justification for that boundary;
- a scope of survey works proposed to determine the current area of each different benthic primary producer habitat type within that local assessment unit; and
- the approach used to assess and quantify historical losses of benthic primary producer habitat within the local assessment unit.

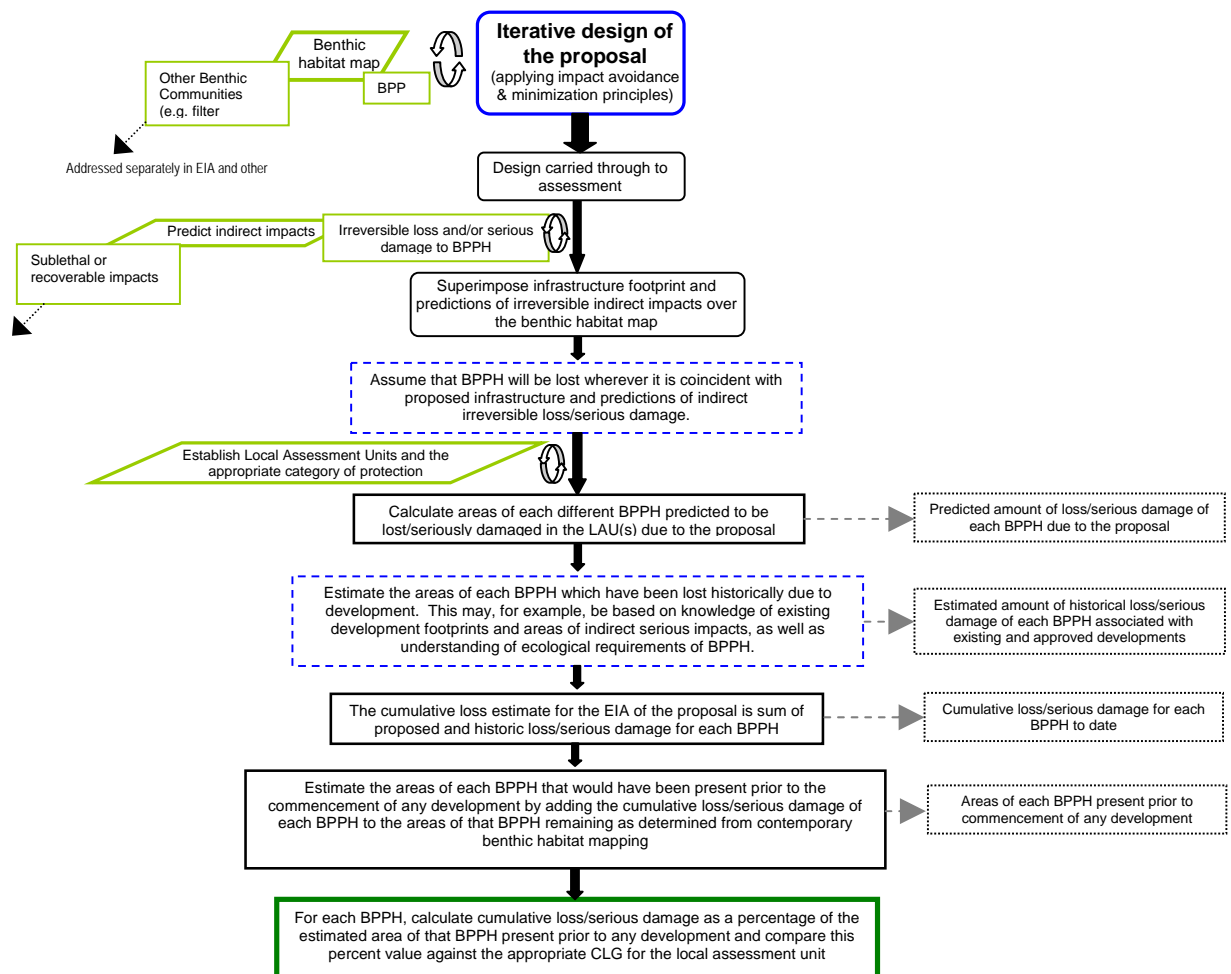
Further detailed guidance is provided in the form of worked examples in Appendix 2.

## 5 RISK-BASED ASSESSMENT GUIDELINES

The risk-based assessment framework outlined in this section is underpinned by six categories of marine ecosystem protection and associated quantitative Cumulative Loss Guidelines (CLGs).

Cumulative Loss Guidelines are intended as tools to help proponents, the EPA and the community to gauge risk to ecological integrity associated with cumulative loss of different benthic primary producer habitats (BPPHs) within a defined local assessment unit. They are percentage values based on the area of benthic primary producer habitat present prior to European habitation. Cumulative Loss Guidelines are not intended to be hard and fast acceptability criteria. Take, for example, a proponent that adequately demonstrates application of the principles in Section 3 and then determines that the cumulative residual loss of benthic primary producer habitat associated with the proposal will not cause the

relevant cumulative loss guideline to be exceeded. If the EPA were to recommend to Government that the proposal should be approved, it would do so on the basis that, risk to ecological integrity from cumulative loss of benthic primary producer habitat below the cumulative loss guideline is acceptably low in the judgement of the EPA. Considered this way, much like a water quality guideline value, cumulative loss guidelines represent a level of cumulative loss that, if not exceeded, is unlikely to pose unacceptable risk to ecological integrity. If on the other hand, a cumulative loss guideline is likely to be or has already been exceeded, it will be incumbent on proponents to present a substantiated technically-rigorous case that additional cumulative losses will not cause ecological integrity to be significantly compromised<sup>4</sup>.



**Figure 2: A flow diagram summarising the application of this Guidance Statement. The dashed lines represent opportunities for feedback to implementation of impact avoidance and minimisation principles through the design of proposals.**

This Environmental Assessment Guideline is therefore considered to afford benefit for staying below the cumulative loss guideline rather than imposing a penalty for proposals that may cause the cumulative loss guideline to be exceeded.

<sup>4</sup> The level of effect on ecological integrity that constitutes a 'significant compromise' will be a judgement of the EPA.

In recognition of the inherent difficulty in high precision measurement of the area of some benthic primary producer habitats, and given the complexity associated with determining the ecological significance of their loss, Cumulative Loss Guidelines will not be considered as hard and fast acceptability criteria.

However, the environmental acceptability of any damage/loss of benthic primary producer habitat will, in all cases, be a judgement of the EPA, based primarily on its consideration of the proponent's application of the first three overarching environmental protection principles and calculations of cumulative loss of each benthic primary producer habitat type and assessment of the overall risk to the ecological integrity within a defined local assessment unit if a proposal were to be implemented. This Environmental Assessment Guideline does not address any potential contribution of artificial or purposely-placed substrates (e.g. rock walls used to armour areas of seabed reclamation, artificial reefs) to the area of benthic primary producer habitat. Nevertheless, the EPA will consider this issue on a case by case basis and outside the framework of this Environmental Assessment Guideline.

For the purpose of assessing cumulative loss against the cumulative loss guidelines set out in this section, proponent's EIA documentation should describe a 'most realistic' benthic primary producer habitat loss scenario which will be the basis for the assessment of this factor. While a 'most realistic' benthic primary producer habitat loss scenario should be presented for assessment by the EPA, proponents are encouraged to consider best and worst case scenarios, and variation inherent in assessments of benthic primary producer habitat loss when determining the loss figure to be presented for assessment.

Proponents are expected to present the 'most realistic' benthic primary producer habitat loss scenario for assessment. This predicted loss should ideally be based on proponents' consideration of a range of potential loss scenarios associated with their proposals.

**Table 1:** Cumulative loss guidelines for benthic primary producer habitat within defined local assessment units for six categories of marine ecosystem protection that will be applied only after proponents can demonstrate to the EPA that all practicable options to avoid/minimise damage/loss of BPPH have been considered.

