DOT307215 Provision of Western Australian Marine Oil Pollution Risk Assessment - Protection Priorities

Protection Priority Assessment for Zone 2: Pilbara - Final Report

16 Oct 2017

Level 4, 600 Murray St
West Perth WA 6005
Australia

301320-09591-EN-REP-0003

www.**advisian**.com

Advisian
WorleyParsons Group

Disclaimer

Report No: 301320-09591-EN-REP-0003 – DOT307215 Provision of Western Australian Marine Oil Pollution Risk Assessment - Protection Priorities: Protection Priority Assessment for Zone 2: Pilbara - Final Report

Rev	Description	Author	Review	Approved	Date
A	Issued for Internal Review	K Swain	A Byron & A Jacob	L Jones	30-May-16
B	Issued for Client Review	K Swain	A Jacobs	L Jones	17-Jun-16
0	Issued for Use	K Swain	A Jacobs	L Jones	5-Aug-16
1	Re-Issued for Use	A Jacobs	L Laver	K Swain	31-May-17
2	Approved	A Jacobs Advisian	K Swain Advisian	E Gifford WA Department of Transport	16-Oct-17

Executive Summary

The Western Australian Department of Transport (DoT) is the Hazard Management Agency (HMA) for marine oil pollution in Western Australia (WA). As the HMA, DoT ensures the capacity of the State to respond to an oil spill is commensurate with the risk.

In order to understand the state's spill risk profile, the DoT is conducting a state-wide marine oil pollution risk assessment. The risk assessment is comprised of two components. The first component identifies the aspects (e.g. fauna, flora, etc.) that are present in each shoreline cell, and evaluates which aspects would be most affected and thus need to be prioritised for protection in the event of an oil spill (i.e. protection priority). These protection priorities were ranked using a five-tier scale, Very Low to Very High (Table 0-1).

Table 0-1: Protection priority ranking

Protection Priority	Ranking
Very High	5
High	4
Medium	3
Low	2
Very Low	1

The second component assesses the likelihood, size, location and type of potential marine oil pollution. The second component is being undertaken by Navigatus Consulting (Navigatus). Navigatus is also combining the protection priority component with the spill likelihood component to give an overall marine oil pollution risk profile for the state. This overall risk profile will identify the key environmentally sensitive areas that are most at risk of being affected by an accidental release of marine oil. The output from Navigatus's assessment is not addressed in this report.

The results of this project will be used to decide how to allocate resources on a regional, state and national level, and will be scrutinised by regional, state and national agencies. Data collected on protection priorities may assist in decision-making both when preparing and responding to marine oil pollution incidents.

For the purposes of this project, state waters have been divided into seven zones (see Figure 1-1) and each zone has been divided into ~10 km by ~20 km areas called shoreline cells. The project is being rolled out on a zone-by-zone basis over the next two to five years. The first protection priorities zone completed was the Pilbara (Zone 2), which was originally finalised in August 2016, and was followed by assessments of the Midwest zone and Swan zone (Zones 3 and 4). However as the Midwest and Swan zone assessments were being finalised, the protection priority rankings developed during the initial Pilbara zone assessment were resulting in the majority of the shoreline cells in the three zones being prioritised as High or Very High for protection in the event of an oil spill.

While the outcome demonstrates that the WA coastline has many highly vulnerable receptors to marine oil pollution, it does not achieve the objective of the project, which is a state-wide assessment that identifies the '*key environmentally sensitive areas that are most at risk of being*

affected by an accidental release of marine oil'. As a result, the drivers for these High and Very High rankings were investigated, and it was identified that a few key state-wide datasets and their priority rankings were driving the majority of the high rankings. These datasets were for the Protected Fauna and Protection Areas categories.

The outcome of the State Wide Overview assessment was a set of more detailed criteria for assigning protection priority rankings for Protected Fauna and Protection Areas categories data. These revised rankings have been incorporated into this assessment of the Pilbara zone, and this report presents the revised results of the assessment following the method developed for the project (Figure 1-2).

This report presents the scope, method and discussion of outputs for the protection priorities identified for environmental, social, cultural and economic areas of significance which may be impacted by a marine oil spill. This report also presents the multi-criteria analysis (MCA) that has been conducted on the geospatial data collected for each category, in order to identify the key areas of protection priority. It also recommends areas for improvement.

The protection priorities assessment for the Pilbara zone has demonstrated that there are many vulnerable and important receptors that will need to be considered in the event of an oil spill. The cumulative ranking for all five categories, for both floating oil and dissolved oil impacts, sees five clusters of shoreline cells in the Pilbara zone being ranked Very High (22 out of 62 shoreline cells), and 33 out of 62 shoreline cells ranked High based on the cumulative assessment.

This process has demonstrated that the Pilbara coastline contains many sensitive and important receptors that will need to be considered in the event of an oil spill. The key driver for the Very High ranking in the Pilbara zone is the presence of Ningaloo coast, which is internationally protected as a World Heritage Area and ranked Very High in the Protection Areas and Cultural Heritage categories. There are also clusters of Very High rankings in four areas, located around significant ports in the Pilbara, which are classified as Very High in the Economic category and overall due to trade worth more than $1B annually in these ports.

More than 50% of the shoreline cells in the Pilbara are ranked High overall for protection from floating oil due to the presence of Protected Fauna and Protection Areas. This High ranking is caused by the likely presence of Critically Endangered animal habitat and breeding areas for whales, turtles, birds and small mammals. The protection areas creating the High ranking are Nature Reserves and Important Wetlands. For the overall rankings of protection from dissolved oil, there are fewer cells ranked High, but it still covers nearly half of the Pilbara zone shoreline cells.

Acknowledgements

Advisian would like to thank the following people who had valuable input into this project:

The Steering Committee:

- Department of Transport (DoT): Emily Gifford – Team Leader Planning and Public Information | Marine Safety;
- Department of Parks and Wildlife:
  - Ralph Talbot-Smith – WALIS Project Manager | Managing Coastal Vulnerability Project (now with Department of Transport);
  - Stuart Field – Principal Policy Officer | Office of the Director General;
  - Steve Rowlands – Parks and Wildlife Data Manager; and
  - Dr Fran Stanley – Deputy Director | Science and Conservation.
- Australian Maritime Safety Authority (AMSA): Paul Irving – Senior Scientific Coordinator | Marine Environment Pollution Response;
- Woodside: Denise McCorry – Senior Environment Advisor;
- Department of Fisheries: Carli Telfer – Senior Management Officer | Biodiversity Branch; and
- Environmental Protection Authority (EPA): Gordon Motherwell – Senior Environmental Officer | Infrastructure Assessments Branch.

Department of Transport Personnel:

- Emily Gifford – Team Leader Planning and Public Information | Marine Safety;
- Matt Verney – Manager Maritime Environmental Emergency Response | Marine Safety;
- Sharon Hu – Senior Geospatial Information Analyst | Coastal Infrastructure;
- Steven James – Manager Geographic Information | Coastal Infrastructure; and
- Rodney Hoath – Director Coastal Information | Coastal Infrastructure.

Navigatus Consulting personnel:

- Kevin Oldham – Service Director | Project Delivery; and
- Matt Bilderbeck – Service Manager and Modelling Development.

Advisian team members and other Advisian personnel:

- Annette Jacobs – Project Manager and MCA Specialist;
- Lorie Jones – Project Sponsor;
- Kate Swain – Senior Environmental Specialist and Report Author;
- Paul Rolfe – Geospatial Information Systems (GIS) Specialist;
- Mark Peel – GIS Specialist;
- Nadene Claydon – Marine Specialist; and
- Dan Hunter – Environment and Society Team Manager.

This page intentionally left blank.

Table of Contents

Figure List

Table List

Appendix A

Acronyms and Abbreviations

AFMA	Australian Fishing Management Authority
AMSA	Australian Maritime Safety Authority
BIA	Biologically Important Area
CALM Act	WA State *Conservation And Land Management Act 1984*
CAMBA	China and Australia Migratory Bird Bilateral Agreement 1986
CAMRIS	Coastal and Marine Resources Information System
CAPAD	Collaborative Australian Protected Areas Database
CD	Conservation Dependent
CR	Critically Endangered
CSMC	Cockburn Sound Management Council
DAA	WA State Department of Aboriginal Affairs
DEC	WA State Department of Environment and Conservation (now called DPaW)
DMP	WA State Department of Mines and Petroleum
DoF	WA State Department of Fisheries
DoT	WA State Department of Transport
DotE	Commonwealth Department of the Environment
DPaW	WA State Department of Parks and Wildlife
ELG	Environment Liaison Group
EN	Endangered
EPA	Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESC	Environmental Scientific Coordinator
ESI	Environmental Sensitivity Index
FHPA	Fish Habitat Protection Area
GDP	Gross Domestic Product
GIS	Geospatial Information System
GSP	Gross State Product
HMA	Hazard Management Agency
IMO	International Maritime Organisation
IPIECA	Global oil and gas industry association for environmental and social issues
IUCN	International Union for Conservation of Nature
JAMBA	Japan and Australia Migratory Bird Bilateral Agreement 1974
KEF	Key Ecological Feature
MCA	Multi-Criteria Analysis

MFB	Marine Futures Biodiversity
MSC	Marine Stewardship Council
NOAA	National Oceanic and Atmospheric Administration
OGP	International Association of Oil and Gas Producers
OS	Other Specially Protected Fauna (under the WC Act)
OSRA	Oil Spill Response Atlas
PROWRP	Pilbara Region Oiled Wildlife Response Plan
PMST	Protected Matters Search Tool
SNES	Species of National Environmental Significance
SPRAT	Species Profile and Threats Database
TBC	To Be Confirmed
TSA	Tourism Satellite Account
UNESCO	United Nations Educational, Scientific and Cultural Organization
VU	Vulnerable
WA	Western Australia
WAM	Western Australian Museum
WC Act	WA State *Wildlife Conservation Act 1950*

Key Terminology

Attribute table	An attribute table has been produced for each shoreline cell summarising the protection priority for each category, for both floating and dissolved hydrocarbons (as the consequence may be different for different forms of a hydrocarbon), and an overall ranking along with a brief description of the priority. This is the deliverable to the Risk Consultant.
Categories	There are five categories for assessment of protection priority: Protected Fauna; Protection Areas; Cultural Heritage; Economic; and Social, Amenity and Recreation. Each cell has been assessed for its protection priority for each of these five categories from Very Low, Low, Medium, High to Very High. These are provided in the form of an attribute table to the Risk Consultant who will integrate these into their model, along with oil spill likelihood and other hydrocarbon spill characteristics, to develop an overall risk ranking for each shoreline cell.
Coastal compartments	Coastal compartments are a physical framework for marine and coastal planning. They are a hierarchy of planning units based on geological features which has been devised by the Departments of Environment and Conservation, Planning, and Transport, and have served as a basis for the shoreline cells (Eliot *et al.,* 2011). There are primary, secondary and tertiary compartments. The tertiary coastal compartments are what the shoreline cells have been based on. The distinction between coastal compartments and shoreline cells has been made to try to avoid confusion when the results of this project are used by the DoT in collaboration with other government agencies that have protocols based on the coastal compartments.
Coastal zone	The coastal zone is defined as the area of the sea, including the water up to the high water mark, which includes the intertidal zone and the debris beach habitat (e.g. dried seagrass).
Components	Risk is comprised of two components: consequence and likelihood. Advisian's scope focusses on the first component, while Navigatus is providing the second component and will be combining both components to give an overall risk ranking.
Data	Data refers to geospatial data (shapefiles) that has been collected and processed using a Geospatial Information System (GIS) to rank and process the data based on its attributes as outlined in this report. These data layers have been overlain with the shoreline cells to provide an output of the overall ranking for each category for each shoreline cell. This system has been used to process extensive and complex sets of geographical data layers with a consistent ranking and geographical accuracy.
Risk Consultant	The Risk Consultant is Navigatus Consulting. Navigatus is assessing the likelihood, size, location and type of potential marine oil pollution for state waters. Navigatus is also incorporating the protection priority outputs from the Protection Priority ranking process with the spill characteristics, to give an overall risk profile for the state.
Sensitive receptors	Sensitive receptors are those receptors that have been identified as sensitive to marine oil pollution and grouped into the five categories. For example, in Protected Fauna, sensitive receptors are birds, mammals, invertebrates, fish and reptiles.
Shoreline cells	Each zone has been divided into geographical units of approximately 10 km x 20 km that are each analysed for priority ranking based on the protection priorities identified in the cell. There are 62 shoreline cells in Zone 2 *Pilbara* (Figure 1-3).
Zones	The WA state waters have been divided into seven (7) zones: Zone 1 *Kimberley*; Zone 2 *Pilbara*; Zone 3 *Midwest*; Zone 4 *Swan*; Zone 5 *South West;* Zone 6 *South Coast*; Zone 7 *Federal Offshore Features* (Figure 1-1).

This page intentionally left blank.

1 Introduction

Oil spills in the marine environment can have wide spread impact and long term consequences on wildlife, fisheries, coastal and marine habitats, human health and livelihood, as well as recreational resources of coastal communities (Gilbert, 1999). In Western Australia (WA), the WA Department of Transport (DoT) is responsible for ensuring the State has the capacity to respond to an oil spill in WA state waters. They are designated as the Hazard Management Agency (HMA) for marine oil pollution in Western Australia. As the HMA, the DoT also ensures the capacity of the State to respond to an oil spill is commensurate with the risk.

To better understand the state's spill risk profile, the DoT is conducting a state-wide marine oil pollution risk assessment. The risk assessment is comprised of two components. The first component evaluates protection priorities of the receiving environment in order to assess potential consequences of oil pollution. The second component assesses the likelihood, size, location and type of potential marine oil spill. Navigatus Consulting is undertaking the second component, and is also combining the protection priority component with the spill likelihood component to give an overall marine oil pollution risk profile for the state. This overall risk profile will identify the key environmentally sensitive areas that are most at risk of being affected by an accidental release of marine oil. The output from Navigatus's assessment is not addressed in this report.

The results of this project will be used to decide how to allocate resources on a regional, state and national level, and will be scrutinised by regional, state and national agencies. Data collected on protection priorities may assist in decision-making both when preparing and responding to marine oil pollution incidents.

For the purposes of this project, state waters have been divided into seven zones (see Figure 1-1). The project is being rolled out on a zone-by-zone basis over the next two to five years. The first protection priorities zone completed was the Pilbara (Zone 2), which was originally finalised in August 2016, and was followed by assessments of the Midwest zone and Swan zone (Zones 3 and 4). However as the Midwest and Swan zone assessments were being finalised, the protection priority rankings which had been developed during the initial Pilbara zone assessment were resulting in much of the shoreline cells in the three zones being prioritised as High or Very High for protection in the event of an oil spill. While the outcome demonstrates that the WA coastline has many highly vulnerable receptors to marine oil pollution, it does not achieve the objective of the project, which is a state-wide assessment that identifies the '*key environmentally sensitive areas that are most at risk of being affected by an accidental release of marine oil*'. As a result, the drivers for these High and Very High rankings has been investigated, and it was identified that a few key state-wide datasets were driving the majority of the rankings. These were datasets in the Protected Fauna and Protection Areas categories.

In the Pilbara, the Protection Areas data driving the high rankings were predominantly mangroves and sheltered intertidal flats, which are prevalent on the Pilbara shoreline, and are considered to be very highly vulnerable to marine oil. This data and other key aspects driving the High and Very High rankings are described in more detail, along with their individual criteria for re-ranking this data, in Section 3 of this report.

The outcome of the State Wide Overview assessment was to define more detailed criteria for assigning protection priority rankings for Protected Fauna and Protection Areas data. These revised

rankings have been incorporated into the assessment of the Pilbara zone, and this report presents the revised results of the assessment.

This report also describes the scope, method and discussion of outputs for the protection priorities identified for environmental, social, cultural and economic areas of significance that may be impacted by a marine oil spill. It also presents the multi-criteria analysis (MCA) that has been done on the geospatial data collected for each category in order to identify the key areas of protection priority. It summarises these priorities and also recommends areas for improvement.

Figure 1-1: Western Australian marine oil pollution risk assessment zones

1.1 Scope

The scope was broken down into four steps:

1. **Acquire information:** Advisian was required to identify, acquire and collate environmental information to assess the ecological, cultural and economic value of spatial units encompassing state waters. Part of this process was to develop a set of categories that group the data in a simple and logical format for ease of use.
2. **Design a system for presenting information:** Information was required to be compiled as an attribute table and will be uploaded to a WebMap Application being developed by the Risk Consultant. The table summarises the outputs by category for a designated sector of state waters. The sectors are geospatial units that have been developed by the Risk Consultant and termed 'shoreline cells' for this project.
3. **Conduct assessment:** All available, relevant spatial data collected was required to be ranked in order of its protection priority in the occurrence of a marine oil pollution event, and processed using a weighting by area and importance for each shoreline cell.
4. **Provide outputs:** A report has been prepared outlining the method, and an attribute table summarising the outputs of the assessment by shoreline cell. The attribute table will be used by the Risk Consultant to upload protection priority information into a WebMap Application.

In addition to the above, a Steering Committee was introduced to facilitate identifying and collecting relevant data and ensure appropriate rankings and processing.

The project scope is summarised in a flowchart in Figure 1-2.

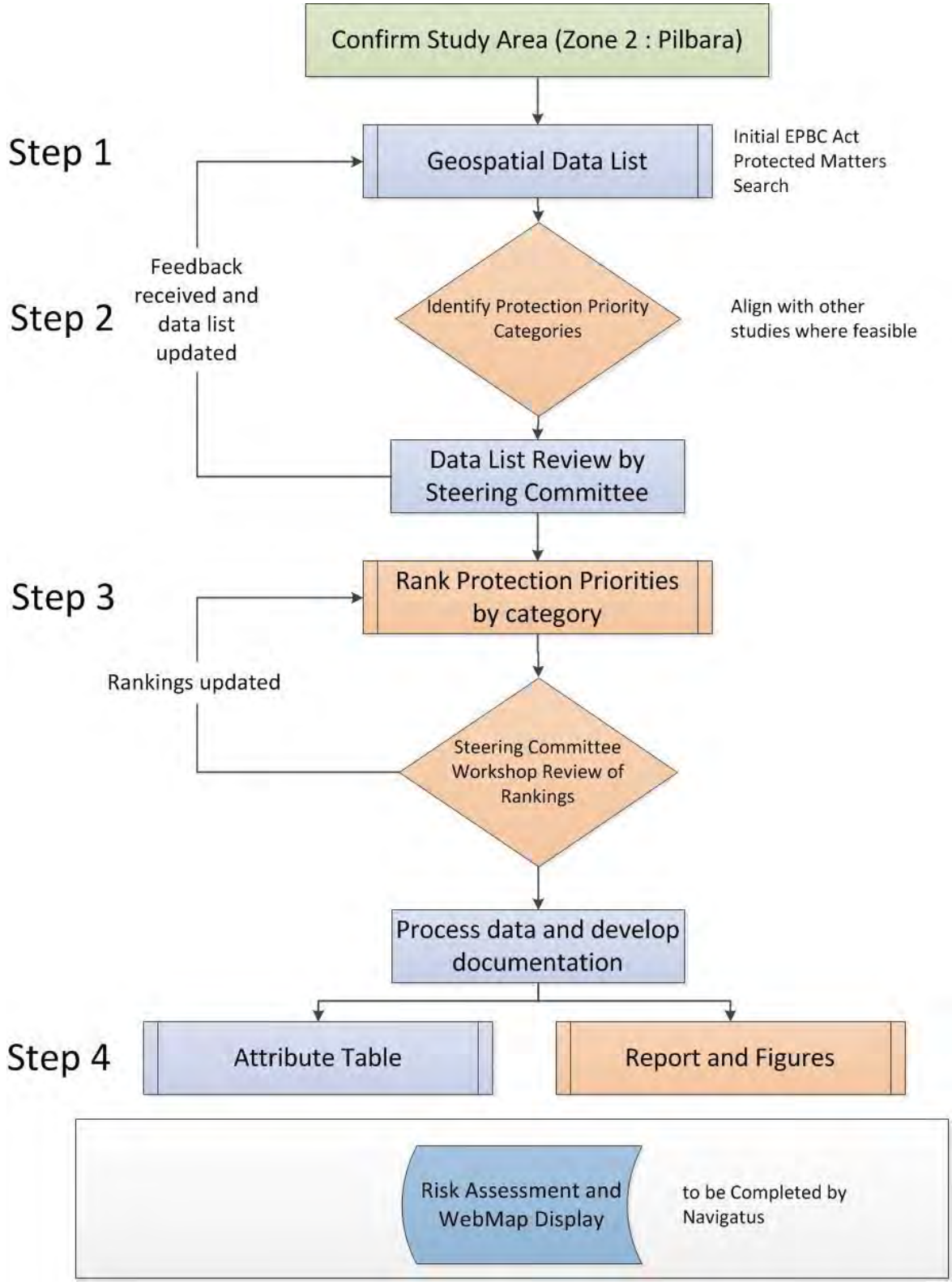

Figure 1-2 Protection priorities project component flowchart

1.2 Protection Priority Categories

The main outcome from step 1 was to develop a set of categories that group protection priorities into categories, following a simple and logical format of similar aspects with respect to vulnerability to a marine oil spill. This approach is based on the Australian Maritime Safety Authority's (AMSA) National Plan for Maritime Environmental Emergencies (the National Plan), as well as similar oil spill risk assessments that have been undertaken.

A number of protection priorities are set out in the National Plan, which is managed by AMSA. The National Plan, along with identifying sensitive receptors, describes how governments and industry will co-operate to respond to shipping casualties and maritime spills. The National Plan has been developed with the Commonwealth and State/Northern Territory government agencies as well as shipping, ports, offshore petroleum production and exploration, oil, salvage and chemical industries. Protection priorities as set out in the National Plan include habitat and cultural resources, rare and/or endangered flora and fauna, commercial resources and amenity areas (AMSA, 2016).

A similar oil spill risk assessment undertaken in New Zealand categorised priorities into five value types (Navigatus, 2005; 2015). These are: species; habitats; social, amenity and recreation; cultural and heritage; and economic. Another similar assessment undertaken in Victoria used the same five categories (Navigatus, 2011).

For Western Australia, five categories were also selected based on the list above, with an amendment from 'habitats' to 'protection areas'. This was changed to allow areas designated for protection (for example a World Heritage Area, or a Key Ecological Feature) to be included. Protection areas identify an area of ecological function beyond the individual habitats that it may comprise, which may not otherwise be included in the assessment.