Category	Description	Cumulative loss guideline*
A	Extremely special areas	0%
B	High protection areas other than above	1%
C	Other designated areas	2%
D	Non-designated area	5%
E	Development areas	10%
F	Areas where cumulative loss guidelines have been significantly exceeded	No net damage/loss

*\* Defined as a percentage of the original area of BPPH within a defined local assessment unit*

Users of this EAG are advised that the:

- cumulative loss guidelines set out in Table 1 above and in the following sections are not intended to be applied as rigid limits; and

- acceptability of any irreversible loss of, or serious damage to, benthic primary producer habitat in the areas detailed below will, in all cases, be a judgement of the EPA.

### **Category A: Extremely Special Areas**

#### a) Area of Application\*

- Marine Nature Reserves created under the provisions of the CALM Act;
- High protection zones in Marine Parks created under the provisions of the CALM Act (i.e. sanctuary zones, recreation zones and some special purpose zones);
- Some zones within Marine Management Areas as detailed in their Management Plans (i.e. some special conservation zones);
- Sanctuary zones in the Rottneest Island Reserve;
- Some Fish Habitat Protection Areas (FHPA) created under the *Fish Resources Management Act 1994* and some special areas within FHPAs as defined in their Management Plans (e.g. Reef Observation Areas and ‘no take’ areas);
- Guideline 1 areas as defined in EPA Guidance Statement No. 1; and
- Other areas identified through a statutory process or by the EPA as having extremely high conservation or ecological significance or otherwise being extremely special.

#### b) Guidance

- No development activities should take place in these areas, nor should there be any development elsewhere, that would cause direct or indirect damage/loss of benthic primary producer habitat or ecological integrity of these areas. (Cumulative Loss Guideline = no loss of BPPH)
- The EPA will give benthic primary producer habitat in these areas the highest degree of protection and as such proponents should be aware that, where development-related activity in these areas will cause the damage/loss of benthic primary producer habitat or pose a substantial risk to ecological integrity, the EPA will adopt a presumption against finding the proposals environmentally acceptable.

### **Category B: High Protection Areas other than the above**

#### (a) Area of Application\*

- Marine Park zones other than those in Category A above;
- Some zones within Marine Management Areas as detailed in their Management Plans (i.e. some special conservation zones);
- Waters of the Rottneest Island Reserve other than those specified in Category A above;

---

\* Proponents should seek advice from the relevant management agencies (e.g. DEC, DoF, Rottneest Island Authority) at an early stage where proposals are located in existing or proposed marine conservation reserves or other specially managed areas.

- Areas recommended for inclusion in WA's marine reserve system (i.e. 'Wilson' report areas, CALM 1994);
  - Guideline 2 areas as defined in EPA Guidance Statement No.1; and
  - Other areas identified through the literature, by statutory processes or by the EPA as having a high conservation or ecological significance or otherwise being special.
- (b) Guidance
- No development should take place that would adversely affect the ecological integrity of these areas.
  - Minor damage/loss of benthic primary producer habitat may be acceptable where proponents can demonstrate that there are no feasible alternatives to avoid damage/loss and/or where proposals are consistent with relevant management plans (e.g. an approved management plan for a marine reserve) or a use of the local assessment unit that is consistent with a State Government decision. (Cumulative Loss Guideline = 1% loss of BPPH)
  - The EPA expects a substantial justification for the proposal supported by technically defensible information demonstrating understanding of the ecological role and value of the benthic primary producer habitat in the local context. Using this understanding, the proponent would be expected to describe and evaluate the significance of potential impacts on ecological integrity.
  - The acceptability of any damage/loss will be a judgement of the EPA.

### **Category C: Other Designated Areas**

- a) Area of Application\*
- All parts of Marine Management Areas other than those set out in Category A and Category B above;
  - Areas as defined in FHPA Management Plans other than those set out in Category A above;
  - Guideline 3 areas as defined in EPA Guidance Statement No. 1; and
  - Areas identified either by the EPA or through the literature as having high conservation significance or otherwise being special, and where the land use has been designated for industrial or related purposes either by a State Government decision, a statutory planning process where environmental factors have been demonstrably addressed, or any other planning process which can be, or has been, referred to the EPA for assessment.
- b) Guidance
- Development proposals should not cause significant direct or indirect loss of benthic primary producer habitat and/or their associated BPP communities, and the

---

\* Proponents should seek advice from the relevant management agencies (e.g. DEC, DoF, Rottnest Island Authority) at an early stage where proposals are located in existing or proposed marine conservation reserves or other specially managed areas.

ecological integrity of the benthic primary producer habitat dependent ecosystems must be maintained.

- Limited damage/loss of benthic primary producer habitat may be acceptable where proponents can demonstrate that there are no feasible alternatives to avoid damage/loss and/or where proposals are consistent with relevant management plans or a use of the local assessment unit that is consistent with a State Government decision. (Cumulative Loss Guideline = 2% loss of BPPH)
- Proponents will need to demonstrate and commit to a 'best practice' approach to minimising impacts and demonstrate how ecological integrity, overall biological value and environmental quality of the area would be protected and maintained.
- The EPA expects proponents to develop and commit to the implementation of a comprehensive environmental management plan (including decommissioning) that has the long-term maintenance of ecological integrity as its primary objective.
- Proposals which can meet the above objectives and have applied the general principles outlined earlier in this document, may be considered by the EPA to be acceptable as long as the cumulative loss guideline would not be exceeded.

#### **Category D: Non-Designated Areas**

##### a) Area of Application

- Non-designated areas identified either by the EPA or through the literature as having conservation or ecological significance, and where the land use has not been designated for industrial or related purposes prior to the formulation of this EAG (e.g. the coast between Leeman and Dongara); and
- General coastal waters other than those in Categories A, B, C, E and F.

##### b) Guidance

- Limited damage/loss of benthic primary producer habitat may be acceptable where proponents can demonstrate that there are no feasible alternatives to avoid damage/loss and/or where proposals are consistent with relevant management plans or a use of the local assessment unit that is consistent with a State Government decision. (Cumulative Loss Guideline = 5% loss of BPPH)
- The EPA expects proponents to design proposals to minimise damage/loss and to develop and commit to the implementation of a comprehensive environmental management plan that provides a context for the development in relation to the local assessment unit and the wider area, with an objective of protecting and maintaining ecological integrity.

**Category E: Development Areas** (e.g. inner or port operational areas)

a) Area of Application

- Port operational areas within Guideline 4 areas as defined in Guidance Statement No. 1, *Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline*; and
- Areas identified either by the EPA or through the literature as having moderate conservation or ecological significance which are either coincident with operational areas and infrastructure associated with existing ports or areas where the land use has been designated for heavy industry, large coastal proposals or related purposes by a State Government decision (e.g. inner port areas), a statutory planning process where environmental factors have been demonstrably addressed, or any other planning process which can be, or has been, referred to the EPA for assessment (e.g. proposals within local assessment units focused on the inner Dampier Port or the Oakajee Port proposal).

b) Guidance

- Moderate damage/loss of benthic primary producer habitat may be acceptable where proponents can demonstrate that there are no feasible alternatives to avoid damage/loss and/or where proposals are consistent with relevant management plans or with a use of the local assessment unit that is consistent with a State Government decision. (e.g. port expansions, dredged navigation channels, seabed reclamations and marinas). (Cumulative Loss Guideline = 10% loss of BPPH)
- It is not the intent of this EAG to put pressure on proponents to propose developments at green-field sites when cumulative loss guidelines at existing brown-field development sites have been or are likely to be exceeded if new development is allowed to proceed. Firstly, proposing development at new green-field sites simply because cumulative loss guidelines at existing development sites have been, or will most likely be, exceeded is not consistent with application of the impact avoidance and minimisation principles that underpin this Guidance Statement. Secondly, as stated earlier, cumulative loss guidelines are not considered to be rigid limits.
- Some declared port areas are very large, in some cases covering 100s of square kilometres. The broader areas of these ports support a range of uses and environmental values that depend on healthy and intact marine ecosystems. Accordingly, Category E is not intended to apply throughout entire port areas. In these cases it is appropriate to define more than one local assessment unit within a port boundary, including a Category E area(s) around the 'inner' or operational parts of port areas.
- Inner or operational parts of ports which may reasonably be included within a Category E local assessment unit are primarily the parts required for safe navigation and facilitation of trade. These parts include areas about jetties, wharfs, berth pockets, turning basins and approach channels. Similarly shallow banks, reefs and areas around offshore islands would not usually be considered in Category E as shallow water depths would generally constrain port operations in these areas. Anchorages, where these are separated from inner port operational infrastructure by

several kilometres would generally not be included in a Category E management unit as these outer port areas often support multiple community uses in addition to port activities.

- The EPA expects the proponent to apply the general principles of assessment (see Section 5.2) and develop and commit to the implementation of a comprehensive environmental management plan with an objective of protecting and maintaining ecological integrity. The plan must provide the basis for the ongoing development of an understanding of the environmental impacts of the proposal in question in the context of existing and approved development and minimising cumulative impacts on benthic primary producer habitat arising or predicted to arise from these developments.
- The acceptability of any damage/loss of benthic primary producer habitat in these areas will be a judgement of the EPA.

**Category F: Areas where cumulative loss guidelines have been significantly exceeded**

a) Area of Application

- Degraded areas where a substantial proportion of benthic primary producer habitat has already been lost (e.g. seagrass-vegetated benthic primary producer habitat in Cockburn Sound and Albany Harbours, Inner Mermaid Sound coral benthic primary producer habitat), and where, in the judgement of the EPA, unacceptable levels of irreversible loss and/or serious damage to, benthic primary producer habitat is likely to occur during the life of the proposed development; and
- Category B, C, D, or E areas where, in the judgement of the EPA, the cumulative loss guideline has been, or is likely to be, *significantly exceeded*.

b) Guidance

- The EPA's environmental objective in these areas is to ensure no net loss of benthic primary producer habitat and where possible, to generate a net gain in the area of benthic primary producer habitat and/or their associated BPP communities. (Target = no net loss, and where possible, a net increase, of BPPH)
- The EPA will judge whether a particular cumulative loss guideline is considered to have been *significantly exceeded*. This judgement will be made on the basis of information supplied by proponents in support of calculations of cumulative loss of, or serious damage to, benthic primary producer habitat.
- The EPA will expect proponents which propose to remove benthic primary producer habitat to have applied the overarching assessment principles of this EAG.
- The EPA expects a substantial justification for the proposal, supported by technically defensible information that demonstrates understanding of the ecological role and value of the benthic primary producer habitat within the local context. Using this understanding, the proponent would be expected to evaluate any impacts, and to determine the significance of those impacts on ecological integrity.

- Proponents will need to demonstrate and commit to a ‘best practice’ approach to minimising impacts and must ensure the maintenance of ecological integrity, overall biological value and environmental quality of the area.
- The EPA expects the proponent to develop and commit to the implementation of a comprehensive environmental management plan that has as its primary objective the long-term maintenance of ecological integrity.

## 6 RESPONSIBILITIES

### Environmental Protection Authority Responsibilities

The EPA will apply this EAG during the assessment of proposals under Part IV of the *Environmental Protection Act 1986* where (insert appropriate text).

### Department of Environment and Conservation Responsibilities

DEC will assist the EPA in applying this EAG in the environmental impact assessment process and in conducting its functions under the *Environmental Protection Act 1986*, giving due consideration to this document.

### Proponent Responsibilities

Consistent with the notion of continuous environmental improvement and adaptive environmental management, the EPA expects proponents to take appropriate measures to protect the environment and to view the requirements of this EAG as representing the minimum requirements necessary to achieve an appropriate level of environmental protection.

## 7 DEFINITIONS

Acronym	Meaning in full
BPPH	Benthic Primary Producer Habitat
CLG	Cumulative Loss Guideline
DEC	Department of Environment and Conservation
EAG	Environmental Assessment Guideline
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
LAU	Local Assessment Unit
MPB	Microphytobenthos
MPRA	Marine Parks and Reserves Authority
WA	Western Australia

## 8 GLOSSARY OF TERMS

Bathymetry	Measures of the underwater depths of the sea floor.
Benthic (zone)	The benthic zone is the ecological region at the lowest level of an ocean, including the sediment surface and some sub-surface layers. The benthic zone begins at the shore line (intertidal or eulittoral zone) and extends downward along the surface of the continental shelf out to sea.
Benthic Primary Producer Habitats (BPPH)	Are functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components. BPPH also include areas of seabed that can support these communities.
Biodiversity	The variety of all life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form. It is often considered at three levels: genetic diversity, species diversity and ecosystem diversity.
Community	Ecologically, any naturally occurring group of different organisms sharing a particular habitat.
Damage	Significant alteration to the structure or function of a community or habitat. Damage is considered serious if the timeframe for full recovery is expected to be longer than 5 years.
Direct loss	Activities causing immediate loss of habitat. In the context of this Guidance Statement, direct losses relate primarily to human activities that have immediate consequences, such as the removal of habitat or communities from the ecosystem due to dredging or land reclamation.
Environmental Values	The particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health.
Ecological integrity	The capability of a defined part of the environment to support and maintain key ecological processes and organisms so that the species composition, diversity and functional organisations it supports are as comparable as possible to those occurring in natural habitats within the region.
Ecosystem	Unit including a community of organisms, the physical and chemical environment of that community, and all the interactions among those organisms and between the organisms and their environment.

Habitat	A specific type of environment inhabited either permanently or temporarily by organisms.
Indirect loss	Losses associated with far-field effects of an activity and not necessarily coincident with the footprints of infrastructure. In the context of this Guidance Statement, indirect losses relate to the effects of human activities that alter the suitability of habitats for growth and survival of benthic primary producers over varying time scales.
Loss	refers to direct removal or destruction of BPPH. Loss is considered to be irreversible and the term is intended to apply to BPPHs which are so significantly modified (e.g. by activities such as excavation or burial) that the impacted BPPH is not predicted to recover to the pre-impact state.
Local assessment unit	A specific geographical area which provides the most effective boundaries for management of cumulative environmental impacts on marine habitats.
Photosynthesis	A process, operating in chlorophyll containing plants, which uses solar energy to convert carbon dioxide and water into carbohydrate.
Primary producer(s)	Organisms (mainly green plants and algae) which can manufacture organic substances (food) from simple inorganic substances.
Species	Generally regarded as a group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not normally breed with members of another group.
Substratum	The layer immediately underneath something or to which it is attached.

## 8 LIMITATIONS

This EAG has been prepared by the EPA to assist proponents and the public. While it represents the contemporary views of the EPA, each proposal which comes before the Authority for environmental impact assessment will be judged on its merits. Proponents who wish to deviate from this document should provide a robust justification for the proposed departure.

## 9 REFERENCES

Biodiversity Working Party (1991). The conservation of biodiversity as it relates to ecologically sustainable development. ESD Secretariat, DASETT, Canberra.

CALM (1994). A representative marine reserve system for Western Australia. Report of the Marine Parks and Reserves Section Working Group. Department of Conservation and Land Management, Perth, Western Australia, June 1994.

EPA (2007). State of the Environment Report: Western Australia 2007. Department of Environment and Conservation, Perth Western Australia.

EPA (2002). Revised Environmental Quality Criteria Reference Document (Cockburn Sound). A supporting document to the draft Environmental Protection (Cockburn Sound) Policy 2002. Environmental Protection Authority, Perth, WA, November 2002.

EPA (2001). Protection of tropical arid zone mangroves along the Pilbara coast: Guidance Statement for the Assessment of Environmental Factors No.1. Environmental Protection Authority, Perth, WA, April 2001.

EPA (2000). Perth's Coastal Waters: Environmental Values and Objectives. Environmental Protection Authority, Perth, WA, December 2000.