As an outcome of the above reviews, and taking into account the Western Australian environment, five categories of interest were defined for assessing the effects of a marine oil pollution event for this project. These are:

1. Protected Fauna;
2. Protection Areas;
3. Cultural Heritage;
4. Economic; and
5. Social, Amenity and Recreation.

1.3 Shoreline Cells

Step 2 required designing a system for presenting information. This involved dividing Western Australia's state waters into sectors to geospatially summarise the information in a WebMap Application. The sectors are geographical units that have been developed by the Risk Consultant. These units have been termed 'shoreline cells' for this project, and are loosely based on the tertiary planning units (coastal compartments) that have been devised by the Departments of Environment and Conservation, Planning, and Transport (Eliot *et al.,* 2011). These are approximately 10 km x 20 km and have been called 'shoreline cells' to distinguish them from the 'coastal compartments' developed by Eliot *et al.* (2011).

The primary, secondary and tertiary coastal compartments were devised as a physical framework for marine and coastal planning, and are currently used by other State departments such as the Department of Parks and Wildlife (DPaW) for oiled wildlife response planning. The coastal compartments define the principal coastal regions and coastal compartments discernible around the Western Australian coast based on known geologic features, landforms, ocean processes and sediment distribution (Eliot *et al.,* 2011). The shoreline cells which were assessed for the Pilbara zone are illustrated in Figure 1-3. There are 62 shoreline cells in the Pilbara zone.

The shoreline cells used in this assessment were initially provided to Advisian by Navigatus. The numbering system was subsequently modified by Navigatus, and sent through to Advisian on 23 May 2016.

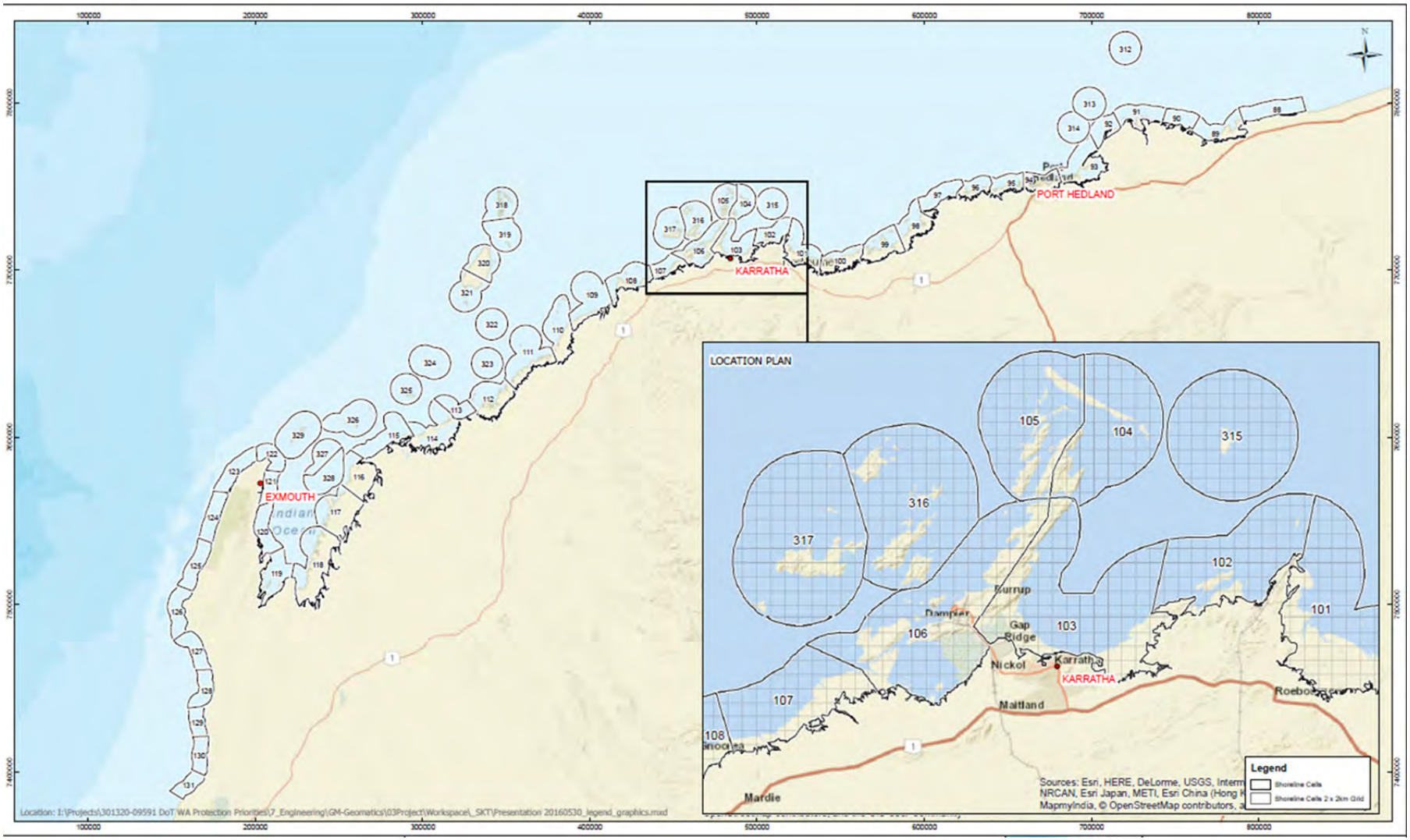

Figure 1-3: Pilbara Zone 2 shoreline cells

1.4 Marine Oil Pollution Effects

The assessment of ranking data (step 3) requires an understanding of vulnerability and susceptibility to marine oil pollution, by the different sensitive receptors identified, in order to give each a ranking of protection priority. This has been challenging because the impact will depend on the sensitivity of the receptor to marine oil, as well as the quantity of oil spilled and the characteristics and properties (type) of oil. The potential effects that have been considered are summarised below.

There are many different types of hydrocarbons that may cause marine pollution, and each has its own complex properties. Oil types range from Heavy Fuel Oils from large shipping vessels to Marine Diesel from supply vessels, to light condensates and crude oils from offshore and nearshore pipeline or platform leaks, and well blowouts (e.g. Montara). Once released into the marine environment, hydrocarbons are subject to weathering and assimilation in the marine environment (Figure 1-4). The timing for this process depends on their complex properties (physical and chemical characteristics), as well as a number of other variables including: the amount spilled; the prevailing climatic and sea conditions; and how long the hydrocarbons remain at sea or wash ashore. Weathering is the process of physically and chemically changing hydrocarbons through spreading, evaporating, dispersing, emulsifying, dissolving, oxidating and biodegrading (French-McCay & Payne, 2001). Oil spill responses can also influence these processes.

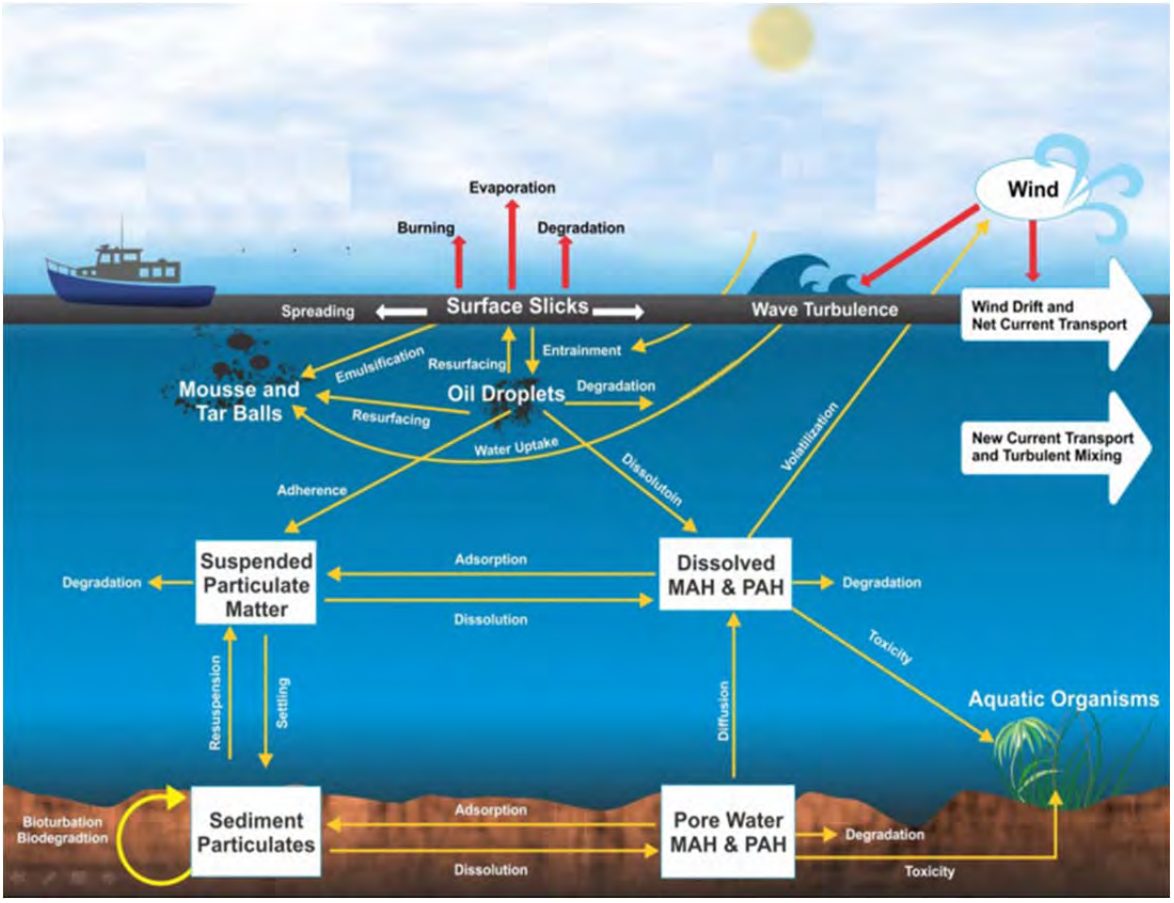

Figure 1-4: Hydrocarbon weathering and biodegradation processes

The effect of each type of hydrocarbon varies, depending on its physical and chemical properties. In general, there are three different forms modelled and assessed for their effects: floating; entrained; and dissolved. Floating occurs because hydrocarbons are typically lighter than water so they float on the surface, often referred to as a 'slick'. Entrained hydrocarbons are small droplets of oil in the water column. These can be various sizes and occur when the hydrocarbons have been released sub-surface, or where floating oil has been mixed into the water column by waves. 'Dissolved' is the soluble component of a hydrocarbon that presents toxic effects depending on the concentration and duration of exposure. In general, these effects and impacts are summarised below for each of the five categories.

For this assessment, entrained oil has been considered as included in the physical effects of oil, which is captured in the 'floating' component of this assessment. Therefore only two rankings have been used: one for the effects of floating hydrocarbons; and one for the effects of dissolved hydrocarbons.

Hydrocarbons may impact the environment (fauna and flora) by one or more ways (ITOPF, 2011):

- Physical smothering, which impacts physiological functions;
- Chemical toxicity, which causes lethal or sub-lethal effects or impairs cellular functions;
- Ecological changes, primarily losing key organisms from a community and opportunistic species taking over habitats; and/or
- Indirect effects, such as the loss of habitat or shelter and the consequent elimination of ecologically important species.

The impacts of hydrocarbons on a cultural heritage site may include:

- Physically degrading a site; and
- Reducing the amenity and emotion of an environmental site that is protected for Indigenous and European heritage reasons.

From an economic perspective, hydrocarbons can:

- Temporarily disrupt operations, resulting in reduction of income, for example a port or an oil & gas facility; and
- Cause long-term economic loss, such as the impact on a fish stock, both through indirect loss of stock and perceived tainting of stock by the oil.

Hydrocarbons may impact on social, amenity and recreational aspects by:

- Reducing the amenity of a site such as a beach or a coral reef;
- Restricting access to a site during clean-up and rehabilitation; and/or
- Giving a perceived loss of amenity due to negative perceptions associated with an 'oil spill'.

1.5 Steering Committee

A Steering Committee was established to facilitate identifying and collecting relevant data and ensure appropriate rankings and processing. This developed through DoT's presentation of the project to the Environment Liaison Group (ELG) of which DoT is a member. Feedback from the ELG on the concept of the project emphasised the importance of the data collection phase. A Steering Committee was therefore established to facilitate liaison with multiple agencies throughout the project. The Steering Committee was comprised of:

- A DoT representative;
- A project team representative(s);
- Multi government agency representatives; and
- Independent representatives (as required).

The Steering Committee members for the Pilbara zone are presented in Table 1-1.

Table 1-1: Steering Committee members for the Pilbara zone

Department	Name	Title
Department of Transport	Emily Gifford	Acting Team Leader Planning and Public Information | Marine Safety
Department of Parks and Wildlife	Ralph Talbot-Smith	WALIS Project Manager | Managing Coastal Vulnerability Project (now with Department of Transport, Manager Cartographic Services | Coastal Infrastructure)
	Stuart Field	Principal Policy Officer | Office of the Director General
	Dr Fran Stanley	Deputy Director | Science and Conservation
AMSA	Paul Irving	Senior Scientific Coordinator | Marine Environment Pollution Response
Woodside	Denise McCorry	Senior Environment Advisor
Department of Fisheries	Carli Telfer	Senior Management Officer | Aquatic Environment Branch
EPA	Gordon Motherwell	Senior Environmental Officer | Infrastructure Assessments Branch

Ben Radford from the Australian Institute of Marine Science was invited to participate in the Steering Committee, however was unable to provide input to the project.

The Steering Committee was asked to:

- Review the list of collected data to ensure it is the best available and, if gaps were identified or datasets missing completely, advise on possible alternate sources of information;
- Direct Advisian to relevant points of contact for additional data, streamlining the process where possible; and
- Provide advice at a workshop to review the selection and weightings of criterion for multi-criteria analysis.

The Steering Committee was provided with the following documentation:

- Terms of Reference that outlined the engagement and commitments to the project (sent 31 March 2016);
- Interim Discussion Paper – Data Collection for Zone 2: Pilbara (301012-09591-EN-REP-0001) (sent 11 April 2016) for review and identification of additional data; and
- Workshop Discussion Paper (301012-09591-EN-EN-REP-0002) (sent 11 May 2016).

A workshop was held with the Steering Committee on 16 May 2016 to review the priority ranking process. The agreed rankings being used for this Pilbara zone and future zones are provided in Section 3. In the Steering Committee Workshop, a number of additional data requirements were also identified. This is discussed in Section 2.

The Steering Committee has provided valuable input, data identification, clarification and experience to the project, and their comments have been incorporated into this project where applicable. It is anticipated that the composition of the Steering Committee will remain largely constant as the project moves across the remaining zones, with local subject matter experts added as appropriate.

In the Workshop on 16 May 2016, the following issues were also discussed:

- Comparing different forms of data at different resolutions – It was agreed that high resolution data was not necessarily a benefit to the project, and a more general identification of sensitivities that can be compared across zones is probably more appropriate;
- Surrogates for certain value measures across zones – This was not an issue in the Pilbara zone as there is a lot of data available, but may become a requirement in other zones where the equivalent amount of data does not yet exist, for example the Kimberley zone;
- Incorporation of seasonality – There was much debate on this, with no definite conclusion reached. In general, data has been included, as an oil spill could occur at any time;
- Display of reliability of data – This was not an issue in the Pilbara zone as all data was sourced from government databases, but it may be an issue in future zones where data needs to be created, for example from subject matter expert experience or using a surrogate; and
- How much data is too much – It was recognised that there would be a limit reached where the effort to collect and incorporate additional data would add little value or change the outcome of the process.

It was also noted that there are some more considerations when preparing to respond to a marine oil pollution incident, including:

- Access and logistics (e.g. boat ramps, roads, mobile phone coverage); and
- Potential dangers to personnel during a response (e.g. crocodile locations, high radiation exposure on the Montebello Islands).

These are recognised as being outside the scope of this assessment, but included here for consideration in the future.

During the rankings revision process undertaken in mid-2017, the Steering Committee was provided with a project update and was invited to comment on the revised rankings. Comments which were made during this review are incorporated into this revision of the Pilbara report.

2 Geospatial Data

2.1 EPBC Act Protected Matters Search Tool

An assessment to identify and gather environmentally and culturally important areas was initially done using the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (PMST). This is an online interactive map maintained by the Commonwealth Department of the Environment (DotE). The search tool was used to generate a report that helped determine whether matters of national environmental significance or other matters protected by the EPBC Act are likely to occur in the area.

The area searched included the Pilbara zone from up to 5 km inland to the approximate state waters boundary (Figure 2-1).

Figure 2-1: EPBC Act Protected Matters search tool area of search

The report provided the following information on the identified matters of national environmental significance:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of International Importance;
- Commonwealth Marine Areas;
- Listed Threatened Ecological Communities;
- Listed Threatened Species; and
- Listed Migratory Species.

Other matters protected by the EPBC Act:

- Commonwealth Land;
- Commonwealth Heritage Places;
- Listed Marine Species;
- Whales and Other Cetaceans;
- Critical Habitats;
- Commonwealth Reserves Terrestrial; and
- Commonwealth Reserves Marine.

Extra information:

- State and Territory Reserves;
- Regional Forest Agreements;
- Invasive Species;
- Nationally Important Wetlands; and
- Key Ecological Features (Marine).

The generated PDF report gives a link to the Resource Data, which was the publically available geospatial data (shapefiles) for each key area identified above. The Resource Data webpage for each dataset also provides metadata, such as an abstract on the data, acronyms and data structure, the creation and revision date, history and access constraints. This data was downloaded and incorporated into this assessment.

The EPBC Act PMST Report varies in some instances from the data incorporated in the report. This is likely due to the dataset being constantly updated and refined through fauna distribution and habitat surveys. The raw geospatial data was taken as the most up-to-date information, and used in this report.

2.2 Other Data Sources

Other data sources were those not publically available and also not in geospatial format. One example of this was information and ratings of beaches from Surf Life Saving WA. In this instance, beach popularity information was identified and a geospatial shapefile created for the beaches from a google maps location file.

2.3 Steering Committee Review of Data List

The geospatial layers outlined in Table 2-1 have been included in the assessment for the Pilbara zone. These data layers were provided to the Steering Committee for review on 14 May 2016, along with the geospatial attributes they represented (e.g. a list of all the protected species that were shown to fall in the Pilbara zone). Table 2-1 summarises the layers, their high level attributes, and when the data was last updated.

The Steering Committee was asked to review the data collected to date and indicate whether:

1. A more up-to-date dataset existed and where it could be sourced from;
2. There was considered to be a data gap and if an alternate source of information for this data existed; and
3. Any data was missing and possible sources for this data.

The data in Figure 1-2 has been grouped into the five categories: Protected Fauna; Protection Areas; Cultural Heritage; Economic; and Social, Amenity and Recreation. This is to facilitate identifying the type of area use that is being assessed.

Some datasets listed in Table 2-1 appear 'old', with a date more than a decade prior to this assessment, for example the Fish Habitat Protection Area (2001), the DotE Directory of Important Wetlands in Australia (2008), and the DoT Shipping and Pilotage Ports (2010). These datasets are not out of date; they reflect that the purpose and geospatial extents defined in the dataset have not changed.