FAO (2007). The World's Mangroves 1980 – 2005: A thematic study prepared in the framework of the Global Forest Resources Assessment 2005. Food and Agriculture Organisation of the United Nations, Rome, 2007

Government of WA (2004). State Water Quality Management Strategy No. 6: Implementation framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Monitoring and Reporting (Guidelines Nos. 4 & 7: National Water Quality Management Strategy). Government of Western Australia 2004.

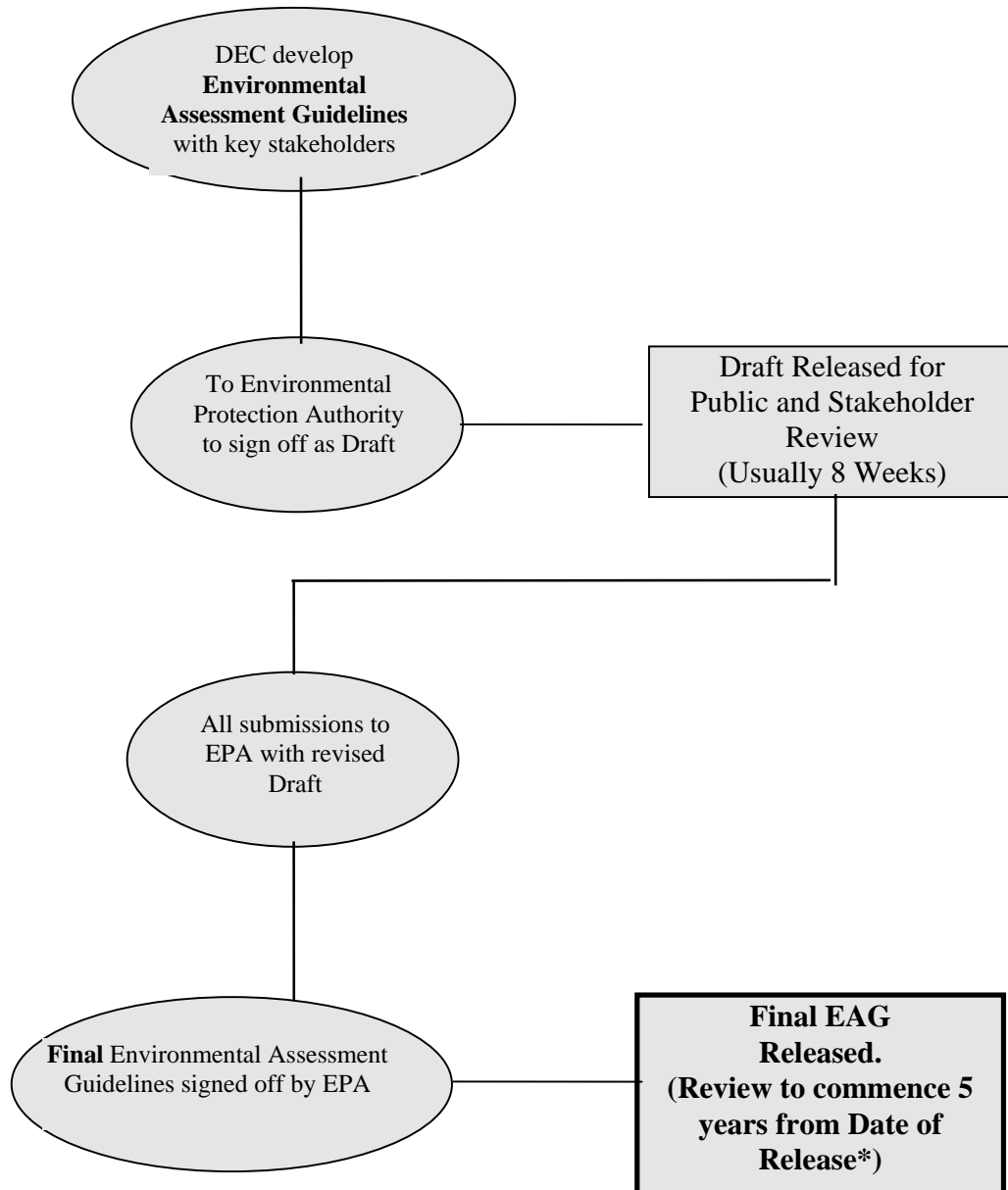
Murrell M.C. Campbell J.C., Hagy III J.C. and Caffrey J.M. (2009). Effects of irradiance on benthic and water column processes in a Gulf of Mexico estuary: Pensacola Bay, Florida, USA. *Estuarine, Coastal and Shelf Science* **81**:501-512.

Waycott M., Duarte C.M., Carruthers T.J.B., Orth R.J., Dennison W.C., Olyarnik S., Calladine A., Fourqurean J.W., Heck, Jr K.L., Hughes A.R., Kendrick G.A., Kenworthy W.J., Short F.T., and Williams S. L. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems

Wilkinson C. (2004). Status of Coral Reefs of the World. Edited by Wilkinson C. Australian Institute of Marine Science, Townsville, 2004

<b>Index</b>	Final EAG	November 2009
<b>Status</b>	Signed-off by the EPA.	
<b>Citation</b>	This document can be cited as: EPA (2009). Environmental Assessment Guideline for Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment. Environmental Protection Authority, Perth, Western Australia.	

## Appendix 1 – Generic Flow Diagram for the Environmental Assessment Guideline Process



\* Environmental Assessment Guidelines may be reviewed earlier if circumstances require it.

## **Appendix 2 - Example Application of Environmental Assessment Guideline No.3**

### **Example 1**

#### **A proposal for minerals stockpiling and export facilities in the Pilbara**

*What is the proposal and where is it located?*

A proposed minerals export development is situated on a stretch of coastline running east-west in the Pilbara. The proposal is within an area identified by the State Government as a strategic industrial area (SIA), which has been located and laid out to maximise potential use by multiple industries. This minerals export proposal is the first proposal for the new SIA.

Key elements of the proposal include:

- a minerals stockpile area,
- a conveyor from the stockpile area to the vessel loading terminal,
- a jetty;
- vessel loading facilities and
- a dredged berth pocket, turning basin and approach channel.

The site for the SIA was selected following a consultative planning and site evaluation process. The only existing development-related impact to benthic habitats in the area is associated with a domestic gas (domgas) pipeline installed some 20 years ago. The availability of an existing supply of gas to the site was one of the factors considered during site evaluation. The domgas pipeline is buried for the majority of its length through WA coastal waters and the shore crossing has been installed by horizontal directional drilling. The pipe surfaces in a mixed species dense mangal zone and a cleared easement is maintained either side of the pipeline for its entire length through the intertidal zone resulting in effectively irreversible loss of all BPPH within the easement.

*What's the environmental setting for the purpose of considering BPPH loss/serious damage?*

In this setting, two broad environments that support BPPH can be considered – onshore and offshore. Surveys have been undertaken over a defined area and by applying a pre-defined habitat classification system to the survey data, a map has been produced that shows the local extent and distribution of each different benthic habitat type including the different BPPHs. The following describes the benthic communities in the area of interest.

Onshore, for five kilometres either side of the proposed development site the coast is characterised by sandy beaches which are perched over a rocky intertidal between small

rocky headlands. The rocky and sandy coast is interrupted in places by the mouths of tidal creeks. Inland from creek mouths, smaller creeks fan out dissecting intertidal mud flats. Dense mangals grow along creek edges and extend along open-ocean shores in both directions some distance away from creek mouths. Moving up the intertidal zone away from the creeks and mangrove lined stretches of open-ocean coast, community composition of the mangal changes and tree/canopy density is reduced as habitats transition through scattered mangrove trees and mud flats, until at the upper limits of the intertidal zone mangroves give way to saltmarsh vegetation.

In the lower intertidal and shallow subtidal, rocky shores support mixed communities of macroalgae. Corals also occur very occasionally in this habitat type, and by applying a clearly-defined classification system to survey data, these areas are mapped as 'macroalgae with scattered corals' BPPH as the live coral cover is determined to be less than 1%.