Table 2-1: Data included in this assessment, custodians and data update information

Layer	Section	Data Source	Last Updated
Protected Fauna			
Birds Mammals Invertebrates Fish Reptiles	3.1.1 3.1.2 3.1.3 3.1.4 3.1.5	▪ Commonwealth Department of the Environment (DotE) Biologically Important Areas (BIA) for marine species ▪ DotE Species of National Environmental Significance (SNES) ▪ WA's Department of Parks and Wildlife (DPaW) for fauna ▪ WA's Department of Fisheries (DoF) Seasonally Protected and Totally Protected Fish	▪ 4 Jan 2016 ▪ 5 Oct 2016 ▪ 14 Oct 2016 ▪ Nov 2016
Protection Areas			
World Heritage Areas	3.2.1	▪ DotE World Heritage Areas	▪ 14 Oct 2015
Terrestrial Protection Areas	3.2.2	▪ DotE Collaborative Australian Protected Areas Database (CAPAD) – terrestrial ▪ DPaW CAPAD terrestrial dataset update ▪ Department of Defence lands	▪ 30 Jun 2014 ▪ Jun 2016 ▪ 15 Dec 2016
Marine Protection Areas	3.2.3	▪ DotE CAPAD – marine ▪ DPaW CAPAD marine dataset update	▪ 30 Jun 2014 ▪ Jun 2016
Ramsar and Nationally Important Wetlands	3.2.4	▪ DotE Ramsar Wetlands of Australia ▪ DotE Directory of Important Wetlands in Australia	▪ 16 Feb 2015 ▪ 15 Oct 2008
Key Ecological Features	3.2.5	▪ DotE Marine Key Ecological Features	▪ 16 Sep 2015
Coastal and Intertidal Habitats	3.2.6	▪ DoT Oil Spill Response Atlas (OSRA) WA shorelines Environmental Sensitivities Index (ESI) ▪ DPaW Marine Habitats ▪ Coastal and Marine Resources Information System (CAMRIS) Benthic Substrate dataset	▪ Apr 2011 ▪ May 2015 ▪ 23 Jan 2008
Coral, Seagrass, Algae and Filter Feeding Communities	3.2.7	▪ OSRA ESI – coral ▪ Coastal and Marine Resources Information System Seagrass ▪ DPaW Marine Habitats - algae	▪ Apr 2011 ▪ 10 Mar 2015 ▪ May 2015
Fish Habitat Protection Areas (FHPAs) and Fisheries Prohibited Areas	3.2.8	DoF Fish Habitat Protection Areas: ▪ DoF Fish Habitat Protection Areas: - Miaboolya Beach - Point Quobba ▪ DoF Closed waters – marine reserves	▪ 2 Mar 2016 ▪ 2 Mar 2016

Layer	Section	Data Source	Last Updated
Protected Areas for Aquaculture and Pearling	3.2.9	▪ Protection areas identified for pearling spat	▪ Dec 2007
Cultural Heritage			
World Heritage Properties	3.3.1	▪ DotE World Heritage Areas	▪ 15 Oct 2015
National Heritage	3.3.1	▪ DotE National Heritage List	▪ 11 Feb 2016
Commonwealth Heritage Places	3.3.1	▪ DotE Commonwealth Heritage – public	▪ 23 Feb 2016
State Protected Heritage	3.3.2	▪ State Register ▪ Conservation Orders ▪ Heritage Agreements ▪ Town Planning Scheme ('Heritage List') ▪ Municipal Inventory	▪ 10 Oct 2016 ▪ 10 Oct 2016 ▪ 10 Oct 2016 ▪ 10 Oct 2016 ▪ 10 Oct 2016
Shipwrecks and Maritime Archaeology	3.3.3	▪ DotE Australian National Shipwrecks ▪ WA Museum Recorded Shipwrecks	▪ 3 Feb 2016 ▪ 28 Jan 2016
Economic			
Aquaculture	3.4.1	▪ DoF Aquaculture Licences	▪ 9 Mar 2016
State Managed Commercial Fisheries	3.4.2	DoF individual shapefiles for each fishery: ▪ West Coast Deep Sea Crustacean ▪ Exmouth Gulf Prawn ▪ Exmouth Gulf Developing Crab ▪ Gascoyne Demersal Scalefish ▪ Onslow Prawn ▪ Nickol Bay Prawn ▪ Kimberley Gillnet and Barramundi ▪ Pilbara Trap ▪ Pilbara Fish Trawl ▪ Pilbara Line ▪ Northern Demersal Scalefish ▪ Mackerel Managed ▪ Pearl Oyster ▪ Beche-de-mer ▪ Pilbara Developmental Crab ▪ Marine Aquarium Fish ▪ Specimen Shell ▪ Land Hermit Crab ▪ Invertebrate Exemption	 ▪ 24 Mar 2015 ▪ 3 Jun 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 20 Apr 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 3 Jan 2013 ▪ 11 Sep 2015 ▪ 3 Jan 2013 ▪ 8 Nov 2012 ▪ 24 Mar 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 11 Sep 2015 ▪ 22 Aug 2015 ▪ 20 Apr 2015

Layer	Section	Data Source	Last Updated
Commonwealth Managed Fisheries	3.4.3	Australian Fishing Management Authority (AFMA):	
		▪ Western Tuna and Billfish	▪ Mar 2016
		▪ Western Skipjack	▪ Mar 2016
		▪ Southern Bluefin Tuna	▪ Mar 2016
Other Commercial Operations	3.4.4	▪ None identified	▪ N/A
Tourism	3.4.7	▪ Tourism WA	▪ Aug 2016
Ports and Shipping	3.4.6	▪ DoT Shipping and Pilotage Ports	▪ 25 Oct 2010
		▪ Landgate Port Authorities	▪ 23 Nov 2016
Water Intake Locations	3.4.7	▪ DoT Water Intake Location	▪ 17 Dec 2012
		▪ DoF Water Intake Locations	▪ 12 Dec 2016
Social, Amenity and Recreation			
Recreational Fishing/Boating Zones	3.5.1	▪ DotE CAPAD – marine	▪ 30 Jun 2016
Beaches	3.5.2	▪ Surf Life Saving WA beach popularity information	▪ May 2016
		▪ Department of Planning – Town location and population size	▪ Nov 2016
		▪ Beaches listed on Tourism's 'Australia's Best Beaches' list	▪ Feb 2016
		▪ DPaW Yacht clubs, jetties, marinas	▪ 2 Nov 2016
		▪ DMP Coastal Landforms dataset	▪ May 2016

2.4 Data Cut-Off and Summary of Inclusion

The Steering Committee's initial review of the data list for the Pilbara zone was intended to identify all additional data layers. A cut-off date of 2 May 2016 was applied in order to allow time to run the processing and provide an output for the Workshop Discussion Paper. A number of additional datasets were also identified in the Steering Committee workshop on 16 May 2016, and a final data cut-off date of 1 July 2016 was applied to produce the final report in August 2016.

With the state-wide overview assessment and re-ranking method adopted to more clearly indicate the key areas for protection priority, this final report for the Pilbara has been updated to include additional datasets that have been identified.

In the future, it is anticipated that when the other zones are assessed over the next two to five years, additional datasets may become available for the Pilbara zone as well as other zones. When the final zone has been completed, it may be advisable to review the early zones to assess the need to include additional datasets.

2.5 Data Excluded

During assessment of the Pilbara zone, the following datasets were identified but have been excluded for the reasons described below. This precedent has been and will continue to be carried into the remaining zones.

1. State Protected Indigenous Cultural Heritage

The WA Department of Aboriginal Affairs (DAA) holds a list of Aboriginal Heritage places protected or assessed under the WA *Aboriginal Heritage Act 1972*. The Aboriginal Heritage Inquiry System details the location and extent of each place protected under the Act. To preserve confidentiality, the exact location and extent of some places are not displayed on the map; however a shaded region (usually with an area of at least 4 km^2) indicates where the place is generally located.

During the Steering Committee Workshop on 16 May 2016 for the first zone assessed (this Pilbara zone), it was raised that the DAA list is largely incomplete, as it only identifies areas that have been registered through Native Title Determinations. It was agreed to remove the dataset to avoid the false impression that this sensitivity is covered.

In the absence of state-specific protection priority data for each shoreline cell, DoT would need to consult with the DAA independently in the event of an oil spill. This precedent is being carried through to the remainder of the zones being assessed.

2. Coastal Landforms

To supplement the OSRA ESI dataset, the WA State Department of Mines and Petroleum (DMP) Coastal Landforms dataset was identified for incorporation into this assessment. On review of the dataset, it was determined that it didn't add any value in identifying coastline portions needing protection (Protection Areas), so it was omitted. This was because of the difficulty associated with assigning a protection priority where the dataset is not consistent in its interpretation of sandy/rocky and inundated shoreline areas.

The Coastal Landforms dataset was however used to identify and include potential recreation beaches in the Social, Amenity and Recreation category. This is because there was no other beach data available for the Pilbara.

3. Oil and Gas Operators

A number of oil and gas operations occur in WA state waters and near the coast, including subsea pipelines. Subsea pipelines were not evaluated as a protection priority as their operation is not expected to be affected in an oil spill. Facilities that operate in state waters may experience economic loss through a safety requirement to shut facilities if an unrelated oil spill enters their operational zone.

Offshore oil and gas facilities have not been included as they do not fall in the shoreline cells, however if they do operate in the zone, their associated infrastructure aspects are included. Associated infrastructure includes port facilities and seawater intakes. Refer to Section 3.4.4 and Section 3.4.5.

3 Ranking of Protection Priorities

Each of the sensitive receptors has been given a classification from Very Low to Very High in order to rank their protection priority in the event of an oil spill, for comparison between the sensitivities (Table 3-1). The rankings have a numerical value as well as a classification. The gradation in this ranking has been selected to balance the relative importance of aspects being ranked. Five levels have been deemed appropriate for relative ease of ranking each of the sensitivities.

When assigning a ranking, a key consideration was whether the sensitivity was *vulnerable* and/or *sensitive* to a marine oil spill. These considerations of how vulnerable the receptor may be to floating or dissolved oil, as well as how sensitive it is, have been included below for each receptor. This was critical to assigning correct rankings for the purposes of the project. For example, coral is highly *sensitive* to marine oil; however if the oil is floating on the surface of the sea and it is a calm day, then the coral is not as *vulnerable* to the oil, as the oil will pass above the coral and not affect it. If the oil was dissolved in the water column, then the coral would be *vulnerable* to it. These considerations of different states of vulnerability have been reflected in the occasional differences between the rankings for floating and dissolved priorities.

Additionally, the information provided in the datasets themselves has been incorporated when allocating protection priority rankings. For example, data confidence, reliability, accuracy and geospatial extent have been included in some instances where this information is available, in order to correctly reflect the key areas that require priority.

Table 3-1: Protection priority ranking

Protection Priority	Ranking
Very High	5
High	4
Medium	3
Low	2
Very Low	1

There were many discussions held in the Steering Committee Workshop (see Section 1.5) regarding these points, and the overall consensus of rankings as agreed with the committee are reflected in the rankings in this report. These rankings also reflect the revised rankings proposed as an outcome of the State Wide Overview assessment, which have been reviewed and endorsed by the core Steering Committee.

3.1 Protected Fauna

Australia's shoreline is home to a vast number of fauna, many of which are endemic to Australia, and some species are of international, regional and local importance. In WA, threatened fauna are protected under Commonwealth and State legislation as well as International agreements, and are listed under the International Union for Conservation of Nature (IUCN) Red List. Key legislation includes:

- Commonwealth EPBC Act which includes nationally significant fauna, and fauna protected under the following international agreements:
  - Japan and Australia Migratory Bird Bilateral Agreement (JAMBA) 1974;
  - China and Australia Migratory Bird Bilateral Agreement (CAMBA) 1986; and
  - Republic of Korea and Australia Migratory Bird Bilateral Agreement 2007.
- Western Australian *Wildlife Conservation Act 1950* (WC Act) which includes fauna of regional and local significance to the state.

The protection priority rankings include the method developed during the initial assessment of the Pilbara zone, which includes assessing the threatened status of a species listed under both the EPBC Act[1] and the WC Act[2], and using whichever is highest. The ranking also takes into account the biological importance of an area to a species, the possible long term consequences the spill can have at a species level, as well as the threatened status of a species.

The BIAs for species were used in this assessment because some fauna are more susceptible to being affected by a marine oil spill during different phases of their lifecycle. For example, breeding areas were given the highest importance, while roosting (in the case of birds), feeding and migrating areas were given lower levels of importance, as the likelihood of a bird coming into contact with the oil and the likely effects of oiling decreased during these activities. Similarly, the likelihood of a whale being affected during feeding and migrating is lower than when it is active in its breeding and aggregation areas with its young.

The datasets used for the Protected Fauna category provided the opportunity to incorporate data confidence, reliability, accuracy and geospatial extent into the rankings. These are described in the tables for each fauna type in the sections below. In general, for the SNES data, species that are 'known', 'likely' and 'may be' in an area are given different weightings, with 'known' the highest and 'may be' the lowest. For the DPaW fauna data, the survey method and certainty of identification were used to distribute the weightings (e.g. caught, trapped or sighted and 'Very Certain, 'Western Australian Museum (WAM) Vouchered' or 'Certain', which are provided in the dataset and give the

[1] The EPBC Act has six conservation categories, three of which have been used in this assessment. The six categories are Extinct, Extinct in the Wild, Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Conservation Dependent (CD). Only CR, EN and VU have been used in this assessment. Extinct and Extinct in the Wild were omitted as, of the seven species listed as Conservation Dependent, these are all fish and no key data was located for these species.

[2] Under the WC Act 11 conservation categories exist. In addition to those listed in the EPBC Act, there are six more used, including CD. The other five are Other specially protected fauna (OS), and Priority species, listed as P1 to P4. For a definition of these please see: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf

highest confidence, while 'secondary signs' and 'fossil' were the lowest along with 'not sure' and 'not defined'.

The process does not exclude species from being responded to if they are not formally protected; all fauna will be responded to in an oil spill event. The process used in this assessment identifies the areas of greatest priority where there are known areas of significant fauna requiring protection.

The ranking also takes into account the effect oil can have on the fauna type. For example, where birds are able to be greatly impacted by oil, whales are less likely to be affected at an individual level due to a number of factors.

Terrestrial fauna has been ranked on the basis of their verified use of the coastal zone. In this context, the coastal zone is defined as the area of the sea, including the water up to the high water mark which includes the intertidal zone and the debris beach habitat (e.g. dried seagrass).

In all zones, the terrestrial fauna data was interrogated further, including a review of all birds, mammals, reptiles and invertebrates data. The fauna habitat information from secondary credible sources was evaluated to determine if they spend any part of their lifecycle in the coastal zone. The secondary sources evaluated included the Species Profile and Threats (SPRAT) database (http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl), Commonwealth and State Recovery Plans (http://www.environment.gov.au/biodiversity/threatened/recovery-plans, https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals) and published EPA reports and records (http://www.epa.wa.gov.au/).

Any fauna which was found to use the coastal zone kept its ranking according to classification, habitat use and record certainty. Any fauna which was found to not use the coastal zone was given a ranking of Very Low for both floating and dissolved oil. This ranking was assigned because the fauna is highly unlikely to be impacted by an oil spill as it does not use the coastal zone; by giving it the lowest ranking possible, the data is still considered in the assessment but does not influence the planning of an oil spill response.

This is discussed more in the sections below.

3.1.1 Birds

Description

WA has an enormous number and diversity of bird species. Almost 550 species of birds have been recorded in the state; 387 of these species have been recorded breeding (Birdlife WA, 2016). 17 of these species are endemic to Western Australia, while many others migrate annually to feed, breed and escape the northern winter. The Pilbara zone is home to approximately 143 species, with 50 of these different species formally protected. The zone plays an important role in providing habitat for both endemic species and migratory birds which are protected under JAMBA and CAMBA.

Bird distribution, species and conservation status (legislated) data was obtained as discrete observation locations from the DPaW's NatureMap database, the DotE Species of National Environmental Significance (SNES) dataset, and generalised distribution polygon information from the DotE Biologically Important Areas (BIA) database.

Key bird species in the Pilbara zone include two Critically Endangered (CR) birds: the curlew sandpiper (*Calidris ferruginea*) and the eastern curlew (*Numenius madagascariensis*); Endangered (EN) birds: southern giant petrel (*Macronectes giganteus*), lesser sand plover (*Charadrius mongolus*) and the Hutton's shearwater (*Puffinus huttoni*); and many Vulnerable (VU) species including the red knot (north-eastern Siberia) (*Calidris canutus rogersi)*, great knot (*Calidris tenuirostris*), Barrow Island black and white fairy-wren (*Malurus leucopterus edouardi*) and Australian fairy tern (*Sterna nereis nereis*). There are also numerous more migratory (IA) species such as the broad-billed sandpiper (*Limicola falcinellus sibiricus*) and the greater sand plover (*Charadrius leschenaultia*) as well as one Priority 4 (P4) species, the grey-tailed tattler (*Tringa brevipes*), and an Other Specially Protected (OS) species, the peregrine falcon (*Falco peregrinus*).

Distribution

The CR curlew sandpiper is known to occur in isolated locations at offshore islands in Shoreline Cells 317 and 318, in the Dampier Archipelago (Shoreline Cells 103 and 106), and in Shoreline Cells 99, 93 and 94 at the east of the Pilbara zone. They are also likely to occur in other locations along the east of the Pilbara near Port Hedland. The CR eastern curlew is more widely distributed along the Pilbara coastline, both from surveys and moderately certain observations. The EN lesser sand plover is also moderately certain from observational data throughout the eastern end of the Pilbara zone, however there are confirmed sightings in the Ningaloo Marine Park area (DPAW, 2015).

Discussion

The bird protection priority ranking considers both the ranking outlined in the WA Pilbara Regional Oiled Wildlife Response Plan (PROWRP) and the threatened status of a species. For the threatened status of a species, its highest priority listing under either the EPBC Act or the WC Act has been used. This is because while some species may not be threatened on a national level, they could be on a state level. The two protection statuses have been compared and whichever is highest has been used. This process ensures species that are protected only at a state level under the WC Act are included in the assessment.

Oiling can have a major impact on birds (French-McCay *et al*., 2002; 2004; 2006). When oiled, bird feathers lose their waterproofness and their insulation which can lead to hypothermia, dehydration, drowning and starvation. Birds coming into contact with oil on the surface will be significantly affected, so floating oil was deemed to have a greater effect on birds than dissolved oil. Birds can also be poisoned via secondary means such as ingestion through preening, or feeding on contaminated prey such as benthic invertebrates.

The rankings also consider the biological importance of an area to the bird species, elevating the priority of an area that could contain high numbers for that species, and for activities associated with breeding and aggregation (such as roosting), which is when birds are considered the most vulnerable. This reflects the possible long term consequences the spill can have at a species level if a spill occurred at critical breeding sites during breeding season.

The rankings also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent. These are included in the protection priority rankings in Table 3-2.

Table 3-2: Bird protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Birds			
Critically Endangered species, if: ▪ Breeding, nesting, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	5	4	**Species considered:** All SNES listed birds, State protected species on the DPaW database, and DotE species listed as having BIAs in the area. **Importance:** Birds that have a higher threatened status were ranked higher. The BIAs considered to be the most important/vulnerable for birds are breeding/nesting habitats, while all other areas including foraging, migration and resting areas were ranked as 'known habitat' and given a lower importance. This is to reflect the higher vulnerability of a bird during nesting, including the vulnerability of its young, and also the aggregation of the birds in certain areas during these times.
Critically Endangered species, if: ▪ Breeding, nesting, aggregation or translocated population Likely to occur ▪ Migration route, foraging, roosting, species or species habitat Known to occur ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, nesting, aggregation or translocated population Known to occur ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	4	3	
Critically Endangered species, if: ▪ Migration route, foraging, roosting, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/ WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, nesting, aggregation or translocated population Likely to occur or low density in area ▪ Migration route, foraging, roosting, species or species habitat Known to occur in the area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, nesting, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM	3	2	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Vouchered/Certain			
Critically Endangered species, if: ▪ Migration, connecting habitat and unknown, significant habitat Known to occur, high density ▪ Distribution, resting, nesting or foraging Likely to occur/low density ▪ Distribution, known core range and foraging May occur ▪ Breeding and aggregation Former Range ▪ Dead Very Certain/WAM Vouchered ▪ Hair/skin or unknown method Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Distribution (low density), resting, nesting or foraging Likely, inter-nesting buffer or Known to occur ▪ Migration route, foraging, roosting, distribution, known core range, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/ WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, nesting, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, roosting, species or species habitat Known to occur in the area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Conservation Dependent, Other specially protected fauna and P1-P4 species, if: ▪ Breeding, nesting, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	2	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Critically Endangered species, if: ▪ Extinct in area, dead, fossils, subfossil or historical record All Endangered, Vulnerable and Other species with a conservation code with all other information.	1	1	
Terrestrial birds which do not use the intertidal zone for any instance of their lifecycle, and do not use the coastal/intertidal zone as any component of their habitat.	1	1	This is researched through two sources which cite no use of the coastal/intertidal zone, one of which is SPRAT.

Data List

- DotE Species of National Environmental Significance (SNES)
- DPaW Protected Fauna
- DotE Biologically Important Areas (BIAs)

3.1.2 Mammals

Description

Western Australia's coastline spans more than 13,500 km and is home to some of the world's most interesting marine and terrestrial mammals. Many are found nowhere else in the world.

Mammal distribution, species and conservation status (legislated) data was obtained as discrete observation locations from the DPaW's NatureMap database, the DotE Species of National Environmental Significance (SNES) dataset, and generalised distribution polygon information from the DotE Biologically Important Areas (BIA) database.

Marine mammals that frequent the Pilbara zone include the EN pygmy blue whale (*Balaenoptera musculus brevicauda*), VU humpback whale (*Megaptera novaeangliae*) the VU southern right whale (*Eubalaena australis*), the OS dugong (*Dugong dugon*) and the P4 Indo-Pacific humpback dolphin (*Sousa sahulensis*).

The coast of the Pilbara is home to the EN black-flanked rock wallaby (*Petrogale lateralis lateralis*), EN northern quoll (*Dasyurus hallucatus*), VU Barrow Island golden bandicoot (*Isoodon auratus barrowensis*), VU Barrow Island wallaroo (*Macropus robustus isabellinus*), and VU and translocated population of Djoongari (*Pseudomys fieldi*).

Distribution

The EN pygmy blue whale has been recorded along the Pilbara coastline, as has the VU humpback whale. The humpback whale however has known resting areas where they congregate with their calves during migration. This occurs in Shoreline Cells 116 to 121, 327 and 328. The VU southern right whale tends to occur further offshore and has only been recorded as sighted in Shoreline Cell 325. The OS dugong is known to breed, forage, calve, nurse and congregate continuously along the nearshore areas from the Dampier Archipelago to the southern end of Ningaloo reef

(Shoreline Cells 112 to 129) inclusive, as well as along the offshore islands (Shoreline Cells 316 to 329). The VU Indo-Pacific humpback dolphin has also been surveyed to occur in the same area as the dugong.

Terrestrial mammals such as the black-flanked rock wallaby are known to occur throughout the Pilbara, with the northern quoll found mainly east of Karratha in the central Pilbara zone. Several species of protected terrestrial mammals are found only on individual islands off the Pilbara coast, like the Barrow Island golden bandicoot and Barrow Island wallaroo.

Discussion

Marine mammals in the Pilbara zone could come in direct contact with floating oil, or potentially ingest hydrocarbons that are dissolved. Physical oiling can burn and irritate eyes of whales and sea lions. The highest likelihood of cetaceans being affected occurs when the mammal becomes coated in oil while surfacing to breathe. Cetaceans may also ingest dissolved oil when feeding in open water, however due to the higher impact associated with direct contact at the surface, floating oil is deemed to have a greater impact on mammals than dissolved oil.

Terrestrial-based mammals such as the EN black-flanked rock wallaby exist in scattered populations restricted to sites with suitable rocky habitat with caves and crevices (DoEE, 2017). A review of the available information for the black-flanked rock wallaby indicates that it does not forage, nest or breed in the coastal zone. It is therefore unlikely to be impacted by an oil spill and is ranked Very Low for protection from floating and dissolved oil. The black-flanked rock wallaby is found in Shoreline Cell 322, which is ranked higher for other protection priorities found in that cell.

The EN northern quoll is found in Shoreline Cells 101, 104 to 105 and 108. Northern quolls do not have highly specific habitat requirements. They occur in a variety of habitats across their range. They are opportunistic foragers that feed on a broad range of items, switching dietary resources according to season and availability. Daytime den sites provide northern quolls with important shelter and protection from predators and weather. However, shelter sites are also non-specific; rocky outcrops, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings have all been recorded. Northern quolls are opportunistic omnivores, consuming a wide range of prey including beetles, grasshoppers, spiders, scorpions and centipedes. They also eat fruit, nectar, and are known to feed on carrion and human refuse. In savannah, their diet usually includes invertebrates, particularly beetles, grasshoppers, spiders and centipedes, but they also eat fruits of at least nine species of plants, particularly favouring the wild grape *Ampelloccissus acetose* (Oakwood, 2008). Vertebrates eaten include 11 species of mammal (e.g. bandicoots, sugar gliders, brush-tail possums and rats), eight species of birds (e.g. brown quail), reptiles (skinks and snakes) and seven species of frog. They also eat bird eggs and nectar of eucalypt and grevillea flowers (Oakwood, 2008). Northern quolls will also scavenge from road kills and garbage bins (Oakwood, 2008 in DoEE, 2017). Based on the information reviewed, it is clear that while the island populations in the Pilbara zone are significant habitat for the northern quoll, the species does not forage, nest or breed in any part of the coastal zone. It is therefore unlikely to be impacted by an oil spill and is ranked Very Low for protection from floating and dissolved oil. The shoreline cells where the northern quoll is found are ranked higher for other protection priorities found in these cells.