Offshore, there are numerous reef outcrops in water depths less than 8 m below mean sea level. Surveys reveal that the substrate of these reefs is biogenic and this supports coral communities with live coral cover ranging between 10% and 50%. Coral communities with similar live coral cover ranges, but growing on igneous boulders, also fringe a small offshore island.

Sand is the most dominant substrate between the reefs. As would be expected on subtidal sandy habitats in the photic zone throughout the State, these areas support microphytobenthos (MPB) communities. Sandy areas are also known to support *Halophila ovalis* and *Halodule uninervis* seagrass. These species are ephemeral and while the temporal variation in their presence/absence and abundance at the site is not understood, their presence and, later, absence has been recorded at the same sites on different occasions. As there is only limited understanding of the marked temporal variation in the presence/absence and abundance of *H. ovalis* and *H. uninervis* at the site, assumptions will need to be made about 'potential' habitat for these seagrasses, based on knowledge of habitat requirements and observations made at the sites where seagrass has been recorded.

In deeper water and where rocky substrates lie beneath thin sand veneers, communities of sessile filter feeders are patchily distributed over wide areas, with patches displaying variable cover of animals.

Results of the contemporary survey work conducted by the proponent are used for two purposes. Firstly, they inform preparation of a benthic habitat map, which in turn is interrogated using Geographic Information System (GIS) techniques to determine the current areas of each different BPPH in the area of interest. Data from the survey work are also considered along with information gathered by the proponent of the domgas pipeline to generate estimates of the pre-development extent of the different habitats in the area of interest.

The proponent supplies the spatial data set informing and arising from these analyses along with spatial data describing the proposal to the EPA to allow for its own internal appraisal of the cumulative loss calculations and add to a data base that will better inform future assessments.

*What are the different benthic communities and of these, which are the BPPHs?*

For the purposes of this example, the following might constitute a list of different BPPH (from the upper intertidal to the subtidal zone):

- Upper intertidal saltmarsh communities;
- Mud flats supporting cyanobacterial mats;
- Mixed species low density mangrove communities;
- Mixed-species dense mangal;
- Mixed species macroalgal communities on lower intertidal and shallow subtidal rocks;
- Subtidal coral communities on biogenic reefs;
- Subtidal coral communities on rocks fringing islands; and
- Ephemeral seagrass and MPB communities.

Other benthic communities:

- sessile benthic filter feeder communities

While sessile filter feeder communities are present and the approximate boundaries of their local extent has been mapped, their potential losses are not considered in the context of this Guidance Statement. In the absence of specific guidance for assessing and considering impacts on these communities, the EPA will expect proponents to predict the extent and the potential ecological consequences of impacts on sessile filter feeder communities and couch these in the context of the framework to be included in the EPA's guidance for the assessment of dredging proposals.

While this example may appear complex in the sense that there are numerous different benthic habitat types which need to be considered, this level of diversity and arrangement of benthic habitats/communities would not be unexpected in many places in northwest WA. The actual number of different BPPH types may vary depending on the proposal and its environmental setting, the proponent's survey effort and the resolution of habitat mapping.

*Applying the assessment principles*

The proponent demonstrated the application of impact avoidance and minimisation principles by clearly setting out to the EPA the measures that have been taken to minimise the loss of BPPH caused by the proposal as far as practicable, recognising that the EPA considers environmental factors rather than economic concerns or the resolution of engineering problems. For example, the proponent's design of the proposed stockpile area evolved during the assessment such that these areas were moved further inland than originally proposed to avoid loss of dense mangal altogether and minimise losses of the

low density mangal. While losses of other intertidal BPPH will still occur if the proposal is allowed to be implemented, the changes made reduce potential losses of structurally important BPPH in the intertidal. The construction and presence of the structure that supports the conveyor will result in loss of mangrove BPPHs, but the proponent has indicated that it will use an open trestle structure rather than a solid fill causeway to support the conveyor and implement a construction method that minimises the use of heavy machinery within the mangals thereby minimising losses of these BPPHs and aids recovery from any disturbances that may occur.

For offshore facilities, clearly documented benthic surveys and habitat mapping has enabled the EPA to understand the proponent's justification for the design and configuration of an open trestle jetty and dredged facilities and the extent of potential loss for different BPPHs.

*What are the residual impacts/losses due to the proposal?*

Based on the design and configuration and construction methods, the proponent has predicted that its proposal will result in the following losses of BPPH:

- Upper intertidal saltmarsh communities – loss of 7.5 ha due to burial of a narrow band of this BPPH. The cumulative irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 7.5 ha plus an additional estimated 0.3 ha due to the existing domgas pipeline easement = 7.8 ha;
- Mud flats supporting cyanobacterial mats – loss of 45 ha due to burial by stockpiles and associated infrastructure. The cumulative irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 45 ha plus an additional estimated 0.7 ha due to the existing domgas pipeline easement = 45.7 ha;
- Mixed species low density mangrove communities - Development of the stock piles and conveyor will cause 1.2 ha direct loss through burial, and serious irreversible damage to an additional 3.7 ha due to indirect effects arising from predicted changes in groundwater hydrology. The cumulative irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 4.9 ha plus an additional estimated 0.2 ha due to the existing dogmas pile line easement = 5.1 ha
- Mixed-species dense mangal – no loss due to stock piles and 0.7 ha due to construction and presence of the open trestle conveyor support structures. The cumulative irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 0.7 ha plus an additional estimated 0.2 ha due to the existing domgas pipeline easement = 0.9 ha
- Mixed species macroalgal communities on lower intertidal and shallow subtidal rocks – no direct or indirect losses predicted. Some impact predicted to occur as a result of dredge plumes, however, the proponent has presented technical information to support its view that recovery from predicted impacts will occur within 5 years following

completion of dredging. As the domgas pipeline also did not cause irreversible loss of this habitat type there is no need to consider the cumulative irreversible loss/serious damage for this habitat in the context of Guidance Statement No.29;

- Subtidal coral communities on biogenic reefs – 1.45 ha direct loss due to burial by jetty support structures and an additional small loss due to excavation by dredging. A further 0.7 ha of irreversible serious damage is predicted to occur at reefs located within 130 m of dredged facilities due to the effects of turbidity and sediment deposition during dredging and the persistence of deposited fine sediment on affected reefs meaning that a ‘realistic’ timeframe for recovery is at least 10 years. The cumulative irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 2.15 ha as installation and presence of the domgas pipeline does not appear to have resulted in any additional loss of this BPPH;
- Subtidal coral communities on rocks fringing islands – these communities are located 9 km from the nearest proposed facility and no irreversible loss is predicted from direct or indirect impacts. Nevertheless, the proponent predicts that some sub-lethal impacts may occur due to the effects of elevated levels of turbidity and/or sediment deposition associated with dredging. As the domgas pipeline also did not cause irreversible loss of this habitat type there is no need to consider the cumulative irreversible loss/serious damage for this BPPH in the context of Guidance Statement No.29; and
- Ephemeral seagrass and MPB communities – the proposal will not result in direct losses of known seagrass BPPH (i.e. the areas where live seagrass has been recorded during the survey work), however, areas identified as being potential habitat for seagrass will be directly and indirectly impacted. 6.2 ha of potential seagrass habitat will be excavated and therefore irreversibly lost. Areas of potential seagrass BPPH near to the dredged areas are predicted to be damaged to the extent that if seagrass were present or if recruitment to the area were to have occurred under natural conditions (whether that be from seeds or vegetative growth), there would be mortality and failure of recruitment respectively. Despite these predictions, based on robust scientific evidence and knowledge from surveys that these species are present in significant quantities immediately outside of the area that is predicted to be influenced by the development, the proponent expects that pre-development environmental conditions would return within 5 years of completion of dredging such that predicted serious damage to seagrass BPPH may not need to be considered irreversible. The irreversible loss/serious damage for this habitat to be considered in the context of the cumulative loss guideline is therefore 6.2 ha.

#### *Local assessment unit and categories of protection*

Three essentially-rectangular local assessment units (LAUs) have been defined in discussion with relevant agency staff and the EPA for the assessment of the proposal. One LAU is centred on the proposed development site and its boundary (described below) captures all of the direct impacts and some of the more severe indirect impacts of the proposed development. The other two LAUs are situated east and west of, and are

contiguous with, the central LAU. These LAUs are situated to capture the full extent of the predicted indirect impacts of the proposal on benthic communities.

The longshore boundaries of the central LAU extend approximately 5 km each side of the site. The landward extent of this LAU is coincident with the highest water mark of the intertidal zone at site, which is approximately 1.5km inland from mean sea-level tide height. The seaward boundary is coincident with the State coastal waters / Commonwealth waters boundary. Accordingly, this LAU covers an area of about 70 km<sup>2</sup> being defined by boundaries ~10 km long in the longshore direction and ~7km wide on the onshore-offshore plain. While this LAU is slightly larger than the recommended 50 km<sup>2</sup>, the proponent has presented a case in support of the proposed LAU to the EPA suggesting that the boundaries recognise prominent coastal features including morphology and location of intertidal creek systems, important intertidal-subtidal ecological linkages/dependencies and relevant administrative boundaries.

The boundaries of each of the other two LAUs situated on each side of the central LAU extend 10 km longshore and from mean sea level tide height offshore approximately 5.5km to the State coastal / Commonwealth waters boundary.

In general, loss of each different BPPH from the central LAU would be considered in the context of the cumulative loss guideline (CLG) for Category E – Development Areas. This reflects Government decisions to focus major development at the SIA. However, during preparation of the EIA documents the proponent has found that the SIA is within an area identified in the 2001 Guidance Statement No.1 as a Guideline 1 area. These areas are defined on the basis they are outside designated industrial areas and associated port areas, and contain regionally significant mangroves. As Government has effectively designated the SIA as an industrial area in the time since release of Guidance Statement No.1, the proponent proposes that the area's status reflects this decision and it is now considered as a Guideline 3 area. Guideline 3 areas are inside designated industrial areas and associated port areas and contain regionally significant mangroves. If the proponent's proposal to reassign the SIA from a Guideline 1 to Guideline 3 area was accepted by the EPA, then cumulative loss of the two mangrove BPPH types from the central LAU should be considered in the context of Category C, where the CLG is 2%. Cumulative loss of each of the other BPPH types would be considered in the context of Category E.

The areas within the other two LAUs are considered by the proponent to be compatible with guidance for Category D – non-designated areas. Accordingly, any losses of BPPH from these two management units would be considered in the context of the CLG for Category D.

Using the information described above, the proponent then follows the steps below to appraise predicted losses against the relevant CLG for each different BPPH type.

**Step 1: What is the 'local assessment unit'?**

Boundaries defined by applying guidance.

**Step 2: What is the current area of each BPPH within the LAU?**

Informed by benthic habitat surveys and mapping.

**Step 3: What area of each BPPH was originally within the LAU?**

Informed by benthic habitat surveys and mapping and consideration of other historical documentation and surveys where available, and clearly-documented assumptions where necessary.

**Step 4: What percentage of the original area of each BPPH is present now?**

The amount of each BPPH remaining, expressed as a percentage of the original area of habitat.

**Step 5: How much more will be lost?**

The additional amount of each BPPH that will be lost from the LAU, if the development proceeds, expressed as a percentage of the original habitat.

**Step 6: How much would be lost in total if project proceeds?**

The percent value calculated in Step 5 is subtracted from the percent value calculated in Step 4 and the result is then subtracted from 100%. This is the total cumulative percentage loss.

**Step 7: Comparison with cumulative loss guideline.**

The total cumulative percentage loss value calculated in Step 6 above is then compared against the cumulative loss guideline relevant to the BPPH type and LAU.

**Step 8: EPA's consideration of cumulative loss**

Appraisals of the percentage cumulative loss values against the appropriate CLG for each BPPH is presented, along with all supporting data, analyses and assumptions, to the EPA for its consideration during the assessment.

***Example 2 – a proposal to cause loss of coral habitat***

A proposed maritime development is situated within a semi-circular bay which has a radius of about 4 km. The bay is sheltered by a coral barrier reef (coral reef BPPH) approximately 4 km offshore measured from the shoreline in the centre of the bay. The local assessment unit defined around this area is assigned to Category E in view of past and present approved activities. A port and an associated access channel were built in the 1970's, taking 89 ha of BPPH. A second channel was dredged in the 1980's to allow for port expansion, removing a further 13 ha. Development of a wastewater discharge pipeline caused the indirect irreversible loss of 58 ha of the coral BPPH due to the effects of eutrophication. A proposal is presented in 1997 to develop a recreational marina which, if built, would cause the unavoidable irreversible loss (after evaluating alternatives) of 20 ha of BPPH.

**Step 1: What is the 'local assessment unit'?**

The physical characteristics of a 'bay', the water circulation patterns and the distribution of benthic habitats provide a good basis to define the bay as the local assessment unit. It has an area of approximately 25 km<sup>2</sup> or 2500 ha.

**Step 2: What is the current area of each BPPH within the LAU?**

Aerial photographs and ground truthing surveys are used to map the different benthic habitats. Corals are dominant and 1,840 ha of coral habitat are estimated to occur in the local assessment unit.

**Step 3: What area of each BPPH was originally within the LAU?**

The local assessment unit currently contains 1,840 ha of coral reef BPPH, and some 160 ha has been lost previously, so the original habitat is estimated to have been:

$$1,840 \text{ ha} + 160 \text{ ha} = 2,000 \text{ ha}.$$

**Step 4: What percentage of the original area of each BPPH is present now?**

The amount of coral reef BPPH remaining, expressed as a percentage of the original habitat, is:

$$\frac{1840}{2000} \times 100 = 92\%.$$

**Step 5: How much more will be lost?**

The additional amount of coral reef BPPH that will be lost from the local assessment unit, if the development proceeds, expressed as a percentage of the original habitat, is:

$$\frac{20}{2000} \times 100 = 1\%.$$

**Step 6: How much would be lost in total if project proceeds?**

The percentage remaining in the local assessment unit, if the development proceeds, is:

$$92\% - 1\% = 91\%.$$

Therefore, the cumulative percentage loss would be:

$$100\% - 91\% = 9\%.$$

**Step 7: Comparison with cumulative loss guideline.**

The total predicted cumulative loss of coral reef BPPH is 9% and is within the cumulative loss guideline for category E areas.

**Step 8: EPA's consideration of cumulative loss**

As the cumulative loss of coral habitat is estimated to be within the cumulative loss guideline, it could be expected that the EPA, in its assessment of BPPH protection, would conclude that this environmental factor could be managed to meet its objectives.