The EN Barrow Island golden bandicoot is a small golden-brown marsupial. It previously occurred throughout central Australia, but is now restricted to Barrow Island (*Isoodon auratus barrowensis*) and the Kimberley (offshore islands and the mainland) and Marchinbar Island (offshore Arnhem Land) (Isoodon auratus auratus). During the day it rests in dense vegetation or other shelter.

During the night it forages by digging for succulents, invertebrates and plant roots (DoEE, 2017). Like other peramelids, the golden bandicoot is omnivorous. From scat analyses (Southgate *et al*., 1996; Palmer *et al*., 2003), the diet of the bandicoot comprises mainly beetles and ants but includes cockroaches, spiders, centipedes and plant material (Palmer *et al*., 2003). Based on the information reviewed, it is clear that while the island populations in the Pilbara zone are significant habitat for the Barrow Island golden bandicoot, the species does not forage, nest or breed in any part of the coastal zone. It is therefore unlikely to be impacted by an oil spill and is ranked Very Low for protection from floating and dissolved oil. The shoreline cells where the Barrow Island golden bandicoot is found are ranked higher for other protection priorities found in these cells.

The EN Barrow Island wallaroo occurs mainly in the deeply dissected country in the central west of Barrow Island, along coastal fringes where low cliffs provide shade and in flood-out flats where grasses other than Triodia dominate (Short & Turner, 1991). The Barrow Island wallaroo is reported to feed on growing flower stalks of Triodia (Short & Turner, 1991 in DoEE, 2017). Based on the information reviewed, it is clear that while the island populations in the Pilbara zone are significant habitat for the Barrow Island wallaroo, the species does not forage, nest or breed in any part of the coastal zone and it is therefore unlikely to be impacted by an oil spill and is ranked Very Low for protection from floating and dissolved oil. Shoreline Cell 119 where the Barrow Island wallaroo is found is ranked higher for other protection priorities found in this cell.

The VU Djoongari inhabits coastal dune vegetation dominated by beach spinifex (*Spinifex longifolius*) and coast daisy bush (*Olearia axillaris*). The Djoongari is vegetarian/omnivorous, and feeds mainly on petals, flowers and insects (DPaW, 2000). Djoongari do not appear to use burrows as commonly as most other Pseudomys species. They are known to construct tunnels and runways in heaps of seagrass piled up on Bernier Island beaches during winter storms (Robinson, 1983), and use above ground nests as diurnal refuges. Burrows are used more during the breeding season (Morris and Speldewinde, 1992). Animals translocated to Doole Island use hollows located above the high water level in mangrove (Avicennia marina) trees as well as sites among rocks and under Triodia for daytime refuges. It is found in Shoreline Cell 119, however given the information reviewed, it is clear that the Djoongari does not use or forage in the coastal zone and therefore is ranked Very Low priority for protection from floating and dissolved oil. The shoreline cell is ranked higher for other protection priorities found in that cell.

Marine mammals whose habitat falls in the spatial extent of the shoreline cells were deemed to have a presence in this environment, and their conservation category was used to determine the ranking for floating and dissolved impact on their shoreline habitat. Marine mammal priority ranking is based on the above, and as with all other fauna rankings, the key biologically important behaviours such as breeding and aggregation areas for whale calves are shown in Table 3-3.

The rankings in Table 3-3 also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent.

Table 3-3: Mammal protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Mammals			
Critically Endangered species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	5	4	**Species considered:** All SNES listed mammals, State protected species on the DPaW database, and DotE species listed as having BIAs in the area. **Importance:** Mammals that have a higher threatened status were ranked higher. The BIAs considered to be the most important/ vulnerable for mammals are breeding/ aggregation/resting areas due to the presence of large numbers of a species, or the presence of calves and juvenile mammals, while all other areas including foraging and migration areas were ranked as 'known habitat' and given a lower importance.
Critically Endangered species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Likely to occur ▪ Migration route, foraging, species or species habitat Known to occur ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Known to occur ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	4	3	
Critically Endangered species, if: ▪ Migration route, foraging, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Likely to occur or low density in area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, calving buffer, interesting, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, calving, congregation, aggregation	3	2	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain			
Southern right whale: all calving information. Critically Endangered species, if: ▪ Migration, connecting habitat and unknown, significant habitat Known to occur, high density ▪ Distribution or foraging Likely to occur/low density ▪ Distribution, calving buffer, known core range and foraging May occur ▪ Breeding, calving and aggregation Former Range ▪ Dead Very Certain/WAM Vouchered ▪ Hair/skin or unknown method Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Distribution (low density), resting, nesting or foraging Likely, Known to occur ▪ Migration route, foraging, distribution, calving buffer, known core range, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/ WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Likely to occur or low density in area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, calving buffer, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Conservation Dependent, Other specially protected fauna and P1-P4 species, if: ▪ Breeding, calving, congregation, aggregation or translocated population Known to occur in the area	2	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain			
Critically Endangered species, if: ▪ Extinct in area, dead, fossils, subfossil or historical record ▪ All Endangered, Vulnerable and Other species with a conservation code with all other information	1	1	
Terrestrial mammal species which do not use the intertidal zone for any instance of their lifecycle, and do not use the coastal/intertidal zone as any component of their habitat.	1	1	This is researched through two sources which cite no use of the coastal/intertidal zone, one of which is SPRAT.
Data List ▪ DotE Species of National Environmental Significance (SNES) ▪ DPaW Protected Fauna ▪ DotE Biologically Important Areas (BIAs)			

3.1.3 Invertebrates

Description

Invertebrates are all animals that lack a backbone. They include marine invertebrates such as crustaceans, coral, sponges, jellyfish and octopus (to name a few), as well as terrestrial invertebrates such as snails, bees and spiders. WA is home to numerous invertebrate species, however no marine invertebrates found in state waters are legislatively protected. While coral is an invertebrate, it is included under Protection Areas as a key benthic habitat (refer to Section 3.2).

Invertebrate distribution, species and conservation status (legislated) data was obtained as discrete observation locations from the DPaW's NatureMap database, the DotE Species of National Environmental Significance (SNES) dataset, and generalised distribution polygon information from the DotE Biologically Important Areas (BIA) database.

Several protected invertebrate species were identified in the Pilbara zone, most of which are VU. However, most have not been included in the assessment because they are subterranean fauna which would not be impacted in an oil spill, for example the *Kumonga exleyi* or Cape Range Remipede and the *Stygiocaris stylifera*. Other species not included are the Barrow Island specific troglobites such as the VU *Draculoides bramstokeri* and VU *Nedsia urifimbriata*.

Included species is the VU Barrow Island millipede (*Speleostrophus nesiotes*).

Distribution

The Cape Range remipede is known only from a single remote anchialine (submerged) cave on the Cape Range Peninsula of Western Australia, located on a coastal plain, 1.7 km inland from the Indian Ocean (Black *et al*., 2001; Yager & Humphreys, 1996). The cave is not linked to the ocean and would not be impacted from a marine oil spill. This is also the case with the *Stygiocaris stylifera*, also found in underground caves of the Cape Range Peninsula.

The VU Barrow Island millipede is only found on Barrow Island, in Shoreline Cells 320 and 321.

Discussion

As some protected terrestrial invertebrates have habitats along the coast, a protection priority ranking has been adopted for terrestrial invertebrates only. The effect on terrestrial invertebrates such as snails, moths, spiders and bees is expected to be fatal if an oil spill washes up on shore and coats their habitat. Dissolved oil will have no effect.

The VU Barrow Island millipede found in Shoreline Cells 320 and 321 was identified from specimens collected at more than 15 m depth. The genus is represented by a single troglomorphic species endemic to the subterranean karst ecosystems of Barrow Island (Car *et al*., 2013). The species therefore does not use the coastal zone for its habitat or for foraging, and is deemed to have a ranking of Very Low for protection from floating and dissolved oil.

The rankings also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent. The protection priority rankings adopted for this assessment are presented in Table 3-4.

Table 3-4: Terrestrial Invertebrate protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Terrestrial Invertebrates			
Critically Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain	5	1	**Species considered:** No marine invertebrates found in WA state waters are legislatively protected. Therefore, all SNES listed terrestrial invertebrates, State protected species on the DPaW database, and DotE species listed as having BIAs in the area. **Importance:** Terrestrial invertebrates may be in the area and tend to be concentrated in highly localised areas. In the event of an oil spill, their coastal habitats may become oiled and this is expected to be fatal. Dissolved oil is not expected to have an impact. Invertebrates that have a higher threatened status were ranked higher. The BIAs considered to be the most important/vulnerable for invertebrates are breeding/nesting habitats, while all other areas including foraging and migration areas were ranked as 'known habitat' and given a lower importance. This is to reflect the higher vulnerability of an invertebrate during breeding,
Critically Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur ▪ Migration route, foraging, species or species habitat Known to occur ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain	4	1	
Critically Endangered species, if: ▪ Migration route, foraging, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the	3	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain			including the vulnerability of its young, and also the aggregation of the species in certain areas during these times.
Critically Endangered species, if: ▪ Migration, connecting habitat and unknown, significant habitat Known to occur or high density ▪ Distribution, nesting or foraging Likely to occur/low density ▪ Distribution, known core range and foraging May occur ▪ Breeding and aggregation Former Range ▪ Dead Very Certain/WAM Vouchered ▪ Hair/skin or unknown method Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Distribution (low density), nesting or foraging Likely or Known to occur ▪ Migration route, foraging, distribution, known core range, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Conservation Dependent, Other specially protected fauna and P1-P4 species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	2	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Critically Endangered species, if: ▪ Extinct in area, dead, fossils, subfossil or historical record All Endangered, Vulnerable and Other species with a conservation code with all other information.	1	1	
Terrestrial invertebrate species which do not use the intertidal zone for any instance of their lifecycle, and do not use the coastal/intertidal zone as any component of their habitat.	1	1	This is researched through two sources which cite no use of the coastal/intertidal zone, one of which is SPRAT.

Data List

- DotE Species of National Environmental Significance (SNES)
- DPaW Protected Fauna
- DotE Biologically Important Areas (BIAs)

3.1.4 Fish

Description

Western Australia is home to more than 1,600 fish species. Many are fished for commercial and recreational purposes, but also collected for home and international aquariums.

Fish species, distribution and conservation status (legislated) data was obtained as discrete observation locations from the DPaW's NatureMap database, the DotE Species of National Environmental Significance (SNES) dataset, and generalised distribution polygon information from the DotE Biologically Important Areas (BIA) database. Information on Totally Protected fish species is sourced from the DoF, however this is not accompanied by geospatial data so the location of species has been drawn from the three previously mentioned geospatial databases.

Protected fish in the Pilbara zone include the VU blind gudgeon (*Milyeringa veritas*). Protected fish also includes sharks, with species found in the Pilbara zone including the VU whale shark (*Rhincodon typus*), the VU great white shark (*Carcharodon carcharias*) and the VU grey nurse shark (*Carcharias taurus*). It also includes river sharks such as the VU green sawfish (*Pristis zijsron*), VU freshwater sawfish (*Pristis microdon*) and the dwarf sawfish *(Pristis clavata*).

'Totally protected' fish and 'seasonally protected, totally protected' fish species, protected under the *State Fish Resources Management Act 1994*, have also been included in this section. In the Pilbara zone, this includes the whale shark.

It's worth noting here that fish habitat protection areas are included in the Protection Areas category, in Section 3.2.8. Also, fishing areas associated with economic and tourism enterprise are included in the Economic category in Section 3.4.

Distribution

The VU blind gudgeon is present mainly along the western edge in the Ningaloo Marine Park area. The VU whale shark is known to occur along the Ningaloo coast, foraging and feeding in Shoreline Cells 123 to 126. It may occur elsewhere along the Pilbara zone coastline. The great white shark is in three areas: it is known to occur off Ningaloo from Shoreline Cells 122 southwards to Shoreline Cell 131; it is likely to occur in the Exmouth Gulf (Shoreline Cells 116 to 122); and also around the Muiron and other offshore islands in the area (Shoreline Cells 326 to 329). It may occur elsewhere in the Pilbara. The VU grey nurse shark is known to occur off the North West Cape, including the waters off Ningaloo. It is likely to be found inshore in closer waters of Shoreline Cells 105 to 121, including all the offshore islands in this area (Shoreline Cells 318 to 329), but is not found east or north of the Dampier Archipelago.

The VU green sawfish is known to occur along the entire Pilbara coastline, out to the 200 m isobath. It is also likely to be found breeding in the nearshore areas throughout the Pilbara zone (all shoreline cells). The VU dwarf sawfish is known to occur from the tip of the North West Cape east, throughout the Pilbara zone. It is also known to breed in Shoreline Cell 88, and is likely to breed at isolated locations along the shoreline in some river systems.

Discussion

Fish are affected by hydrocarbons through physical smothering impacting on physiological functions, or by chemical toxicity causing lethal or sub-lethal effects or impairing cellular functions. The worst impacts will occur through chemical toxicity effects on smaller species such as pipefish. This could lead to accumulation of hydrocarbons in tissues, and in the worst instance could lead to mortality or sub-lethal stress.

The species conservation category and its use of the area, such as breeding or aggregation areas, versus ‘normal range’, were used to determine its ranking presented in Table 3-5. The rankings also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent.

Table 3-5: Fish protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Fish			
Critically Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	4	5	**Species considered:** All SNES listed fish, State protected species on the DPaW database, and DotE species listed as having BIAs in the area. **Importance:** Fish that have a higher threatened status were ranked higher. The BIAs considered to be the most important/vulnerable for fish are breeding/ aggregation habitats, as oil will have more of an effect on juvenile fish, while all other areas including foraging and normal range areas were ranked as 'known habitat' and given a lower importance.
Critically Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur ▪ Migration route, foraging, species or species habitat Known to occur ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	3	4	
Critically Endangered species, if: ▪ Migration route, foraging, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the	2	3	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain			
Critically Endangered species, if: ▪ Migration, connecting habitat and unknown, significant habitat Known to occur, high density ▪ Distribution or foraging Likely to occur/low density ▪ Distribution, known core range and foraging May occur ▪ Breeding and aggregation Former Range ▪ Dead Very Certain/WAM Vouchered ▪ Hair/skin or unknown method Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Distribution (low density) or foraging Likely or Known to occur ▪ Migration route, foraging, distribution, known core range, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Conservation Dependent, Other specially protected fauna and P1-P4 species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain	1	2	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Critically Endangered species, if: ▪ Extinct in area, dead, fossils, subfossil or historical record All Endangered, Vulnerable and Other species with a conservation code with all other information.	1	1	
Freshwater fish species which do not use the intertidal zone for any instance of their lifecycle, and do not use the coastal/intertidal zone as any component of their habitat.	1	1	This is researched through two sources which cite no use of the coastal/intertidal zone, one of which is SPRAT.

Data List

- DotE Species of National Environmental Significance (SNES)
- DPaW Protected Fauna
- DotE Biologically Important Areas (BIAs)

3.1.5 Reptiles

Description

Western Australia's marine and coastal environment contains unique, diverse and fragile ecosystems and species – from tropical waters in the north, to temperate waters in the south. Reptile distribution, species and legislated protection classification data was obtained as discrete observation locations from the DPaW's NatureMap database. This data is contained in the SNES dataset obtained from DotE, and generalised distribution polygon information is obtained from the Biologically Important Areas (BIA) database.

Reptiles found in the Pilbara zone include the CR short-nosed sea snake (*Aipysurus apraefrontalis*), the EN loggerhead turtle (*Caretta caretta*), VU flatback turtle (*Natator depressus*), VU hawksbill turtle (*Eretmochelys imbricata*), EN leatherback turtle (*Dermochelys coriacea*) and the VU green turtle (*Chelonia mydas*). Terrestrial reptiles include the VU Airlie Island ctenotus (*Ctenotus angusticeps*), EN Nevin's three-toed slider (*Lerista nevinae*) and the P3 Cape Range slider (*Lerista allochira*).

Distribution

The CR short-nosed sea snake is likely to be found throughout the Pilbara zone, from the Exmouth Gulf to the north and east, predominantly in water less than 50 m deep. There is one known location in the Exmouth Gulf, but this falls outside of any shoreline cells. Further offshore of the 50 m isobath, these species may occur.

The EN loggerhead turtles are known to occur in all Shoreline Cells except 88, 97, 98 and 99. The species is known to breed and aggregate on and near beaches in the Dampier Archipelago, in Shoreline Cells 105, 106 and 107 as well as 316 and 317. Other known congregation and breeding areas include Barrow and Montebello Islands (Shoreline Cells 318 to 321) and the Ningaloo Marine Park (Shoreline Cells 121 to 128).

The VU flatback turtle is known to congregate in waters throughout the Pilbara zone. It also breeds on the beaches throughout the zone. The VU hawksbill, EN leatherback and VU green turtle species are known to occur in very similar locations to the EN loggerhead, known to occur throughout the Pilbara, with known breeding and aggregation areas focussing on the same beaches and shoreline cells described above.

The VU Airlie Island ctenotus may occur on the beaches from Shoreline Cell 88 to 114. It is likely to occur in scattered locations of Shoreline Cells 93, 94, 95, 96, 98, 106, 108, 111 and 112. The only location where this is known to occur is Airlie Island in Shoreline Cell 324.

The EN Nevin's three-toed slider and the P3 Cape Range slider are both found on the Cape Range Peninsula.

Discussion

The assessment of impacts on reptiles considered that physical oiling by floating oil causes irritation to sensitive organs such as eyes. There is a chance for chemical toxicity via ingestion, particularly for marine reptiles such as turtles that feed or aggregate in shallow water habitats where oil can accumulate. As a result, floating oil was deemed to have more of an effect on reptiles than dissolved oil. This is also because reptiles hold their breath underwater and are unlikely to directly ingest dissolved oil.

In the protection priority ranking for reptiles (Table 3-6), the conservation category as well as the above considerations were taken into account. The species' key uses such as nesting and breeding were also considered. Note too that the SNES dataset uses the terminology nesting/ breeding which implies 'aggregation' of a species. 'Aggregation' is used in the BIA dataset and is referenced in the other protected fauna rankings used in this category. Aggregation of a species in a single area allows a large number of the species to be impacted if that area is affected by an oil spill. Therefore the nesting/breeding areas (aggregation) have a higher ranking than foraging and inter-nesting. The priority rankings can be found in Table 3-6 and consider data confidence, reliability, survey method type, accuracy and geospatial extent.

The VU Airlie Island ctenotus generally inhabits the landward fringe of salt marsh communities in samphire shrubland or marine couch grassland (Maryan *et al*., 2013 in DoEE, 2017) in the intertidal zone along mangrove (grey mangrove (*Avicennia marina*) with occasional red mangrove (*Rhizophora stylosa*)) margins, however, subtle differences in vegetation/topography exist among sites where the species has been recorded (Biologic 2012). The Airlie Island ctenotus is strongly associated with samphire species *Tectornia halocnemoides subsp. tenuis* and *Suaeda arbusculoides*, which occur on clayey soils, and mixed herb and grass cover of *Muellerolimon salicorniaceum* and *Sporobolus virginicus*, which occur on sandy soils (Maryan *et al*., 2013). The Airlie Island Ctenotus feeds on invertebrates, which are common among grass tussocks (DoEE, 2017). Based on the evidence that the Airlie Island ctenotus has been found in the intertidal zone and in mangrove habitat, it is deemed to use the coastal zone for its habitat. The ranking assigned to the Airlie Island ctenotus is aligned with the ranking for other marine reptiles. The record in Shoreline Cell 324 is a vouchered specimen, so has a ranking of Medium for floating and Low for dissolved oil impact.

The EN Nevin's three-toed slider (*Lerista nevinae*) is abundant in the coastal dunes to the north of the project area (Biota Environmental Sciences, 2008). *Lerista nevinae* is abundant in coastal dunes (Biota Environmental Sciences, 2008 in RPS, 2016). There is a lack of information around the distribution of this sub-species from the family *l.muelleri*, however information from the WA Museum indicates that the species is found associated with a coastal dune vegetated with *Acacia*

coriacea and low shrubs. Other members of the species feed on termites and ants in leaf litter, however this information was not confirmed for this sub-species (WAM, 2016). The Nevin's three-toed slider is found in Shoreline Cell 101, which gives the cell a Very Low ranking for protection from floating and dissolved oil, however other aspects in this shoreline cell give it a higher protection priority ranking.

Table 3-6: Reptile protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Reptiles			
Critically Endangered species, if: ▪ Nesting, breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	5	4	**Species considered:** All SNES reptiles listed as well as State protected species listed on the DPaW database and DotE species listed as having BIAs in the area. **Importance:** Reptiles that have a higher threatened status were ranked higher. The BIAs considered to be the most important/vulnerable for reptiles are breeding/nesting habitats and aggregation areas, while all other areas including foraging, migration and inter-nesting areas were ranked as 'known habitat' and given a lower importance. This is to reflect the higher vulnerability of a reptile during nesting, including the vulnerability of its young, and also the aggregation of the reptiles in certain areas during these times.
Critically Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur ▪ Migration route, foraging, inter-nesting species or species habitat Known to occur ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, nesting, congregation, aggregation or translocated population Known to occur/Certain ▪ Caught, trapped or sighted Very Certain/WAM Vouchered/Certain	4	3	
Critically Endangered species, if: ▪ Migration route, foraging, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, inter-nesting, known core range and foraging Known to occur in DPaW	3	2	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain			
Critically Endangered species, if: ▪ Migration, connecting habitat and unknown, significant habitat Known to occur or high density ▪ Distribution, resting, nesting, foraging or inter-nesting buffer Likely to occur or low density ▪ Distribution, inter-nesting, known core range and foraging May occur ▪ Breeding and aggregation Former Range ▪ Dead Very Certain/WAM Vouchered ▪ Hair/skin or unknown method Moderately Certain, Not Defined or Not Sure Endangered species, if: ▪ Distribution (low density), nesting or foraging Likely, inter-nesting buffer or Known to occur ▪ Migration route, foraging, distribution, inter-nesting, known core range, species or species habitat Likely to occur in the area ▪ Hair/skin or unknown method Very Certain/WAM Vouchered/Certain ▪ Secondary signs Moderately Certain, Not Defined or Not Sure Vulnerable species, if: ▪ Breeding, congregation, aggregation or translocated population Likely to occur or low density in the area ▪ Migration route, foraging, species or species habitat Known to occur in the area ▪ Distribution, inter-nesting, known core range and foraging Known to occur in DPaW database ▪ Secondary signs Very Certain/WAM Vouchered/Certain	2	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Conservation Dependent, Other specially protected fauna and P1-P4 species, if: ▪ Breeding, congregation, aggregation or translocated population Known to occur in the area ▪ Caught, trapped or sighted Very Certain/ WAM Vouchered/Certain			
Critically Endangered species, if: ▪ Extinct in area, dead, fossils, subfossil or historical record All Endangered, Vulnerable and Other species with a conservation code with all other information.	1	1	
Terrestrial reptile species which do not use the intertidal zone for any instance of their lifecycle, and do not use the coastal/intertidal zone as any component of their habitat.	1	1	This is researched through two sources which cite no use of the coastal/intertidal zone, one of which is SPRAT.
Data List ▪ DotE Species of National Environmental Significance (SNES) ▪ DPaW Protected Fauna ▪ DotE Biologically Important Areas (BIAs)			

3.2 Protection Areas

Protection areas consist of habitats and ecosystems that are important for protection (such as unique ecosystems) or for supporting locally, regionally and internationally important flora and fauna. Habitats include mangroves, coral, seagrass, wetlands, fish spawning grounds, or Key Ecological Features (KEF). Protection areas include both formally protected areas through State or Commonwealth legislation, as well as important habitats identified through ecological and scientific literature, e.g. seagrass, mangroves and coral.