## **Appendix 3 - Contextual Information**

This appendix outlines high-level background information and the findings of relevant scientific studies aimed at providing context for the Environmental Assessment Guideline and its intended use

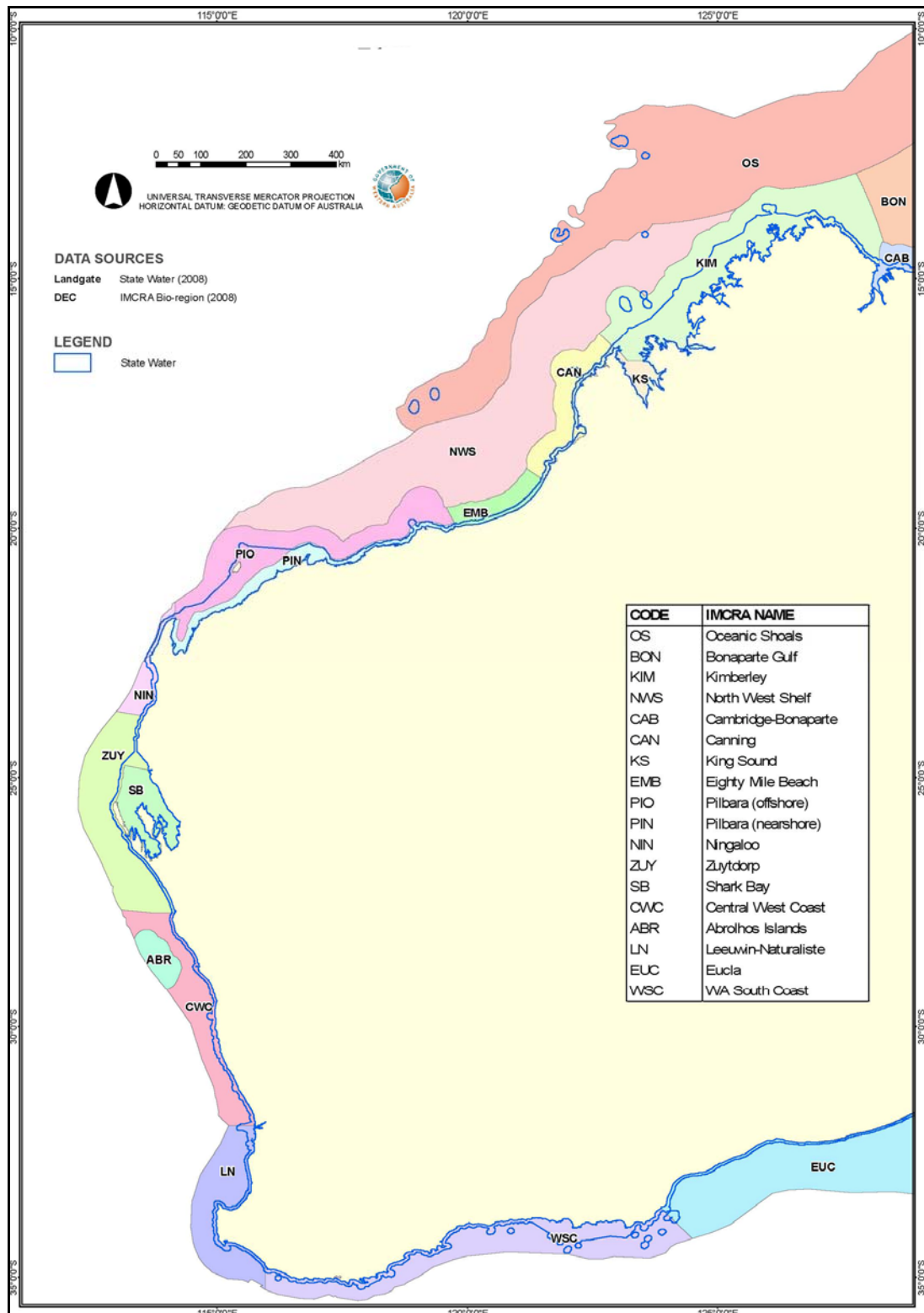
### **Western Australia's marine environmental setting**

Western Australia's coastline and marine environment is vast, extending across 21 degrees of latitude from the cool-temperate south coast to the warm tropical north Kimberley. One commonly-quoted figure is that WA has over 12,000 km of coastline extending from the boarder areas with South Australia to the Northern Territory. However, a recent estimate made using contemporary coastline data has revealed that there are around 12,000 km of coastline in the Kimberley region alone, and the length of the entire WA coastline is of the order of 30,000 km.

This very extensive marine environment supports a remarkable diversity of life, with the characteristic biological communities and ecosystems varying considerably with change in latitude. The Integrated Marine and Coastal Regionalisation of Australia (IMRCA Version 4.0), an ecosystem-based regionalisation of Australian waters, recognises 16 meso-scale bioregions that are coincident with WA coastal waters (Figure A3-1). Key ecological characteristics of these bioregions include hard-substrate reef communities which are common in temperate waters. Kelps and other attached macroalgae are often the most visually prominent and highest biomass components in these communities, though attached filter feeding invertebrates are also sometimes common. With around 26 species represented, Western Australia has the most diverse seagrass flora in the world (Walker and Prince 1987). Extensive meadows dominated by perennial temperate species occur in sandy sheltered embayments and coastal lagoons from the south coast to as far north as Shark Bay, where the seagrass meadows have been recognised as a World Heritage value. Progressing northward, corals become more common on the reefs, and tropical species of seagrasses occur on sand and mud substrata. Further north, mangrove communities become very well developed and, in regions such as the Kimberley, these communities display a very high degree in intactness. Extremely diverse coral reefs and biogenic algal-dominated reefs and shoals are common off mainland and island coasts in the tropical north. Shelf edge atolls, and submerged and emergent shoals and banks which support rich pelagic and benthic communities, including BPPHs, occur in the clearer offshore waters of the Kimberley and Oceanic Shoals bioregions.

### **The importance of benthic primary producer habitats**

Benthic primary producer habitats play important roles in maintaining the integrity of a great array of fundamental ecological processes. There is strong evidence that the presence of BPPH enhances biodiversity through provision of structurally complex habitat, provision of refuge, and increased food supply. In terms of services BPPH provide to human populations, they form the foundation of many marine food webs which in turn support productive and economically-important fisheries and attenuate wave and current energy which in turn helps to maintain, stabilise and protect shorelines and coastal infrastructure. Maintaining healthy and viable BPPH may also bolster the resilience of some important fisheries and maintain our use of the coasts in the face of increased demands and climate change effects. Examples of key ecological roles and values of BPPH are outlined below.



**Figure A3-1: Integrated Marine and Coastal Regionalisation of Australia meso-scale bioregions along the Western Australian mainland and islands**

### Primary productivity

Through the process of photosynthesis, benthic primary producers generate organic matter from carbon dioxide, water and nutrients, using sunlight for energy. This organic matter is then available to be consumed as food, either directly where it is attached to its substrate (e.g. dugongs grazing on seagrass; fish grazing on turf algae), in unattached forms in other linked habitats (e.g. seagrass associated fish consuming drift kelp transported from nearby reefs - Vanderklift and Wernberg 2008, and surf zone deposits of drift macroalgae and seagrass that influences fish communities - Crawley *et al.* 2006). Contemporary research is pointing to the contribution of benthic primary production to the functioning of pelagic systems (Lohrer, *et al.* 2004) and the potential roles played by marine benthic primary production in subsidising terrestrial food webs.

### Substrate and shelter

In addition to being highly productive, benthic primary producer habitats provide structurally complex habitat for the growth of sessile organisms (both plants and animals) and shelter for the juveniles and adults of mobile biota such as fish and invertebrates. They also support substratum-dwelling microbes and animals that feed on the organic matter produced and trapped within the BPPH. Coral reef habitats for example, are considered to be among the most diverse living systems in the world. Some BPPHs provide services critical for the life history of benthic primary producers themselves and species of marine animal. Crustose coralline algae for example grow over coral skeletons and in doing so consolidate the coral reef formations we see in many locations in tropical WA. Crustose coralline algae are also known to enhance settlement and metamorphosis of newly settled coral larvae (e.g. Heyward and Negri 1999; Morse *et al.* 1996) recruitment of abalone, a very important invertebrate grazer in some temperate reef systems (Roberts *et al.* 2004; Daume *et al.* 1999) which underpins a lucrative commercial fishery.

### Physical stability

Benthic primary producer habitats can assist in stabilising unconsolidated subtidal and intertidal sediments and protecting shorelines and coastal infrastructure. Mangrove communities help to stabilise and protect coastal margins from the effects of storm surges associated with tropical cyclones. Reefs act attenuate swell wave energy protecting inshore areas and shorelines. Maintaining these roles will become increasingly important for mitigating against effects on our coasts and coastal infrastructure of sea level rise and increased frequency and intensity of storms associated with climate change.

### Ecological value

The ecological value and function of benthic primary producer habitats varies depending on factors such as species dominance and abundance, geographic location, seasonal, annual and interannual patterns of abundance, recovery potential, relative contributions of predominant organisms to the system's productivity, structural complexity and/or nutritional value.

For example, in eastern Shark Bay, there are specific and localised *Halodule* sp. seagrass meadows. These meadows are of great ecological importance as a food source for breeding aggregations of dugong during the non-winter months. While the same species also occurs in areas outside the dugong's normal range, and has intrinsic value as a BPP throughout its distribution, the *Halodule* in Shark Bay has special value as a food source for a significant biodiversity conservation value, dugong, during a critical part of its life cycle and during a particular season. In view of this, the EPA would consider any proposal that might cause loss of these Shark Bay *Halodule* BPPH in the context of these important ecological services and potential flow-on effects to biodiversity values.

In another example, seagrasses such as *Halophila* and *Posidonia* are known for their intrinsic value as primary producers, but the relatively low recovery potential and high structural complexity of *Posidonia*-dominated benthic primary producer habitat are important factors to consider when assessing the relative value of these different seagrass-dominated BPPHs and the potential ecological (and biodiversity) consequences of their loss.

### **Scales of functional ecological connectivity**

Connectivity usually refers to linkages between populations of marine plants and animals in different places. The term connectivity has been used to refer to “the demographic linking of local populations through the exchange of individuals among them as larvae, juveniles or adults” (Sale *et al.* 2005) and also to describe trophic linkages among communities and species.

In recent years, there has been increased focus among marine scientists on better understanding connectivity in marine systems. In WA, scientific research has examined questions relating to scales of functional ecological connectivity in both tropical and temperate ecosystems. While there are still many questions remaining un-answered at this time, recent progress in the area of connectivity science is helping us understand more about relevant functional ecological scales of connectivity which in turn helps inform design and management of marine protected areas as well as the application of spatially-based environmental protection frameworks like the one described in this Environmental Assessment Guideline.

Trophic linkages among reefs and seagrass meadows in WA and the spatial extent of their influences has been study off the metropolitan and mid-west coasts. Researchers have measured the transport and consumption of drifting algae between reef systems separated by kilometers of non-reef habitat (Vanderklift and Wernberg 2008) and between reefs and seagrass meadows (100s of meters, Wernberg *et al.* 2006). The length scales of linkages measured by these researchers range from 10-100s of meters to 10s of kilometers.

Genetic studies on selected coral species from northwest WA reefs (Underwood 2009, Underwood *et al.* 2007) have been applied to infer that for the sites studied, functional ecological scales of connectivity are of the order of 20 km or less (Underwood *et al.* 2009). These findings are corroborated by the results from a growing body of scientific research on fish and coral species, and reviews (e.g. McCook *et al.* 2009) that suggest ecologically

relevant connectivity among a wide array of marine populations is often localized (<10–20 km).

The findings of the research cited above, as well as other local research that elucidates the scales of functional ecological connectivity and the differing contributions of different habitat types to the functioning of ecosystems (e.g. Hyndes and Lavery 2005) lend empirical support for the consideration of habitat loss at local (primarily <10-20 km) scales to address the objective of maintaining ecological integrity. These studies also point to the importance of considering the losses of each benthic primary producer habitat type independently so that the relative proportionality of different habitats within a defined area can be maintained.

## References

- Crawley K.R., Hyndes G.A. and Ayvazian S.G. (2006). The influence of different volumes and types of detached macrophytes on fish community structure in surf zones of sandy beaches. *Mar. Ecol. Prog. Ser.* **307**: 233-246
- Daume S., Brand-Gardner S. and Woelkerling W.J. (1999). Settlement of abalone larvae (*Haliotis laevigata* Donovan) in response to nongeniculate coralline red algae (Corallinales, Rhodophyta). *J. Exp. Mar. Biol. Ecol.* **234**:125-143
- Heyward A.J. and Negri A. P. (1999). Natural inducers for coral larval metamorphosis. *Coral Reefs* **18**:273-279
- Hyndes G. A. and Lavery P. (2005). Does transported seagrass provide an important trophic link in unvegetated, nearshore areas? *Estuarine Coastal & Shelf Science* 63:633-643
- Lohrer A.M., Thrush S. F. & Gibbs M.M. (2004). Bioturbators enhance ecosystem function through complex biogeochemical interactions. *Nature* 431: 1092-1095
- McCook L.J., Almany G.R., Berumen M.L., Day J.C., Green A.L., Jones G.P., Leis J.M., Planes S., Russ G.R., Sale P. F. and Thorrold S.R. (2009). Management under uncertainty: guide-lines for incorporating connectivity into the protection of coral reefs. *Coral Reefs* 28:353–366
- Morse A.N.C., Iwao K., Baba M., Shimoike K., Hayashibara T. AND Omori M. (1996). An ancient chemosensory mechanism brings new life to coral reefs. *Biol. Bull.* **191**:149-154
- Roberts R.D., Kaspar H.F, and Barker R.J. (2004). [Settlement of abalone larvae in response to five species of coralline algae](#). *Journal of Shellfisheries Research* 23:975–987
- Sale PF, Cowen RK, Danilowicz BS, Jones GP, Kritzer JP, Lindeman KC, Planes C, Polunin NVC, Russ GR, Sadovy YJ, Steneck RS (2005) Critical science gaps impede use of no-take fishery reserves. *Trends Ecol Evol* 20:74-80.

Underwood J. N., Smith L. D., van Oppen M. J. H., and Gilmour J. P. (2007). Multiple scales of genetic connectivity in a brooding coral on isolated reefs following catastrophic bleaching. *Molecular Ecology* 16:771–784.

Underwood J. N., Smith L. D., van Oppen M. J. H., and Gilmour J. P. (2009). Ecologically relevant dispersal of corals on isolated reefs: implications for managing resilience. *Ecological Applications*, **19**, 18-29

Underwood J. N (2009). Genetic diversity and divergence among coastal and offshore reefs in a hard coral depend on geographic discontinuity and oceanic currents. *Applications*, **2** 222-233.

Vanderklift M.A. and Wernberg T. (2008). Detached kelps from distant sources are a food subsidy for sea urchins. *Oecologia* 157:327–335

Walker D.I. and Prince R.I.T. (1987). Distribution and biogeography of seagrass species on the northwest coast of Australia. *Aquatic Botany* **29**: 19-32

Wernberg T., Vanderklift M. A., How J. and Lavery P.S. (2006). Export of detached macroalgae from reefs to adjacent seagrass beds. *Oecologia* **147**: 692–701

## **Appendix 4 - Submitting Proposal Boundaries and Benthic Habitat Information as Spatial Data for Environmental Impact Assessment**

This Appendix describes the format of proposal boundaries and benthic habitat information required to be submitted as spatial data to the EPA as part of an environmental impact assessment proposal.

### **What is spatial data?**

Spatial data is digital information which can be used in computer mapping software; this information is also referred to as GIS or CAD data. If your organisation or environmental advisors/consultants have GIS or CAD personnel; or there are maps showing infrastructure and/or biological information, or engineering drawings associated with your proposal, then you have spatial data.

### **Why are proposal boundaries and benthic habitat information required to be submitted to the EPA as spatial data?**

The EPA values proposal boundaries and benthic habitat information as spatial data and uses them to;

- i) find what environmental assets and issues are on or near the proposal
- ii) to serve as a administrative record
- iii) to communicate where the EPA has made decisions to others and their processes
- iv) conduct its own verification of predicted impacts

### **What are the specifications required?**

Proponents are required to submit GIS or CAD data on CD, depicting the proposal extent, geo-referenced and conforming to the following parameters:

- i) datum: GDA94
- ii) projection: Geographic (latitude/longitude) or Map Grid of Australia (MGA)
- iii) format: ESRI shapefile, geodatabase or coverage, Microstation or AutoCAD
- iv) where a series of activities are proposed, each should be individually mapped
- v) each mapped boundary should be clearly labelled (CAD) or attributed (GIS)