During the Pilbara zone's first iteration and Steering Committee review, it was recognised that, due to a number of political, land tenure, time and funding constraints, there may be areas that are equivalent to one of the protection area categories but do not have the legal status of a protected area. It was agreed that if an area has been recommended as a marine park or national park, but for legal or land tenure (or other) reasons is not yet (at the time of the assessment) legally designated as one, it should be included in the assessment for protection under the marine park/ national park, etc., protection ranking. Also, if an area cannot legally become a marine park/ national park, etc., for similar reasons outlined above, but it has been demonstrated that the area has the ecological value equivalent to a formally recognised park, it should be included in the assessment.

There were two such areas in the Pilbara, deemed to be equivalent to one of the protection area categories. These areas are described in '*A Representative Marine Reserve System for Western Australia*', a report by the Marine Reserves Selection Working Group (Wilson *et al.*, 1994). These areas are Cowrie Beach (Shoreline Cell 97) and Robe (Shoreline Cell 111), which are discussed further in Section 3.2.3, Marine Protection Areas.

3.2.1 World Heritage Areas

Description

Australia has 14 World Heritage areas. These are places or areas that the United Nations Educational, Scientific and Cultural Organization (UNESCO) has agreed are worthy of special protection, because they represent the best examples of the world's cultural and natural heritage and are considered to be of outstanding value to humanity (UNESCO, 2008).

There are two categories for heritage protection: cultural heritage; and natural heritage. Some UNESCO World Heritage areas are classed as either one category or the other, while some are classed under both categories. This section includes World Heritage areas listed only for their natural heritage value, or those listed for both their natural and cultural heritage values. Areas listed on the UNESCO World Heritage List for only their cultural heritage have been included in the Cultural Heritage priority ranking (see Section 3.3.1).

The DotE World Heritage Areas dataset was used to delineate the World Heritage areas in the Pilbara zone. On the western edge, the Ningaloo Coast World Heritage areas cover 11 shoreline cells. The UNESCO World Heritage Council does not list areas only nominated for World Heritage listing. At the time of this report, globally there are 44 World Heritage Area nominations, with 40 assessed and four incomplete. There are a further 37 proposed for review in 2017 (UNESCO, 2017). There are three areas on the Tentative List, proposed by Australia in 2017, however these are not in Western Australia.

Distribution

The DotE World Heritage Areas dataset was used to delineate the World Heritage areas in the Pilbara zone. There is one World Heritage Area in the Pilbara zone: the Ningaloo Marine park area in the western edge of Zone 2. No additional proposed or nominated evidence for the Pilbara zone has been identified.

Discussion

There are ten criteria against which a site can be nominated for inclusion in the list of World Heritage areas. While some sites fulfil more than one criteria, for the purposes of the overall assessment, all World Heritage recognised areas have been ranked equally (highest ranking) as it is considered that a loss or impact on the site would be a loss or impact of global significance.

As a site selected for its outstanding natural value, all World Heritage areas have been given the highest priority for protection from the effects of both floating and dissolved oil. There is one World Heritage Area in the Pilbara zone: the Ningaloo Marine park area in the western edge of Zone 2. As a result of the Ningaloo Marine Park, 12 shoreline cells have the protection priority ranking listed in Table 3-7.

Table 3-7: World Heritage Properties protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
World Heritage Properties (Natural and Natural & Cultural Heritage)			
All World Heritage Areas	5	5	**Importance:** World Heritage areas have the highest priority for protection from the effects of both floating and dissolved oil.

Data List

- World Heritage Areas (DotE World Heritage Areas)

3.2.2 Terrestrial Protection Areas

Description

Terrestrial protection areas are those specified in Commonwealth or State law, such as national parks, nature reserves, conservation parks, Indigenous protected areas and miscellaneous reserves, to preserve the natural and cultural characteristics of an area. Nearly two thirds of the protected areas in Australia is publicly owned and managed by the Australian government or State and Territory governments. This includes over 9,700 protected areas covering more than 103 million hectares or 13.4 per cent of Australia (DotE, 2013). The largest component of this is in WA where 35.64 million hectares are protected across 1,562 areas, which is 34.51% of the total National Reserve Network (DotE, 2013). The majority of this land is managed by DPaW.

Terrestrial protection areas have been identified through the DotE Collaborative Australian Protected Areas Database (CAPAD). The dataset is updated every two years and, while the previous version is dated 2014, DPaW was able to provide an updated marine and terrestrial dataset for lands vested in its department (from July 2016). Within the CAPAD dataset, the conservation areas under the WA *Conservation and Land Management Act 1984* (CALM Act) include IUCN protected areas categories. IUCN is the International Union for Conservation of Nature which has created a set of categories that have been internationally adopted as the standard for defining and recording protected areas. The conservation categories listed in the CALM Act are:

IA (Strict Nature Reserve): Protected areas that are strictly set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.

IB (Wilderness Area): Protected areas that are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, which are protected and managed to preserve their natural condition.

II (National Park): Protected areas that are large natural or near-natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

III (National Monument): Protected areas that are set aside to protect a specific natural monument which can be a landform, sea mount, sub-marine cavern, geological feature such as a cave, or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

IV (Habitat/Species Management Area): Protected areas that aim to protect particular species or habitats and whose management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

V (Protected Landscape/Seascape): Protected areas where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value, and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

IUCN VI (Protected area with sustainable use of natural resources): Protected areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management, and where low-level, non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

Other types of reserves including 5(1)(g) Reserves: Within the meaning of the CALM Act, land reserved under the *Land Act 1933* which: is vested in the Conservation Commission of WA that is not a national park, conservation park, nature reserve, marine park or marine nature reserve; or immediately before the commencement of the CALM Act, was vested in, or under the control and management of the National Parks Authority but not as a national park. (On the proclamation of the CALM Act, all these reserves were automatically vested in the Conservation Commission of WA). These reserves have a wide variety of purposes, but are normally related to recreation, wildlife conservation, infrastructure and historical features. These are managed by the WA DPaW and can have any of the above IUCN classifications for management.

5(1)(h) Reserves: Within the meaning of the CALM Act, land reserved under the *Land Administration Act 1997* which: is vested in the Conservation Commission of WA that is not a national park, conservation reserve, nature reserve, marine park or marine nature reserve; or immediately before the commencement of the CALM Act, was vested in, or under the control and management of the National Parks Authority but not as a National Park. (On the proclamation of the CALM Act, all these reserves were automatically vested in the Conservation Commission of WA). These reserves have a wide variety of purposes, but are normally related to recreation, wildlife conservation, infrastructure and historical features. These are managed by the WA DPaW and can have any of the above IUCN classifications for management.

Indigenous Protected Areas: Indigenous community owned and managed lands in Australia. They form the second largest component of the National Reserve System covering three per cent of Australia. These can have any of the above IUCN classifications for management.

Miscellaneous Reserves: Defined by the WA Department of Mines and Petroleum in its description of land type categories in TENGRAPH® as Freehold land held by the Executive Director of DPaW. Under Section 131 of the CALM Act, this freehold land can be sold by DPaW. These can have any of the above IUCN classifications for management.

Distribution

In the Pilbara zone, there are 21 listed conservation areas, including six 5(1)(h) reserves, seven nature reserves rated Indigenous Protection Area (IA), and four National Parks classified as IUCN II areas. The National Parks with a terrestrial protection component include the Montebello Islands, Bundegi Coastal Park in the Exmouth Gulf, and the Bundegi and Jurabi Coastal Parks. There are 13 IA nature reserves, mainly covering the islands along the Pilbara coastline, the better known including Barrow, Thevenard, Muiron and Locker Islands.

Discussion

The land tenure of the conservation parks, national parks and nature reserves has a long standing protection status in Australian legislation. The proposed ranking for these legislated terrestrial protection areas is presented in Table 3-8. As noted in Section 3.2, it has been recognised that due to a number of political, land tenure, time and funding constraints, there may be areas that are proposed or scientifically recognised to be important areas, but are yet to become or will never be able to become formally protected, and therefore are not legally recognised as such. These would have been included in this assessment as their equivalent legal protection category, if any had been identified.

In the Steering Committee Workshop on 16 May 2016, it was highlighted that the designated boundary of a terrestrial protection area may be either to the high water mark, or to the low water mark. If the boundary was to the low water mark, the area for protection included the intertidal zone. Therefore consideration of the effects of marine pollution in the intertidal zone needed to be incorporated into the terrestrial area assessment. In response, the terrestrial parks in this assessment have been divided into parks that include the intertidal zone and those that have a boundary to the high water mark (terrestrial only), and the potential impacts ranked accordingly.

From the processing and review of the data in the Pilbara zone, it was apparent that there were no terrestrial conservation areas which needed to be split for the areas inside and outside of the intertidal zones, to facilitate applying separate rankings. The distinction has however been incorporated in anticipation that it may later be considered in the other zones of this assessment. The Cape Range National Park on the Ningaloo coastline at the west of the Pilbara zone incorporates both a terrestrial and shoreline footprint into the shapefile. However, since the habitat protection associated with the Cape Range National Park includes the beach, the ranking was applied for the intertidal zone as well. Similarly, the terrestrial reserve Bundegi and Jurabi Coastal Parks include protection of the coastal vegetation and the beach area up to low water mark (Shire of Exmouth and CALM, 1999), and for this reason has been ranked accordingly.

Table 3-8: Terrestrial Protection Areas protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
National and State Terrestrial Protection Areas			
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* (conservation park, national park, nature reserve) ranked IUCN IA (Strict Nature Reserve) and IB (Wilderness Area) *Includes the intertidal zone*	4	3	**Importance:** A Strict Nature Reserve is mainly managed for scientific research. Wilderness Areas are managed for their wilderness protection. Both are key examples of unspoilt areas of wilderness with restricted human access. These pristine areas are the most important to protect from anthropogenic impacts such as an oil spill.
Same as above but: *Does not include the intertidal zone*	3	N/A	
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN II (National Park), III (National Monument), IV (Habitat/ Species Management Area), V (Protected Landscape/Seascape) *Includes the intertidal zone*	3	2	**Importance:** National Parks, National Monuments, Habitat/ Species Management Areas and Protected Landscape/Seascape are typically larger areas protected to preserve a larger ecosystem or feature. Therefore the impacts from an oil spill are expected to be less as the areas are larger.
Same as above but: *Does not include the intertidal zone*	2	N/A	
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN VI (Managed Resource Protected Area) and all other types: 5(1)(g) reserves, 5(1)(h) reserves, Indigenous Protected Areas, Miscellaneous Reserves and Regional Parks *Includes the intertidal zone*	2	1	**Importance:** All other reserved areas have land tenure not as secure as conservation areas described above. Managed Resource Protected Areas typically have a level of human interaction and recreation. Managed mainly for conservation, they still have an element of disturbance through sharing their natural resources with the public.
Same as above but: *Does not include the intertidal zone*	1	N/A	
Data List ▪ DotE CAPAD – Terrestrial (30 June 2014) with DPaW update (30 June 2016)			

3.2.3 Marine Protection Areas

Description

Marine protection areas in WA state waters are areas specified in State law such as state marine parks, state marine reserves, fish habitat protection areas and reef protection areas. Marine protection areas are used alongside fisheries management to contribute to a sustainable marine environment and conserve aquatic biodiversity. Commonwealth protected areas may also be put in place, however these are in waters between three and 200 nautical miles off the WA coast under Commonwealth legislation (i.e. adjacent to state waters).

Marine protection areas have been sourced from the Commonwealth DotE CAPAD Marine dataset. The CAPAD Marine dataset provides both spatial and text information about government, Indigenous and privately protected areas for continental Australia. State and Territory conservation agencies supplied data current to 30 June 2014 to the DotE for inclusion. It is updated by the DotE every two years, however DPaW was able to provide an updated marine and terrestrial dataset for lands vested in its department. The WA DoF also provided updated datasets for areas managed for fisheries. Protected areas offshore include:

- 5(1)(g) Reserves;
- Fish Habitat Protection Areas;
- Marine Management Areas;
- Marine Nature Reserves;
- Marine Parks; and
- Nature Reserves.

These reserves were then classified by the IUCN system described above in Section 3.2.2 for terrestrial protection areas. Fish Habitat Protection areas, along with Closed Waters areas, are described in Section 3.2.8.

Distribution

Within the Pilbara zone, there are six marine protection areas. There are four IUCN-type IA reserves, which deserve the highest level of protection, including Barrow, Montebello and Muiron Islands and the Ningaloo Peninsula, one IUCN-type II Commonwealth Marine Reserve at Dampier, and a Marine Park (IUCN-type IV) at Eighty Mile Beach on the eastern edge of the Pilbara zone.

There are two proposed Conservation Areas described in the Wilson (1994) report – Cowrie Beach (Shoreline Cell 97) and Robe (Shoreline Cell 111) – which do not fall into the protected areas listed above. Cowrie Beach is an important rookery site for flatback turtles, and Robe contains mangrove habitats deemed to be the most diverse mangrove stands on the Pilbara coast (Wilson *et al*, 1994).

Discussion

The land tenure for marine nature reserves, marine parks or marine management areas has a long-standing protection status in Australian legislation. The proposed ranking for marine protection areas is presented in Table 3-9. As discussed in Section 3.2.2, Terrestrial Protection Areas, the designation of the boundary of a marine protection area may be either to the high water mark, or to the low water mark, and thus may or may not include an intertidal zone. As such, the

potential impact could be different depending on the boundary. Therefore the marine parks have been divided into parks that include the intertidal zone (i.e. that have a boundary to the high water mark) and those that only go to the low water mark (i.e. subtidal only). This is reflected in the rankings in Table 3-9.

The shoreline cells covered by the four IUCN-type IA reserve areas are Shoreline Cells 318 to 321. These are ranked High for protection from both dissolved and floating oil because of the marine protection area ranking. Shoreline Cell 111, identified to contain a proposed reserve at Robe, is ranked High for protection from floating and dissolved oil due to the presence of the Great Sandy Island Terrestrial Nature Reserve (IUCN-type IA, Section 3.2.2), which means other measures are in place to protect this shoreline cell. Shoreline Cell 97 (Cowrie Beach) is currently ranked Medium for protection from both dissolved and floating oil as a result of its categorisation as exposed tidal flats (Section 3.2.6).

As noted in Section 3.2, it has been recognised that due to a number of political, land tenure, time and funding constraints, there may be areas that are proposed to become marine protection areas but are not yet legally recognised as such. Two areas have been identified and described above for consideration as marine parks in the future, and these have been included in the assessment.

Table 3-9: Marine Protection Areas protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
National and State Marine Protection Areas			
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* (marine nature reserve, marine park or marine management area) ranked IUCN IA (Strict Nature Reserve) and IB (Wilderness Area) *Includes intertidal zone*	4	4	**Importance:** Strict Nature Reserves are mainly managed for scientific research. Wilderness Areas are managed for their wilderness protection. They are key examples of unspoilt areas of wilderness with restricted human access. These pristine areas are the most important to protect from anthropogenic impacts such as an oil spill.
A-Class Reserve vested under the *Fish Resources Management Act 1994*	4	4	
Same as above, but: *Subtidal only*	3	4	
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN II (National Park), III (National Monument), IV (Habitat/ Species Management Area), V (Protected Landscape/Seascape)	3	3	**Importance:** The land tenure of the conservation parks, national parks and nature reserves has a long standing protection status in Australian legislation. National Parks, National Monuments, Habitat/Species Management Areas and Protected Landscape/Seascape are typically larger areas protected to preserve a larger ecosystem or feature. Therefore the impacts from an oil spill are expected to be less as the areas are larger.
Same as above, but: *Subtidal only*	2	3	
All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN VI (Managed Resource Protected Area) and all other types (existing and proposed): 5(1)(g) reserves, 5(1)(h) reserves, Indigenous Protected Areas, Miscellaneous Reserves	2	2	**Importance:** All other reserved areas have land tenure not as secure as conservation areas described above. Managed Resource Protected Areas typically have a level of human interaction and recreation. Managed mainly for conservation, they still have an element of disturbance through sharing their natural resources with the public.
Same as above, but: *Subtidal only*	1	2	
Data List ▪ DotE CAPAD – Terrestrial and Marine (30 June 2014) with DPaW update (30 June 2016)			

3.2.4 Wetlands

Description

There are two levels of protected wetlands in Australia: Ramsar wetlands; and Wetlands of National Importance.

Ramsar wetlands are wetlands of international importance identified under the Ramsar Convention for conservation and sustainable use and management. The Ramsar Convention aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. Ramsar wetlands are protected in Australia under the EPBC Act as a matter of national environmental significance. They are wetlands identified as representative, rare or unique, or important for conserving biological diversity, and are often recognised for supporting international and migratory bird species. Under the Ramsar Convention, a wide variety of natural and human-made habitat types, ranging from rivers to coral reefs, can be classified as wetlands. Wetlands include swamps, marshes, billabongs, lakes, salt marshes, mudflats, mangroves, coral reefs, fens, peat bogs, or bodies of water – whether natural or artificial, permanent or temporary. There are even underground wetlands.

Nationally important wetlands are those wetlands that are recognised for their national significance. In Australia, these are also protected under the EPBC Act and are listed for one or more of six reasons:

1. It is representative of a biogeographic region in Australia;
2. It plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex;
3. It is important as the habitat for animal taxa at a vulnerable stage in their lifecycles, or provides a refuge when adverse conditions such as drought prevail;
4. It supports 1% or more of the national populations of any native plant or animal taxa;
5. It supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level; and/or
6. It is of outstanding historical or cultural significance.

Ramsar wetlands were identified using the DotE Ramsar Wetlands of Australia geospatial dataset, and nationally important wetlands were identified using the Directory of Important Wetlands in Australia spatial database.

Distribution

One Ramsar wetland is located on the eastern-most edge of the Pilbara zone associated with Eighty Mile Beach. It covers Shoreline Cells 88 and 89.

Discussion

Ramsar wetlands are wetlands of international importance protected under the EPBC Act for management and protection as a matter of national environmental significance. As a site selected for its international importance, and because a wetland is likely to be significantly affected in the long term due to its complex remediation, it is given the highest priority for protection from both

floating and dissolved oil. Nationally important wetlands are given the second highest ranking for the same reasons. These rankings are presented in Table 3-10.

There is some duplication between the nationally important wetlands listing and Ramsar wetlands listing. Wetlands are also included as a shoreline type in the OSRA ESI dataset. However, where coastline characteristics are identified as nationally or internationally significant (e.g. a wetland), this higher ranking prevails (Table 3-10).

Table 3-10: Ramsar and Nationally Important Wetlands protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Ramsar Wetlands			
All Ramsar wetlands	5	5	**Importance:** Wetlands of international importance protected under the EPBC Act for management and protection as a matter of national environmental significance.
All nationally important wetlands	4	4	**Importance:** Wetlands which are classified as nationally important.
Data List ▪ DotE Ramsar Wetlands of Australia (22 April 2015)			

3.2.5 Key Ecological Features

Description

Marine Key Ecological Features (KEFs) are elements of the marine environment that, based on current scientific understanding, are considered to be regionally important, either for the region's marine biodiversity or for ecosystem function and integrity. KEFs have been identified in this assessment using the National Key Ecological Features geospatial database obtained from the DotE. While all KEFs are in Commonwealth waters, the shoreline cell boundaries may overlap with some Commonwealth waters, and therefore some KEFs. However no KEFs were found in the Pilbara zone.

Distribution

There were no KEFs found in the Pilbara zone.

Discussion

KEFs are considered to be regionally important, either for the region's marine biodiversity or for ecosystem function and integrity, so have been given the rankings proposed in Table 3-11.

Table 3-11: Key Ecological Features protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Key Ecological Features			
Key Ecological Features	2	3	**Importance:** As a site selected for regional marine importance, KEFs are given the third highest priority for protection from dissolved oil as all features are submerged. They are given a lower priority for floating oil.

Data List

- DotE Marine Key Ecological Features (16 Sep 2015)

3.2.6 Coastal and Intertidal Habitats

Description

WA has many unique and nationally, regionally and locally important coastal and intertidal habitats. These include ecologically important mangroves in the north to white sandy beaches in the south, and from rocky landscapes to sheltered intertidal flats in between.

The data representing coastal habitats predominantly came from the Oil Spill Response Atlas (OSRA) developed by AMSA and maintained by the DoT. These layers are represented by 'WA Shoreline ESI' data where ESI stands for Environmental Sensitivities Index. The spill contingency planning requirements of the USA *Oil Pollution Act of 1990* and similar legislation passed by many states in the US, require information on the location of sensitive resources to be used as the basis for establishing protection priorities. As such, a standardised system has been developed in the US known as the ESI. The index categorises the shoreline into its type and sensitivity to marine oil pollution. The ESI is widely accepted around the world as the standard for sensitivity rating, used for planning oil spill response to shoreline contact.

The Marine Futures Biodiversity (MFB) project (Government of Australia, 2008) mapped the biodiversity of five key regions along the WA coastline including Abrolhos Island, Broke Inlet, Geographe Bay, Jurien Bay, Middle Island (Recherche Archipelago), Point Ann (Fitzgerald National Park), Rottnest Island and Southwest Capes. None of these areas fall in the Pilbara zone.

The Department of Mines and Petroleum (DMP) Coastal Landforms dataset was also identified for inclusion in this section, however, as described in Section 2.5, this was excluded from the first zone assessment. This was because it was difficult to assign a protection priority, as the dataset is not consistent in its interpretation of sandy/rocky and inundated shoreline areas equivalent to the ESI or DPaW Marine Habitat datasets above.

Distribution

The coastal characteristics of the Pilbara zone are dominated by fine to medium grained sand beaches, and both sheltered and exposed tidal flats, in a continuous stretch along the coastline. There are abundant mangroves, sheltered tidal flats and areas classified as Islands in the ESI dataset.

Discussion

For the various types of shoreline (and riverine or lacustrine ecosystems), the widely accepted ESI can be adapted for each country. The ESI, ranging from 1 (low sensitivity) to 10 (very high sensitivity), integrates the:

- Shoreline type (grain size, slope), which determines the movement and capacity of oil penetration and/or burial on the shore;
- Exposure to waves (and tidal energy), which determines the natural persistence time of oil on the shoreline; and
- General biological productivity and sensitivity.

Shorelines which are sheltered tidal flats incorporating mangrove and swamp habitats are more susceptible to long term impacts from an oil spill of both floating and dissolved oil, while rocky exposed shorelines are the least susceptible. Shorelines which include beaches and sandy areas are considered to be moderately difficult to rehabilitate, moderately ecologically sensitive, and also are likely to contain areas used for human resources purposes such as beaches and archaeological sites.

Mangroves and sheltered intertidal flats are found in most of the shoreline cells along the Pilbara. In a similar oil spill risk assessment undertaken in Victoria, mangroves and other habitat types have been ranked in accordance with abundance in the shoreline cell, where higher abundance was given a higher ranking. In the Tasmanian assessment, the approach was to elevate or retain the weightings on a cell-by-cell basis where there were one high value criteria and more than five moderate value criteria. These methods were also considered before WA decided on the most appropriate approach in addressing the abundance of mangrove and sheltered intertidal flats in the Pilbara zone. It was acknowledged that environment value is not solely dependent on abundance, i.e. isolated or small stands of mangroves can be environmentally significant. However, in WA, a ranking based in abundance was deemed appropriate to distinguish between mangrove areas of varying value. The abundance-based approach does not preclude small or isolated stands of mangroves from being given a higher rating as protection areas or potential protection areas (also discussed in Section 8.3).

The ESI categories ‘mangroves’ and ‘sheltered intertidal flats’ have been ranked by their abundance in the shoreline cells. The abundance was calculated based on its area in each shoreline cell, with an area of mangroves greater than 3,000 ha deemed to be the most important (and ranked the highest, with High for protection from both dissolved and floating oil). A graduated scale modelled on the Victorian example was then applied, with sheltered tidal flats >3,000 ha and mangroves of 1,000-3,000 ha ranked Medium for protection from both dissolved and floating oil. Where there are less than 1,000 ha mangroves and 1,000-3,000 ha sheltered tidal flats, these were ranked Low for protection from both floating and dissolved oil.

The DPaW Marine habitats dataset is predominantly areas of seagrass and coral which are included in the following section on Coral, Seagrass, Algae and Filter Feeding Communities (Section 3.2.7).

Table 3-12: Coastal and Intertidal Habitat protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Shoreline Geomorphology and Coastal Landforms			
ESI 10: 10A Salt and brackish water marshes; 10B Freshwater marshes; 10C Swamps; 10D Mangroves with >3,000 ha per shoreline cell	4	4	**Importance:** Based on the NOAA and IPIECA/IMO/OGP Environmental Sensitivities Index, the classifications and rankings have been adopted from the above and take into account: 1. Shoreline Classification – ranked according to a scale relating to sensitivity, natural persistence of oil, and ease of clean up. 2. Biological Resources – including oil-sensitive animals and rare plants, and habitats which are used by oil-sensitive species or are themselves sensitive to oil spills, such as submersed aquatic vegetation and coral reefs. 3. Human-Use Resources – specific areas that have added sensitivity and value because of their use, such as beaches, parks, marine sanctuaries, water intakes and archaeological sites. See http://response.restoration.noaa.gov/sites/default/files/ESI_Guidelines.pdf for further discussion regarding the classifications.
ESI 7, 8 and 9: 7 Exposed tidal flats; 8A Sheltered scarps in bedrock, mud or clay and sheltered rocky shore; 8B Sheltered, solid man-made structures; 8C Sheltered riprap; 8D Sheltered rocky rubble shores; 8E Peat shorelines; 9A Sheltered tidal flats >3,000 ha per shoreline cell; 9B Vegetated low banks; 9C Hypersaline tidal flats; 10D Mangroves with between 1,000 and 3,000 ha per shoreline cell	3	3	
ESI 3, 4, 5 and 6: 3A Fine- to medium-grained sand beaches; 3B Scarps and steep slopes in sand; 4 Coarse-grained sand beaches; 5 Mixed sand and gravel beaches; 6A Gravel beaches (granules and pebbles); 6B Riprap structures and gravel beaches (cobbles and boulders) CAMRIS marc, calcareous clay, gravel, sand silt, mud pelagic clay and volcanic grit; 10D Mangroves <1,000 ha per shoreline cell; 9A Sheltered tidal flats with between 1,000 ha and 3,000 ha per shoreline cell	2	2	
ESI 1 and 2: 1A Exposed rocky shore; 1B Exposed, solid man-made structures; 1C Exposed rocky cliffs with boulder talus base; 2A Exposed wave-cut platforms in bedrock, mud or clay; 2B Exposed scarps and steep slopes in clay; and 9A Sheltered tidal flats with <1,000 ha per shoreline cell	1	1	
Data List ▪ DoT OSRA ESI dataset (April 2011) ▪ DPaW Marine Habitat dataset (May 2015)			

3.2.7 Coral, Seagrass, Algae and Filter Feeding Communities

Description

Corals are significant benthic primary producers that play a key role in the ecosystem of many reef environs and have an iconic status in the environment. Corals are invertebrates, typically forming colonies of individual polyps. They contain photosynthetic unicellular algae called zooxanthellae and are therefore reliant on sunlight for their survival. Corals can be grouped into the following categories:

- Scleractinian corals (hard corals) – reef building corals;
- Non-scleractinian corals (sometimes referred to as calcified soft corals) – generally not considered to be reef building; and
- Soft corals belonging to the order *Alcyonacea* – non-reef building.

Seagrasses are important primary producers in tropical inshore waters as they provide energy and nutrients for detrital grazing food webs. They are also directly grazed by protected animals such as dugongs and green turtles, and provide refuge areas for fishes and invertebrates (DEC, 2007).

Algae are important primary producers, and support diverse and abundant fauna of small invertebrates that are the principal food source for many inshore fish species.

Coral, seagrass, algae and filter feeding community distribution has been determined from the OSRA ESI data layer, the DPaW Marine Habitat dataset and the CAMRIS Seagrass dataset.

It is noted that seagrass and algae fall under the definition of 'fish' in the *Fish Resources Management Act 1994*, however all mapped seagrass and algae have been included in this section rather than in Section 3.2.8.

Distribution

Coral reefs are found along three key areas in the Pilbara zone: along the western edge at Ningaloo Reef (Shoreline Cells 122 to 131); offshore along Barrow and Montebello Islands (Shoreline Cells 318 to 322); and in the Dampier Archipelago (Shoreline Cells 102 to 108 and 315 to 317).

Algae including macroalgae have been mapped in small areas in Shoreline Cells 123 to 128 and 329, with larger areas found in Shoreline Cells 318 to 322, on Montebello and Barrow Islands, and in Shoreline Cells 106 to 109 west of Dampier. There are smaller patches associated with the islands in Shoreline Cells 105, 316 and 317 in the Dampier Archipelago.

Filter feeding community distribution has not been extensively mapped, with limited geospatial data available. No filter feeding communities were mapped as part of the DPaW Marine Habitat dataset in the Pilbara zone.

Discussion

Corals are sensitive to dissolved hydrocarbons because they are affected by toxicity at a cellular level. Unless the coral reef is routinely exposed during tides, a greater impact is noticed from dissolved oil compared to floating oil. The negative effects of an oil spill in coral include:

- Increased algal growth;
- Slower growth rates;
- Lower fecundity;
- Localised tissue rupture;
- Premature explosion of larvae; and
- Excessive mucous production (Hayes *et al.,* 1992).

Corals which have a greater sensitivity to oil spills include those which are fringing reefs and intertidal reef flats where direct contact with floating oil is likely, and in shallow waters 1-5 m deep (Hayes *et al.*, 1992).

How an oil spill affects coral depends on the species and maturity of the coral (e.g. early stages of life are very sensitive to oil) as well as the means and level of exposure to oil. Exposing coral to small amounts of oil for an extended period can be just as harmful as large amounts of oil for a brief time. These considerations have resulted in coral receiving the highest protection priority ranking in Table 3-13.

Seagrasses in intertidal areas are at greater risk of impact from oil and are an important food source for associated fauna. Taylor and Rasheed (2011) found that seagrass meadows are not significantly affected by an oil spill when compared to the non-impacted, reference seagrass meadow. For this reason, seagrass was ranked lower than coral, but still ranked Medium as they provide important habitat for threatened turtles, fish and invertebrates.

Algae typically colonises an area in response to mortality of coral because of an oil spill. The impacts of dissolved oil are greater than floating oil in the cellular level poisoning of algae growth, but the impacts on algae are secondary as the algae support fauna species and provide food sources for fish. The literature appears to support the observation that the direct impacts on algae from oil are limited and they recover readily following an oil spill event (Lobban and Harrison, 1994). For these reasons ,algae has been ranked below coral and seagrass.

Filter feeding communities play important roles in purifying water, creating habitat and controlling shoreline erosion. These communities are often wide spread and diverse, with impacts from a spill including degradation, impaired reproduction and growth development.

In the Pilbara zone, the extent of coral ranked High for protection from dissolved oil is distributed over the same shoreline cells covered by IUCN-type IA (strict Nature Reserve), however these shoreline cells are ranked Medium for protection from dissolved oil for the Terrestrial Protection Areas category. In Shoreline Cells 103 to 109 (Dampier Archipelago) and 315 to 322 (Barrow Island and Montebello), the mapped presence of coral (broad-scale intertidal and subtidal coral reef) is driving a higher ranking to those cells for the Protection Areas category from the impact of dissolved oil.

Table 3-13: Coral, Seagrass and Algae protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Coral, Seagrass and Kelp			
Coral	3	4	**Importance:** Corals are particularly sensitive to dissolved hydrocarbons.
Seagrass	2	3	**Importance:** Seagrasses are grazed by protected animals and provide refuge areas for fish and invertebrates.
Algae and filter feeding communities	1	2	**Importance:** Algae and filter feeding communities including sponges are important primary producers, and support diverse and abundant fauna of small invertebrates that are the principal food source for many inshore fish species.

Data List

- Coral Reef data in the OSRA ESI data layer (April 2011)
- DPaW Marine Habitat dataset (May 2015)
- CAMRIS coastal seafloor distribution (23 January 2008)

3.2.8 Fish Habitat Protection Areas and Closed Waters

Description

The WA DoF is responsible for managing commercial fisheries off the coast of WA in state and commonwealth waters (under the Offshore Constitutional Agreement). Fish and their habitats in a particular area can also be given special protection and management by including them in a Fish Habitat Protection Area (FHPA). These areas are set aside under section 115 of the *Fish Resources Management Act 1994* for the following purposes:

- The conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem;
- The culture and propagation of fish and experimental purposes related to that culture and propagation; and/or
- The management of fish and activities relating to the appreciation or observation of fish.

The distribution information has been determined from the CAPAD fish habitat protection areas data and the DoF habitat protection areas.

In addition, areas can be closed under section 43 of the *Fish Resource Management Act 1994* (FRMA). This prohibition can include closed waters (Marine Reserves), gear restrictions, species restrictions and designated fishing zones.

Distribution

There are no Fish Habitat Protection areas from the CAPAD dataset which fall in the Pilbara zone.

There are three areas in the Pilbara zone which are closed to fishing under section 43 of the FRMA (1994). These are:

- Ningaloo Marine Park prohibition on commercial fishing in Shoreline Cells 122 to 131;
- Muiron Island Marine Park prohibition on commercial fishing in Shoreline Cell 329; and
- Barrow Island and Montebello Islands Marine Park prohibition on commercial fishing in Shoreline Cells 319 to 320.

Discussion

FHPAs protect the continued sustainability of a particular species, or multiple species. Fish in a key habitat exposed to dissolved aromatic hydrocarbons are at risk of toxic effects; they are less likely to be physically oiled by floating oil. Areas closed under section 43 of this Act are protected for environmental conservation, and all areas have a prohibition of fishing equivalent to a sanctuary, and are therefore given a higher ranking for protection. These rankings are presented in Table 3-14.

Shoreline Cells 122 to 131 (Ningaloo Marine Park) and 329 (Muiron Island Management Area) are ranked High for protection from floating and dissolved oil due to the areas closed to fishing under the FRMA (1994). Shoreline Cells 319 and 320 are also closed to commercial fishing under the FRMA (1994) and are part of the Barrow Island and Montebello Islands Marine Park.

There are no Fish Habitat Protection areas from the CAPAD dataset which fall in the Pilbara zone.

Table 3-14: Fish Habitat Protection Areas protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Fish Habitat Protection Areas			
Areas closed under section 43 of the *Fish Resource Management Act 1994*	4	4	**Importance:** Areas closed under section 43 of this Act prohibit fishing. This prohibition can include closed waters (Marine Reserves), gear restrictions, species restrictions and designated fishing zones.
Fish habitat protection areas in the CAPAD dataset	3	3	**Importance:** Fish habitat protection areas protect the continuing sustainability of a particular species, or multiple species. Fish in a key habitat exposed to dissolved aromatic hydrocarbons are at risk of toxic effects. Fish are less likely to become physically oiled by floating oil.
Data List ▪ CAPAD fish habitat protection areas (June 2014) ▪ DoF FRMA (1994) Prohibition on Commercial Fishing areas (November 2016)			

3.2.9 Aquaculture and Pearling Areas

Description

Aquaculture is defined as the cultivation of marine and freshwater organisms for human use or consumption. Aquaculture in Western Australia includes abalone, barramundi, black bream, coral, live rock, marine finfish, marron, mussels and oysters, pearls, prawns, redclaw crayfish, silver perch, trout and yabbies (Aquaculture Council of WA, 2016). Protection areas for aquaculture would include livestock collection locations, for example wild spat collection for cultivating pearls.

Aquaculture areas identified for protection either legally or informally were sought from the WA DoF. Note that the economic assessment of aquaculture licence areas is included in Section 3.4.

Distribution

The pearling industry relies almost exclusively on the harvest of pearl oysters from Eighty Mile Beach south of Broome. There are no alternative sources of wild stock that are significant enough to support the Australian pearling industry, though there are some known exclusive patches along the Pilbara coast.

The wild spat collection area for pearling at Eighty Mile Beach is found on the eastern-most extent of the Pilbara zone.

Discussion

Aquaculture wild stocks would be for abalone, coral, live rock, mussels, and wild spat for pearls. These are sessile, so would be impacted more by dissolved oil than by floating oil because they are filter feeders.

All other wild aquaculture stocks for fish, prawns, crayfish, trout and yabbies would be able to be resourced from a number of areas and even from other aquaculture farms. The rankings for future inclusion of areas are presented in Table 3-15.

Table 3-15: Aquaculture and Pearling Areas protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Aquaculture and Pearling Areas			
Wild stocks for aquaculture	2	3	**Importance:** Wild aquaculture stock would be impacted more by dissolved oil than by floating oil because these wild stocks are sessile filter feeders.

Data List

- Eighty Mile Beach harvest area, literature: DoF FRDC Project No. 2000/127

3.3 Cultural Heritage

Defining cultural heritage for inclusion in this heading for this project has been challenging. This is due to our evolving understanding of what heritage is. This definition continues to expand as people come to realise that cultural and natural heritage are closely integrated. Heritage is still regarded as consisting of 'special places', but there is an emerging recognition by Indigenous and non-Indigenous Australians of intangible heritage and cultural landscapes, and of the importance of heritage as a part of people's locality and identity (Beeton *et al.,* 2006).

From a cultural heritage perspective, there is currently strong interest in recognising intangible heritage, gaining a better understanding of how Indigenous people value land and landscape, and involving communities in identifying strong and special associations with place (Beeton *et al.,* 2006). For this assessment, the current cultural heritage listing of places has been used, as identified by current Australian legislation.

There are different levels of heritage listing in Australia – world, national, state/territory and local. At the highest level are places on the World Heritage List which are protected for their contribution to the global natural or cultural heritage, or both. For example, Uluru-Kata Tjuta National Park is protected for both its natural and cultural heritage contribution. On a local heritage list there might be a local nature reserve protected for local Indigenous cultural purposes or the local Post Office (AHC, 2009).

There are many heritage lists in Australia. Some are kept by the different levels of government while other lists are maintained by community or professional organisations. The main government list for WA is outlined in Table 3-16 (taken from AHC, 2009).

Table 3-16: Australian heritage lists by level of administration

Level of Administration	Heritage List
UNESCO	World Heritage – the list is maintained by the World Heritage Centre of the United Nations Educational, Scientific and Cultural Organisation (UNESCO), based in Paris
Commonwealth	National Heritage Commonwealth Heritage *[Register of the National Estate (which was phased out in 2012 and is now an historic list)]* Historic Shipwrecks Register
State and Territory	WA – Register of Heritage Places Generally – some states and territories also maintain a separate Indigenous site register WA state protected shipwrecks
Local	WA – Municipal Inventory

In addition to meeting different levels of criteria for protection (a collection of principles, characteristics and categories used to help decide if a place has heritage value), there is also a question of the threshold for heritage listing. The threshold is the level of heritage value that a place must demonstrate to be included on a heritage list. The heritage lists at each level use different thresholds to decide what places to include. These levels have been used to determine their level of protection priority. Examples of the thresholds used at different levels are indicated in Table 3-17. These are discussed further in each section below.

Table 3-17: Threshold levels for heritage lists in Australia

Level of Administration	Heritage List	Threshold
UNESCO	World Heritage	Outstanding universal value
Commonwealth	National Heritage	Outstanding heritage value to the nation
	Commonwealth Heritage	Significant heritage value
State and Territory	State and Territory Heritage	Importance or significance in the state or territory
Local	Local Heritage	Importance or significance to the local community

3.3.1 Commonwealth Protected Heritage

Description

Commonwealth protected heritage is that which has outstanding heritage value to the nation of Australia. There are three types of properties which are Commonwealth protected in Australia:

- World Heritage Areas;
- National Heritage Areas; and
- Commonwealth Heritage Places.

The datasets used to determine the distribution of Commonwealth protected heritage properties included the DotE's World Heritage areas, National Heritage List and Commonwealth Heritage List, which are publicly accessible.

It is noted that heritage places can be on multiple lists. Values of places on the Commonwealth Heritage List might be protected under more than one provision of the EPBC Act. For example, a Commonwealth Heritage Place might also be on the National Heritage List or the World Heritage List.

In this context, the cultural aspect means the Indigenous cultural aspect, the non-Indigenous cultural aspect, or both.

Distribution

In the Pilbara zone, there is one World Heritage Area (the Ningaloo Coast) designated for its outstanding Universal Value. It was inscribed in 2011 and recognises the outstanding universal value of the area's diverse and abundant marine life, its amazing cave fauna, and the spectacular

contrast between the colourful underwater scenery and the arid and rugged land of the Cape Range (DotE, 2016).

The Dampier Archipelago is on the National Heritage List because it contains one of the densest concentrations of rock engravings in Australia, with some sites containing thousands or tens of thousands of images (DotE, 2016). It is on the National Heritage List due to its rarity, the events it represents, and that it has the principal characteristics of a class of places.

The Learmonth Air Weapons range near Exmouth is listed on the Commonwealth Heritage Register.

Discussion

World Heritage Areas

In 2005, Australia had 14 World Heritage areas. These are places or areas that the United Nations Educational, Scientific and Cultural Organization (UNESCO) has agreed are worthy of special protection because they represent the best examples of the world's cultural and natural heritage.

Due to two categories for protection – cultural heritage and natural heritage – only World Heritage areas listed for their cultural heritage values have been included in the assessment under this section. Areas listed on the UNESCO World Heritage List, for their natural heritage and joint natural and cultural heritage, have been included in the Protection Areas priority ranking (refer to Section 3.2.1).

The Ningaloo Coast is a World Heritage Area for Cultural Heritage, and Shoreline Cells 122 to 131 and 329 have been given the ranking of Very High for protection from floating and dissolved oil, as presented in Table 3-18.

National Heritage Places

National Heritage Properties data has been sourced from the DotE. This data provides location and attribute information for places nominated to and included in the National Heritage List, as determined by the Australian Government and managed by the DotE Wildlife Division. As described in Table 3-17, National Heritage listed properties are protected for their outstanding heritage value to the nation, so they require a high level of protection, only one level below World Heritage.

The National Heritage Properties list includes the place name, class (Indigenous, natural, historic) and status. Places subject to confidentiality agreements are included in this data, but the location is generalised to the bounding 250k map sheet. Note that all confidential agreements are inland and do not affect the outcome of this project. The location data for nominated places that have been rejected, are ineligible, removed or destroyed have not been included in this assessment.

There are three National Heritage Places found in the Pilbara zone, with the Ningaloo Coast appearing on this list as well as the Montebello to Barrow Island in Shoreline Cells 318 to 322 and the Dampier Archipelago (Indigenous Listed Place) in Shoreline Cells 103 to 107.

Commonwealth Heritage Places

The Commonwealth Heritage List includes natural, Indigenous and historic heritage places owned or controlled by the Australian Government and protected under the EPBC Act. Places with Commonwealth Heritage values are protected under section 26 of the EPBC Act ("Protection of environment from actions involving Commonwealth land") which protects against "significant impact on the environment in…Commonwealth land", which specifies that "the heritage values of a place are part of the environment". These include places connected to defence, communications, customs and other government activities that also reflect Australia's development as a nation. As described in Table 3-17, Commonwealth Heritage Places are protected for their significant heritage value to the nation, so they are considered to be of a Medium priority ranking, behind National Heritage Places and World Heritage areas.

Data for places currently nominated or being assessed are not included in the list, so they have been excluded from this assessment as they are not yet protected under the EPBC Act. Places subject to confidentiality agreements are not included in this data.

Heritage areas which are comprised of artefacts relating to the rock or ground surface are ranked higher for protection from floating oil compared to dissolved oil, however those sites which are associated with the natural environment are ranked equally high for protection from floating and dissolved oil impacts.

There is one Commonwealth Heritage Place in the Pilbara zone: Ningaloo Coast. Because the shoreline cells are also covered by the World Heritage Area classification, the shoreline cells retain their higher ranking of Very High for protection from floating and dissolved oil, instead of the lesser ranking created by the Commonwealth Heritage Place listing.

There are seven Shoreline Cells (103 to 107 and 316 to 317) which are listed due to an Indigenous Listed Heritage Place on the Dampier Archipelago, and are given a ranking of High for protection from floating and dissolved oil.

There are five shoreline cells around Barrow-Montebello Islands which are ranked according to their classification as a Natural Heritage Place. They have been ranked High for protection from both floating and dissolved oil.

Table 3-18: Commonwealth Protected Heritage Properties protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
World Heritage Properties (Cultural Heritage)			
All World Heritage Areas	5	5	**Importance:** As a site selected for its outstanding universal value, all World Heritage areas have been given the highest priority for protection from both floating and dissolved oil.
National Heritage Places			
Indigenous and historic heritage places	4	3	**Importance:** As a site selected for its outstanding cultural value to the nation, these National Heritage Areas have been given a high priority for protection from floating oil, as these sites are nationally important and could be impacted physically by floating oil. A slightly reduced priority ranking for protection from dissolved oil has been given, as these sites are less likely to be affected by dissolved oil.
Natural heritage places	4	4	**Importance:** As a site selected for its outstanding natural heritage value to the nation, these National Heritage Areas have been given a high priority for protection from both floating and dissolved oil, as these sites are nationally important and could be impacted physically by either floating or dissolved oil.
Commonwealth Heritage Places			
Indigenous and historic heritage places	3	2	**Importance:** As a site selected for its significant cultural heritage value, these Commonwealth Heritage Areas have been given a medium priority for protection from floating oil as these sites are nationally significant and could be impacted physically by floating oil. A slightly reduced priority ranking for protection from dissolved oil has been given, as these sites are less likely to be affected by dissolved oil.
Natural heritage places	3	3	**Importance:** As a site selected for its significant natural heritage value, these Commonwealth Heritage Areas have been given a medium priority for protection from floating and dissolved oil, as these sites are nationally significant and could be impacted physically by either floating or dissolved oil.

Data List

- DotE National, Commonwealth and Natural Heritage (Public) (January 2016)
- DotE World Heritage Areas (October 2016)

3.3.2 State Protected Heritage

Description

Places are listed for protection at a state level under the *Heritage of Western Australia Act 1990*. There are a number of different types of listings under the Act. Those included in this assessment are intended to include the places on the State Register, Conservation Order and Heritage Agreement lists. The different types of WA State Statutory Listings are provided in Table 3-19.

Table 3-19: Western Australia State Statutory Listings and other listings

Type	Organisation	Legislation	What is Listed	No. of Places in WA
State Statutory Listings				
State Register	Heritage Council (assisted by the State Heritage Office)	*Heritage of Western Australia Act 1990*	Places of state significance included in the State Register of Heritage Places	1,400
Conservation Order	Heritage Council (assisted by the State Heritage Office)	*Heritage of Western Australia Act 1990*	Places of state significance or potential state significance (special cases)	5
Heritage Agreement	Heritage Council (assisted by the State Heritage Office)	*Heritage of Western Australia Act 1990*	Places protected by long-term agreement between the parties	100
Town Planning Scheme ('Heritage List')	Local Governments	*Planning and Development Act 2005*; Local Planning Schemes	Places of local heritage significance	9,000
Other Listings				
Local Government Inventory ('Municipal Inventory')	Local Governments	Mandated under the *Heritage of Western Australia Act 1990* but controlled by Local Governments	Places of local significance	20,000
List of Classified Places	The National Trust of Australia (WA)	The *National Trust of Australia (WA) Act 1964*	Places of local, state or national significance	2,300

Town Planning Scheme 'Heritage Listed' places, Municipal Inventory Places and List of Classified Places have been excluded as there are too many (>30,000 in total).

Places listed on the State Register, Conservation Order list and Heritage Agreement list along with their geospatial datasets were sourced from data.wa.gov.au, provided by the State Heritage Office.

The DAA Aboriginal Heritage Listed Places dataset was also identified for inclusion in this section, However, as described in Section 2.5, this was deliberately excluded from the first zone assessed (this Pilbara zone) as the DAA list is largely incomplete; it only identifies areas that have been

registered through Native Title Determinations. The dataset was agreed to be removed to avoid a false impression that this sensitivity is covered.

In the absence of state-specific protection priority data for each shoreline cell, DoT would need to consult with the DAA independently in the event of an oil spill. This precedent is being carried through to the remainder of the zones being assessed.

Distribution

There are nine sites listed on the State Register. The majority of the sites are associated with the larger settlements along the Pilbara coastline: Shoreline Cells 120 to 131 (Ningaloo Coast), 114 to 115 (Onslow), 103 to 105 (Dampier and Karratha) and 94 (Port Hedland). The sites listed on the State Register are Dalgety House, District Medical Officers Quarters and St Matthews Anglican Church in Port Hedland; Cossack Town Site Precinct and Jarman Island Lighthouse in Karratha; Old Onslow Town Site in Onslow; and Vlaming and Point Cloates Lighthouses and Norwegian Bay Whaling Station in Exmouth.

There are no Heritage Agreement sites or Conservation Order listed sites in the Pilbara zone.

Discussion

The majority of State protected heritage are buildings or man-made historical places protected for their value to state history. However there are some natural sites, therefore the terrestrial and marine sites are ranked equally high for floating and dissolved impacts. The rankings for protection priority for these sites are presented in Table 3-20.

Based on these rankings, Shoreline Cells 128 to 131, 103 to 105, 115 to 114 and 94 have been ranked Medium for protection from both floating and dissolved oil, due to State protected heritage places in these cells. These cells do however have a higher ranked priority in them in the Cultural Heritage category, so the presence of the State protected heritage places do not appear in the attribute table.

Table 3-20: State Properties protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
State Heritage Places			
State protected heritage places	3	3	**Importance:** As a site selected for its significant cultural and/or natural heritage value, these State Heritage Areas have been given a Medium priority for protection from floating and dissolved oil, as these sites are significant to the state and could be impacted physically by either floating or dissolved oil.

Data List

- DotE National Heritage (Public) (22 January 2016)
- State Heritage Office State Register dataset (October 2016)
- Conservation Orders dataset (October 2016)
- Heritage Agreement dataset (October 2016)

3.3.3 Shipwrecks and Maritime Archaeology

Description

The *Commonwealth Historic Shipwrecks Act 1976* protects all shipwrecks that are more than 75 years old. The Australian National Shipwrecks Database records all known Maritime Cultural Heritage (shipwrecks, aircraft, relics and other underwater cultural heritage) in Australian waters. Historic shipwrecks (>75 years) are protected under the *Historic Shipwrecks Act 1976*. Other wrecks that are not yet historic are protected under the *Navigation Act 2012*. This data has been sourced from the DotE and was last updated 3 February 2016. All shipwrecks have been recorded in this dataset, so this assessment uses only ships wrecked before 1941.

The State *Maritime Archaeology Act 1973* protects pre-1900 maritime archaeological sites on state lands and in state waters, such as protected bays, harbours and rivers. Maritime archaeological sites include shipwrecks, early maritime infrastructure, land sites associated with exploration, maritime industries (such as whaling and pearling camps) and shipwreck survivor camps. The WA Museum is responsible for administering both Acts in WA, so this dataset was sourced from them.

Distribution

There are 109 Commonwealth protected shipwrecks and marine archaeology sites along the Pilbara coastline; about half are also protected under State legislation. These wrecks are found continuously along the Pilbara zone, with a cluster found on the Ningaloo Coast and Montebello Islands.

There are 14 shoreline cells in the Pilbara zone which contain Commonwealth protected shipwrecks. The shipwrecks and marine archaeology sites include shipwrecks east of and around Port Hedland (Cossack, Delaware, Endeavour, Ettica, Leighton, Edith, Brondeg, Boodarie Landing, Yule, Balla Balla, Crown of England, Pearl, Mary B and Minderoo), with the now-demolished Port Hedland Jetty protected in the Shoreline Cells 89, 90, 94 and 95.

Further west, Depuch Island inscriptions and graves are located in Shoreline Cell 99 and are protected under Commonwealth Maritime Cultural Heritage. Along the Ningaloo Coastline up to Onslow, shipwrecks Airlie, Cossack, Cutty Sark, Eclipse and Hawk are listed in Shoreline Cells 115 and 120, and the Old Onslow Jetty in Shoreline Cell 114.

Discussion

All shipwrecks, aircraft, relics and other underwater cultural heritage provide national heritage history, however it is not anticipated that floating or dissolved oil will destroy the wrecks. A shipwreck protected under Commonwealth Maritime Cultural Heritage has been ranked higher than under State protection mechanisms, which is reflected in the rankings given (Table 3-21). Given the below rankings and distribution of maritime archaeology in the Pilbara zone, Shoreline Cells 89, 90, 94, 95, 99, 101, 109, 110, 112, 114, 115, 120, 313 and 314 are ranked Medium for protection from floating and dissolved oil.

Table 3-21: Shipwrecks protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Nationally Protected Shipwrecks			
Commonwealth Maritime Cultural Heritage	3	3	**Importance:** All shipwrecks, aircraft, relics and other underwater cultural heritage provide national heritage history, but it is not anticipated that floating or dissolved oil will destroy the wrecks, so they have been ranked as Medium priority for protection from both dissolved and floating oil.
State Protected Shipwrecks			
WA protected shipwrecks and maritime archaeology	2	2	**Importance:** These shipwrecks provide state heritage history, but it is not anticipated that floating or dissolved oil will destroy the wrecks or maritime archaeology, so they have been ranked as Low priority for protection from both dissolved and floating oil.

Data List

- DotE Australian National Shipwrecks Database (3 February 2016)
- WA Museum State Protected Shipwrecks (June 2016)

3.4 Economic

Western Australia sources a great deal of wealth from its coastal assets. For example, WA's shipping exports were worth an estimated $127 billion in 2015/16. This was a 38 per cent contribution to the nation's exports, with more than half of Australia's total trade tonnage handled by WA ports (DoT, 2016). Aquaculture and fisheries also bring in significant profits to the state and are also considered for protection in this assessment.

The following information has been assessed for economic factors in each zone:

- Aquaculture;
- State Managed Fisheries;
- Commonwealth Managed Fisheries;
- Other Commercial Operations;
- Tourism;
- Ports and Shipping; and
- Water Intake Locations.

To standardise the comparison, a ranking system has been devised using the economic value per year in relation to Western Australia's gross state product (GSP). The GSP was $249 billion in 2014-15, contributing 15% of Australia's gross domestic product (GDP) (DSD, 2015). The economic estimates presented here have not allowed for any changes in pricing and have been used as an indication at the time of this assessment. This is summarised in Table 3-22 which presents the assumed priority ranking based on economic value per year. The table also includes the time taken for fisheries and aquaculture stocks to recover.

Table 3-22: Economic determination used to priority rank economic values

Economic Annual Value	Ranking	Description
>$1B (>0.5% of State GDP) Or $501M - $1B (0.25-0.5% of State GDP) and recovery of species is >11 years	5	State managed commercial fisheries, Commonwealth managed commercial fisheries, ports and shipping, marine aquaculture and tourism. State Managed Fisheries are reported per region. Therefore the economic value for the fishery for that region is what has been used.
$501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years	4	
$101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years	3	
$21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years Or <$20M (<0.01% State GDP) and recovery of species is >11 years	2	
<$20M (<0.01% State GDP) and recovery of species is <10 years	1	

3.4.1 Aquaculture

Description

Aquaculture is defined as the cultivation of marine and freshwater organisms for human use or consumption. Aquaculture in Western Australia includes abalone, barramundi, black bream, coral, live rock, marine finfish, marron, mussels and oysters, pearls, prawns, redclaw crayfish, silver perch, trout and yabbies (Aquaculture Council of WA, 2016).

Aquaculture in WA is managed through the licencing of permits through the DoF. Aquaculture licence areas and geospatial locations were obtained from the WA DoF. It should be noted that, for confidentiality reasons, the type of aquaculture being undertaken was not able to be provided.

Distribution

Western Australia is broken down into bioregions in which aquaculture licences are managed. There are six managed bioregions that cover WA; two are present in the Pilbara:

- Gascoyne Coast Bioregion, which extends from Zuytdorp Cliffs to the Ashburton River south of Onslow; and
- North Coast Bioregion, which extends from the Ashburton River to the Northern Territory border.

Discussion

The economic impact of disruption to aquaculture depends on the marine stock being cultured, which have different recovery rates. Depending on the type of aquaculture, the effects of an oil spill will also vary. For pearl oysters, it is acknowledged that an oil spill is unlikely to affect all licence areas at once. If an oil spill affects an oyster fishery, it is likely that the year's catch will be impacted and the fishery will take three to four years to recover (DoF, 2013). However for finfish, it may take six to ten years following an oil spill for hatching to mature and reach a size appropriate for market. In the event of a spill, dissolved oil is expected to have the highest impact, however, the total impact will depend on their age and maturity.

Coral and live rock are widely varied and the diversity of coral and associated species provides considerable flexibility in the range of culture systems and technologies that can be employed. In the event of a spill, as these species are subsurface, they are expected to be affected greater by dissolved oil than floating oil, with a year's worth of stock lost or affected. The species vary from very common to very rare and therefore recovery time is just as varied.

Individual values for each aquaculture type however are not available, for confidentiality reasons. Therefore for the purposes of this assessment, all aquaculture licence areas have been given a single protection priority ranking (Table 3-23).

Due to aquaculture sites listed in Shoreline Cells 99, 110, 117 and 121, these cells are given a ranking of Low for protection from floating oil and Medium for protection from dissolved oil.

Table 3-23: Aquaculture protection priority ranking

Type (in each Region)	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Aquaculture Licenced Areas			
Aquaculture Licenced areas	2	3	**Importance:** Pearls & Pearl Oysters $67M annual value in 2014 (DoF, 2014), <10 year recovery
Data List ▪ DoF aquaculture licence areas (March 2015)			

3.4.2 State Managed Commercial Fisheries

Description

WA State managed commercial fisheries occur in all WA state waters, and contributed $1.5 billion to WA's Gross State Product from commercial and recreational fishing sectors in 2014/15 (DoF, 2015e). $490 million was the value of the State's commercial fisheries, which includes aquaculture production. A total of 2,191 commercial fishing licences were issued in 2014/15 (DoF, 2015e).

Prawns harvested for commercial use in WA mostly consist of brown tiger (tiger), western king (king) and banana prawns, and live in nearshore coastal waters (DoF, 2013b). They typically don't surface so they are not expected to be directly affected by floating oil. If affected in oceanic waters, recovery time is typically one to two years, as they take six to eight months to reach maturity, but not all species spawn throughout the year (DoF, 2013b). All commercial data for prawn fisheries

was multiplied by a recovery factor of two years. Prawns are collected using an otter trawler at water depths around 15-60 m (Kangas *et al.*, 2006).

Crabs targeted for commercial fishing in WA are typically blue swimmer crabs. They live in estuaries, sheltered bays and offshore waters up to 50 m deep. They typically don't surface, so they are not expected to be directly affected by floating oil. Recovery time if affected by dissolved oil is one to two years for complete biological recovery, as they take a year to reach maturity (DoF, 2015a). Commercial data for crab fisheries was multiplied by a recovery factor of two.

Demersal fisheries, including the West Coast Inshore Demersal suite and Gascoyne Demersal Scalefish Fishery, occur in waters 20-250 m deep with approximately 100 species targeted. The most important species are West Australian dhufish and pink snapper, with other species captured including redthroat emperor, bight redfish and baldchin groper (DoF, 2015c). Pink snapper mature at around four years (DoF, 2015b) and are demersal (bottom-dwelling), but also spend some of their lives in the mid to upper water levels. Therefore they are likely to take four to ten years to recover.

Beche-de-mer are also known as sea cucumbers or trepan, and are in the Phylum *Echinodermata*, Class *Holothuroidea*. They are soft-bodied, elongated animals that usually live with their ventral surface in contact with the benthic substrate or buried in the substrate. They are collected by hand, by diving or wading in shallow waters. The recovery factor of sea cucumbers in an environment of severe depletion can be as much as 50 years (FAO, 2008). Within the Pilbara zone, there are seven State managed commercial fisheries:

- Nickol Bay Prawn Managed Fishery;
- Onslow Prawn Managed Fishery;
- Exmouth Gulf Prawn Managed Fishery;
- Exmouth Gulf Developing Crab Fishery;
- West Coast Deep Sea Crustacean Managed Fishery;
- North Coast Demersal Fisheries (Pilbara Interim Fish Trawl Managed Fishery); and
- Beche-de-mer Fishery.

The commercial information for each State managed commercial fishery includes data around its annual value in millions of dollars, unless three or less licences have been issued. In this case, the value is not publically available. This information is available within the DoF Status of Fisheries Annual Reports.

Annual value has been indicated below, with recovery of fisheries also considered and ranked in reference to Table 3-20. In the extreme, pink snapper for example reaches maturity (which allows them to reproduce) between the ages of four to eight years, and lives to the age of 30-45 years. Therefore recovery time may be in the decades if the entire population was impacted. However as the fishery area is so large, while this is possible, it is not probable, and in all cases the economic annual value has been used as the primary indicator of protection priority.

Distribution

The catch target species and location for each fishery is outlined in Table 3-24. The Onslow Prawn Managed Fishery covers one-third of the Pilbara zone from Shoreline Cells 106 to 115 and offshore around the islands as far as Shoreline Cell 326 (Tortoise Island) in the west and Shoreline Cell 316 (Cape Bruguieres) in the east.

The Nickol Bay Prawn Managed Fishery covers half of the Pilbara zone, from Shoreline Cell 103 to the boundary with Zone 1 to Shoreline Cell 88 in the east. It extends 130 nm offshore, and the habitats where the prawns are harvested are mainly seagrass beds.

Exmouth Gulf Prawn Managed and the Exmouth Gulf Developing Crab fisheries are located in the Exmouth Gulf, covering Shoreline Cells 115 to 122 and the offshore islands of Serrurier, Muiron, Observation and Victor in Shoreline Cells 326 to 329 of the Exmouth Gulf.

The West Coast Deep Sea Crustacean Managed Fishery covers most of the Western Australian coastline and out to 300 nm, and the North Coast Demersal Fisheries (Pilbara Interim Fish Trawl Managed Fishery) covers all the shoreline cells in the Pilbara zone.

The Beche-de-mer Fishery is found in the Dampier Archipelago in the waters of Shoreline Cells 102 to 108 and offshore in Shoreline Cells 315 to 317. There is an isolated collection area on the eastern-most boundary of the Pilbara zone in Shoreline Cells 88 and 89.

Discussion

To determine the economic impact of an oil spill on a commercial fishery, fish stock recovery time was assessed to determine the overall impact of an oil spill on the fish stock, and the net loss the fishery would encounter as a result.

The recovery time of fish and crustacean fishing stocks depends on the lifecycle of the catch, as well as the form of impacting oil. A fishery will not be affected greatly by floating oil but will be by dissolved oil. Some stock will take two years or more to recover, such as lobsters which take four years to reach maturity, in which case it will have an economic loss of more than one year depending on the species.

Annual value has been indicated below, with recovery of fisheries also considered and ranked in reference to Table 3-22.

Table 3-24: State Managed Commercial Fisheries protection priority ranking

Value Measure	Ranking		Description
	Floating	Dissolved	
State Managed Fisheries			
>$1B (>0.5% of State GDP) Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years	4	5	State Managed Fisheries income is reported by the WA DoF per region per year. This has been coupled with the time for a species to recover, typically taken as number of years to reach maturity and reproduce, which allows sustainable commercial fishing to recommence. If the catch area (i.e. the area that catch is actually taken from in the license area) described in the Status of Fisheries report is greater than ten shoreline cells (the size of the smallest zone), then the ranking is lowered by one level.
$501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years	3	4	
$101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years	2	3	
$21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years Or <$20M (<0.01% State GDP) and recovery of species is >11 years	1	2	
<$20M (<0.01% State GDP) and recovery of species is <10 years	1	1	

Data List

- West Coast Deep Sea Crustacean (24 March 2015)
- Exmouth Gulf Prawn (3 June 2015)
- Exmouth Gulf Developing Crab Fishery (11 September 2015)
- Gascoyne Demersal Scalefish (11 September 2015)
- Onslow Prawn (20 April 2015)
- Nickol Bay Prawn (11 September 2015)
- Kimberley Gillnet and Barramundi (11 September 2015)
- Pilbara Trap (11 September 2015)
- Pilbara Fish Trawl (3 January 2013)
- Pilbara Line (11 September 2015)
- Northern Demersal Scalefish (3 September 2013)
- Mackerel Managed (8 November 2012)
- Pearl Oyster (24 March 2015)
- Beche-de-mer Fishery (11 September 2015)
- Pilbara Developmental Crab (11 September 2015)
- Marine Aquarium Fish (11 September 2015)
- Specimen Shell (11 September 2015)
- Land Hermit Crab (22 August 2015)
- Invertebrate Exemption (20 April 2015)
- DoF Annual Fisheries Report (2014-15)

3.4.3 Commonwealth Managed Fisheries

Description

Commonwealth fisheries contributed approximately $400 million in gross value of product to Australia in 2015-16 (AFMA, 2016). The fisheries are typically limited to the Commonwealth waters (from the state waters boundary to the Exclusive Economic Zone, 200 nautical miles from land) and administered by the federal Australian Fishing Management Authority (AFMA).

The permit area for each fishery is often a very large portion of Australia's Exclusive Economic Zone, so the area of concentrated effort for each fishery for the years of 2000 to 2015 has been used. This was provided by AFMA. This data allows a smaller area of economic importance for the fishery to be identified, rather than the entire permit area.

There are three Commonwealth managed fisheries which overlap the Pilbara zone. These are:

- Western Tuna and Billfish Fishery;
- Western Skipjack Tuna Fishery; and
- Southern Bluefin Tuna Fishery.

Distribution

All three of the Commonwealth managed fisheries listed above cover the entire Pilbara zone.

The Western Tuna and Billfish Fishery is managed by limiting the catch of tuna and billfish species, restricting how many boats can fish and regulating what gear they can use. The species caught in the fishery are also caught by many other countries. Australia's catch of tuna and billfish is a very small part of the total catch internationally. There are records of catches in the Pilbara zone so this has been included in the assessment.

The Western Skipjack Tuna Fishery covers the entire sea area around Australia, out to 200 nm from the coast. It is split into two sectors: the Eastern Skipjack Tuna Fishery; and the Western Skipjack Tuna Fishery. There has been no fishing effort in either of the skipjack tuna fisheries since the 2008-09 fishing season, because of the variable availability of stock and the prices received for the product. Therefore no shoreline cells in the Pilbara zone have been captured to contain areas of fishing for skipjack tuna.

The Southern Bluefin Tuna Fishery covers the entire sea area around Australia, out to 200 nm from the coast. The species is most commonly caught off the New South Wales coastline, and no areas of concentrated fishing effort overlap with any shoreline cells in the Pilbara zone.

A fourth Commonwealth managed fishery is located adjacent to the Pilbara zone, the North West Slope Trawl Fishery. It is located in deep water from the coast north and west of Exmouth, beyond Port Hedland, between the 200 m depth contour to the outer limit of the Australian Fishing Zone, but does not fall in any of the shoreline cells.

Discussion

Using the rankings from Table 3-25, all shoreline cells in the Pilbara zone are given a protection priority ranking of Very Low for protection from both floating and dissolved oil due to the presence of Commonwealth managed fisheries.

Table 3-25: Commonwealth Managed Fisheries protection priority ranking

Value Measure	Ranking		Description
	Floating	Dissolved	
Commonwealth Managed Fisheries			
>$1B (>0.5% of State GDP) Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years	4	5	Commonwealth Managed Fisheries income is reported by the Australian Fisheries Management Authority (AFMA) annually. This has been coupled with the time for a species to recover, typically taken as number of years to reach maturity and reproduce, which allows sustainable commercial fishing to recommence. Effort of fishing has also been provided by AFMA on a 10 km by 10 km grid for each fishery.
$501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years	3	4	
$101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years	2	3	
$21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years Or <$20M (<0.01% State GDP) and recovery of species is >11 years	1	2	
<$20M (<0.01% State GDP) and recovery of species is <10 years	1	1	

Data List

- Fishing effort for Western Tuna and Billfish Fishery (March 2016)
- Fishing effort for Western Skipjack Tuna Fishery (March 2016)
- Fishing effort for Southern Bluefin Tuna Fishery (March 2016)
- Commonwealth Managed Fisheries concentrated areas of fishing effort and fishery status report (AFMA, 2016)

3.4.4 Ports and Shipping

Description

Ports are used for importing and exporting goods and generate substantial economic income for WA. WA's exports accounted for more than 876 million tonnes in 2015/16 which accounted for 41 per cent of Australia's merchandise exports in 2015/16 (DoT, 2016). Exports to China alone were worth $54.1 billion.

Western Australia's trading ports are managed by either port authorities governed by the *Port Authorities Act 1999* or non-port authorities ports governed by *the Shipping and Pilotage Act 1967* and the *Marine Harbours Act 1981*. The boundaries for each port were sourced from the WA DoT.

Shipping channels have not been included in this assessment. They are primarily in open-ocean, so are not captured in the shoreline cells. In addition, vessels can generally manoeuvre around a spill, so their impact is difficult to quantify. However, where a shipping channel enters a port, this has been included in the assessment.

Distribution

There are 14 ports in the Pilbara zone; two fall in the Pilbara Ports jurisdiction. The largest is Port Hedland, which exports iron ore and is the worlds' largest bulk export port. It had 5,800 ship movements in 2014 (Pilbara Ports, 2016).

Port Hedland Port (Pilbara Port Authority) found in Shoreline Cells 93 to 95 and Port of Barrow Island (Shoreline Cells 319 to 321) have been ranked Very High for protection from both floating and dissolved oil, based on the potential impact from a spill on the port operations.

Port of Dampier (Shoreline Cells 103, 105-6, 316-317), Port Walcott (Shoreline Cells 101 to 102), Port of Onslow (Shoreline Cell 324) and Ashburton Port Area (Shoreline Cells 114 to 115 and 325), have been ranked a High for protection from floating and dissolved oil.

Varanus Island (Shoreline Cell 319) is ranked a Medium for protection from floating and dissolved oil.

Discussion

The two largest ports (Port Hedland and Barrow Island) are ranked the highest according to the value of their export. Ashburton Port has been identified as a Strategic Industrial Estate to be developed. It is given its ranking based on its future importance. A port which is not currently producing, but is forecast to produce a very high-ranked economic annual export value, is ranked High to distinguish it from active ports.

Port Hedland Port (Pilbara Port Authority) estimates exports based on iron ore alone are $44B in 2014 (444 million tonnes exported in 2014/15) (DoT, 2015). This clearly puts Port Hedland Port in the Very High ranking category.

Port of Barrow Island is privately owned and operated for exporting hydrocarbons (by Chevron Australia). Crude oil and LNG is exported from Gorgon (~$67B per year based on current oil price). This is ranked a Very High for protection from floating and dissolved oil.

Port of Dampier is the second largest import/export port in WA behind Port Hedland. Export was 171 million tonnes in 2014/15. This has been ranked a High for protection from both floating and dissolved oil, based on the potential impact from a spill on the port operations.

Port Walcott is the third largest port in WA. 149 million tonnes (total throughput) were exported in 2014/15. It is ranked a High for protection from floating and dissolved oil.

Ashburton Port is identified as a Strategic Industrial Estate to be developed. It is given its ranking based on its future importance and is given a ranking of High for protection from floating and dissolved oil.

Onslow Port is privately owned and operated by Chevron Australia for exporting hydrocarbons. Export LNG from Wheatstone is expected to start in 2017/18 (~$67B per year based on current oil

price). Onslow Port has been ranked High for protection from both floating and dissolved oil, based on the potential impact from a spill on the port operations.

Varanus Island is a privately operated port exporting hydrocarbons (operated by Quadrant Energy Ltd). Varanus produces up to 6,000 barrels of oil and condensate, and up to 390 TJ of gas per day (Quadrant Energy, 2016). The exports total $38M + $78M (based on AUD $38/bbl and AUD$0.55 per GJ), which is more than $101M per annum, giving it a ranking of Low for protection from the impacts of floating and dissolved oil.

Port of Cape Preston is not yet operating and will export iron ore for CITIC Pacific Ltd/Mineralogy Pty Ltd. It has been ranked Low for protection from the impacts of floating and dissolved oil.

The other ports included in the assessment are Balla Balla (proposed port with unconfirmed export tonnage), Arlie Island (decommissioned), Thevenard Island (pending decommission), Exmouth (cruise liner destination, unknown commercial importance), Point Cloates (unknown commercial importance) and Maud Landing Port Area. These have been given a ranking of Very Low for protection from both floating and dissolved oil.

Economic values are not publically available for all ports in Western Australia. The annual reports are based on tonnes of export and import. As such, the annual reported total throughput for each port has been used as a basis of ranking.

The rankings of ports by commercial significance based on tonnage throughput are presented in Table 3-26.

Table 3-26: Ports protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Ports			
>401 million tonnes annually	5	5	**Importance:** Significant import and export for the state, resulting in an estimated very high economic value equivalent to >$1B annually, in line with Table 3-22.
101-400 million tonnes annually	4	4	**Importance:** Major import and export for the state, resulting in an estimated high economic value equivalent to $501M-$1B annually, in line with Table 3-22.
11-100 million tonnes annually	3	3	**Importance:** Medium import and export for the state, resulting in an estimated moderate economic value equivalent to $101M-$500M annually, in line with Table 3-22.
1.1-10 million tonnes annually	2	2	**Importance:** Minor import and export for the state, resulting in an estimated low economic value equivalent to $101M-$500M annually, in line with Table 3-22.
<1 million tonnes annually	1	1	**Importance:** Very minor import and export for the state, resulting in an estimated very low economic value equivalent to <$20M annually in line with Table 3-22.

Data List

- DoT Annual Report – WA Ports (2014)
- DPI Port Authorities (October 2010)

3.4.5 Water Intake Locations

Description

Seawater is sucked from the ocean in some industries for various processes. These include creating potable water via reverse osmosis, cooling water for large machinery, and fresh seawater for aquaculture. Oil sucked into an intake can cause damage to the operating facility and, depending on the facility, the damage may be significant. The DoT has created a dataset of known locations of prescribed premises that intake ocean water. The dataset includes locations of known major outfalls, and locations of proposed major industrial developments that may require seawater intake.

This dataset has been supplemented with DoF aquaculture and research facility seawater intake locations.

In this assessment, only intake locations were deemed to be potentially affected by an oil spill, so outfalls are not included in this assessment.

Distribution

There are eight intake locations in the Pilbara zone.

There is a desalination plant intake in Shoreline Cell 94 which is the Fortescue Metals Group Desalination Plant at Anderson Point, and one in Shoreline Cell 106 which is a Water Corporation intake.

Shoreline Cells 106 (Dampier Salt) and 114 (Onslow Salt) contain saltwater intakes for solar salt plants.

The other purpose for the ocean intake is for LNG processing on the Burrup Peninsula and near Onslow, in Shoreline Cells 106 and 115 respectively.

In Shoreline Cell 106 (Burrup), there is an intake for power station cooling. This is the Pilbara Iron Company (Rio Tinto) power station which is not in use.

Discussion

Water intakes will generally stop operating to limit the impact the oil spill will have on their product. While the intake locations are fixed and are impacted equally by floating and dissolved oil, the scale of the impact is very low due to the likely dilution and monitoring processes in place at these facilities.

A reverse osmosis desalination plant may be able to cease pumping for a time. The production loss is not readily quantified, but their repair and maintenance as a result of oil impact is substantial. These have been given the highest ranking for water intakes, with a High for protection from floating oil and a Very High for protection from dissolved oil. The desalination plant intake in Shoreline Cell 106 is given this protection priority.

Cooling water intakes are less sensitive and can keep running during light oiling. Where they are at the surface, a boom around the intake would be enough to keep them running, and where they are below the surface, it is assumed that the dissolved or entrained oil would be at a low enough

concentration that they can keep running. Shoreline Cells 106 and 115 for the cooling water intakes for the Pluto and Wheatstone LNG processing facilities are ranked Low for protection from dissolved and floating oil. Shoreline Cell 106 (Burrup) has an intake for power station cooling. This is the Pilbara Iron Company (Rio Tinto) power station and has therefore also been given a Low priority for protection from both floating and dissolved oil.

The economic impact of ceasing pumping from the ocean intake at a solar salt facility is likely to be moderate in terms of the state's GDP, with Dampier Salt in Karratha producing 3 Mtpa and Onslow Salt producing 1.5 Mtpa (EPA, 1991). The revenue of salt is in the order of $44/ton (Freedonia, 2014), meaning a potential impact of $133M if an oil spill was to impact a year's production of salt. This is however unlikely because a salt facility can stop pumping seawater into the evaporation ponds for a period of time. Shoreline Cells 106 (Dampier Salt) and 114 (Onslow Salt) contain saltwater intakes for solar salt plants, and have been ranked Low for protection from both floating and dissolved oil.

Table 3-27: Seawater Intake Locations protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Water Intake Locations			
Reverse osmosis potable water plant seawater intakes	4	5	**Importance:** The seawater intake points in WA are positioned at the mid water depth and normally offshore, to reduce the potential for an oil slick to be drawn in. These intakes can be shut down and rely on dams to supply product for short periods, however, they are very vulnerable to oil destroying the membranes. It is estimated that it would cost $20M-$100M to replace all membranes in a reverse osmosis plant, and cost the State many more millions of dollars to source drinking water while it is being replaced.
Cooling water intakes for power stations	3	3	**Importance:** Cooling water intakes are far less sensitive and can keep running during light oiling. Where they are at the surface, a boom around the intake would be enough to keep them running; where they are below the surface, it is assumed that the dissolved or entrained oil would be at a low enough concentration that they can keep running.
Salt works seawater intakes	2	2	**Importance:** If an oil spill occurred, salt water intake would cease and production would stall until the potential for contamination had passed. A salt works facility has detectors on the intakes to screen for any contamination, to allow pumping into the evaporation ponds to cease and not contaminate the salt being produced.
Aquaculture seawater intakes	2	2	**Importance:** Onshore aquaculture facilities would lose their stock. This is expected to have a 'low' economic impact as the onshore aquaculture facilities are small.
Seawater intakes for LNG facilities	2	2	**Importance:** These are proposed intakes only and not operational, so have been ranked lower than operational cooling water intakes. LNG facilities use seawater for cooling. Cooling water intakes are less sensitive and can keep running during light oiling. Where they are at the surface, a boom around the intake would be enough to keep them running; where they are below the surface, it is assumed the dissolved or entrained oil would be at a low enough concentration that they can keep running.

Data List

- OSRA seawater intake locations and types (April 2011)
- DoF Aquaculture and research facility intake and outfall locations (December 2016)

3.4.6 Other Commercial Operations

A number of other commercial operations occur in WA state waters and near the coast. This includes oil and gas operations, salt works, power stations and mining facilities. Subsea pipelines have not been included in this assessment as their operation is not expected to be affected by an oil spill.

Oil and gas facilities in state waters may experience economic loss through a safety requirement to shut facilities if an unrelated oil spill enters their operational zone. Offshore oil and gas facilities have not been included as they do not fall in the shoreline cells, however associated infrastructure aspects are included (see Section 2.5 for further information).

Other commercial operations such as salt works and power stations have been accounted for through their infrastructure associated with the marine environment, which are port facilities and seawater intakes. Refer to Section 3.4.4 and Section 3.4.5. Salt works are covered under seawater intakes, as are power stations and other facilities that use seawater either in a cooling process or for other purposes.

It was not feasible to capture proposed (future) oil and gas developments in this study, because there was no way to determine the scale of the impact and thus determine a protection priority ranking.

3.4.7 Tourism

Description

Tourism is a key economic driver, generating more than 97,000 jobs and injecting $10 billion into the Western Australian economy by Gross State Product (Tourism WA, 2016). Coastal and waters tourism is a significant portion of this income due to the majority of the towns, infrastructure and sites located along the coast. A distinction has been made in this assessment between activities that draw tourists to a site and generate economic income, and those activities undertaken by locals for recreational purposes. This section assesses activities that generate economic income via tourist activities in the Pilbara zone such as:

- Whale and dolphin watching;
- Scuba diving and snorkelling;
- Beach activities such as surfing;
- Sailing; and
- Hotel revenue.

Tourism Research Australia (TRA) publishes data annually on the income from tourism (TRA, 2016). This data is available per tourism region, and in the Pilbara zone the following regions are included in this assessment:

- Exmouth;
- Ashburton;
- Karratha; and
- Port Hedland.

In August 2016, TRA released an update for 2014-15 on the Tourism Satellite Account (TSA).

A TSA is a set of statistical tables based on data from the Australian Bureau of Statistics, which measure the contribution of tourism to the Australian economy. The TSA reports the contribution of tourism to the economy in relation to total output, value added and employment. TSAs need to be developed because there is no tourism 'industry' identified in the current national accounting framework.

Distribution

The contribution from tourism ranges from $208M per annum in Karratha to $77M per annum in Ashburton. The total revenue from tourism in Western Australia is $8,689M, of which 1-2% comes from the Pilbara region (TRA, 2014).

Discussion

To produce an opportunity cost for tourism to include in this assessment, the value of the tourism in millions of dollars per annum was assigned to the shoreline cell where each of the major centres are located in the regions. Realistically in the event of an oil spill, the impact on tourism is expected to be locally restricted to the shoreline cell where the impact occurs. It is important to identify the shoreline cells which contribute to the economy via tourism and thus be aware that, when planning a response to an oil spill, secondary impacts to tourism may be the result. The rankings for protection priority are presented in Table 3-28.

Based on these rankings all shoreline cells in the Pilbara zone are given a ranking of Very Low for protection from both floating and dissolved oil, as the Pilbara zone provides a fairly minor portion of the state's tourism.

Table 3-28: Tourism protection priority category

Tourism Area	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Tourism Region key population centre >10% of State income from tourism	3	3	Income from tourism as a proportion of the state-wide tourism revenue is greater than 10%, indicating a significant contribution by tourism in that shoreline cell.
Tourism Region key population centre 5-10% of State income from tourism	2	2	Income from tourism as a proportion of the state-wide tourism revenue falls between 5-10%, indicating a significant contribution by tourism in that shoreline cell.
Tourism Region key population centre <5% of State income from tourism	1	1	Income from tourism as a proportion of the state-wide tourism revenue is less than 5%, indicating that the priority for protection at a state level is less than for other areas contributing more revenue.

Data List

- TRA 2015 for TSA boundaries and tourism statistics for 2015

3.5 Social, Amenity and Recreation

The social, amenity and recreational importance of an area has been assessed by considering:

- Town population;
- Recreational fishing/boating zones;
- Jetties, marinas and yacht clubs;
- Snorkelling sites; and
- Beaches.

The towns located in the Pilbara zone along with their population size are listed in Table 3-29.

Table 3-29: Towns in the Pilbara zone and their approximate populations

Town	Population
Port Hedland	~20,000
Karratha	~26,000
Dampier	~2,000
Onslow	~1,000
Learmonth	~500
Exmouth	~2,500
Coral Bay	~4,500

3.5.1 Recreational Fishing/Boating Zones

Description

Recreational fishing and boating are key recreational activities undertaken in WA. These activities are often associated with marine management areas and marine parks. The marine park dataset has been sourced from the DotE CAPAD Marine dataset and an updated DPaW CAPAD dataset. These two datasets include areas in the marine park category, with designations including:

- Sanctuary Zones;
- Recreational Zones;
- Special Purpose Zones; and
- General Use Zones.

Distribution

In the Pilbara zone, the Ningaloo Marine Park is the most well-known, located at the western edge of the zone. The Muiron Islands Marine Management Area is adjacent to the Ningaloo area on the edge of the Exmouth Gulf. Between Exmouth and Karratha are the Barrow Island Marine Management Area and Marine Park, and the Montebello Islands Marine Park. Adjacent to Karratha are the proposed Dampier Archipelago Marine Park and Regnard Island Marine Management Area.

Since these zones are generally smaller subsets in a marine park category which is used for the full range of recreational pursuits, the category level was assigned a relatively low weighting.

Discussion

The use of the marine park and management areas is related to water-based recreational pursuits. The impact from an oil spill will be a tendency to avoid the area, with flow-on effects in local regional commercial benefit. When ranking the marine parks for impacts from an oil spill, floating oil will visually detract from people pursuing fishing or water sports in these areas. Dissolved oil may impact on species and decrease the catch for an area. The significance of an oil spill is largely related to the amount of oil which comes ashore and is present in the fishing and recreational zones; and its impact on visual amenity. The rankings for recreational fishing/boating zones are presented in Table 3-30.

Based on these rankings, shoreline cells associated with the Marine Parks in the Pilbara are ranked Low for protection from floating oil and dissolved oil. These shoreline cells include the ones encompassing Ningaloo Marine Park (Shoreline Cells 121 to 131 and 329), Montebello and Barrow Islands (Shoreline Cells 318 to 322) and Eighty Mile Beach (Shoreline Cells 88 to 90).

Table 3-30: Recreational Fishing/Boating Zones protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Multi-Use Zones (for boating and fishing)			
Marine Management Areas	2	2	**Importance:** Floating oil will visually detract from people pursuing fishing in these areas. Dissolved oil may impact on species and decrease the fishing for an area.
Marine Parks	2	2	**Importance:** Floating oil will visually detract from people pursuing fishing in these areas. Dissolved oil may impact on species and decrease the fishing for an area.
Marine Nature Reserve	2	2	**Importance:** Floating oil will visually detract from people pursuing marine recreation in these areas. Dissolved oil may impact on species and decrease the fishing/species to observe, and the visual amenity of an area.

Data List

- DotE CAPAD multi-user zones in marine management areas or marine parks (June 2014)
- DPaW CAPAD (June 2016)

3.5.2 Beaches

Description

WA has some of the most iconic beaches in Australia. From the unique Shell Beach at Monkey Mia in the north to the pure white sandy beaches near Esperance in the south, many people who live in WA choose to do so to be near the beach. Beaches are used for recreation, amenity and social events and may be significant to local residents as well as tourists. The dataset for patrolled beaches in WA was obtained from Surf Life Saving WA, who provided annual visitor statistics of their patrolled beaches.

The protection priority of beaches associated with tourism has been captured indirectly in Section 3.4.7. Tourism is where the experience associated with a major centre includes beach-based activities (e.g. fishing from shore).

The beaches data in the DMP Coastal Landforms dataset was used to identify 'sandy' in the shoreline geomorphology, because the more popular beaches tend to be those with wide sandy beaches (i.e. fine- to medium-grained sand beaches). This was used as a proxy for actual visitation data to identify shoreline cells with potentially popular beaches.

Distribution

Turquoise Bay, near Exmouth (Shoreline Cell 124) is ranked as one of the top ten beaches in Western Australia by Tourism WA. Shoreline cells around Port Hedland (Shoreline Cells 94 and 101 to 108) have sandy beaches including Airey Point, Beebingarra Creek, Finucane, Honeymoon Cove, Mount Beach, Bougner Entrance, Searipple Passage, Dolphin Island and a number of other beaches in the DMP Coastal Landforms dataset.

Shoreline cells near Onslow (114 and 115) contain Coolgra Point and Baresand Point beaches, which appear in the DMP Coastal Landforms dataset.

Discussion

Beaches in the context of social aspects are mainly used for recreation, and may be significant to local residents as well as tourists. The dataset regarding number of visitors for patrolled beaches was obtained from Surf Life Saving WA, however none of these beaches fall in the Pilbara zone.

There are no 'Blue Flag' beaches in Australia (Denmark, 2016) and there is no standardised ranking system for beaches in Australia in terms of amenity, patronage and popularity.

Priority ranking is based on the number of visitors. As the estimated number of visitors was not provided for all beaches, the Low ranking is based on the amenity impact from floating oil, due to the population sizes of the closest towns (Table 3-29). Turquoise Bay (Shoreline Cell 124) has been ranked Low for protection from floating oil and Very Low for protection from dissolved oil.

All other beaches listed in shoreline cells described above also give a ranking of Low for protection from dissolved oil and Very Low for protection from floating oil based on Table 3-31 below.

Table 3-31: Beaches protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Beaches			
Beaches with >1 million visitors a year	3	2	**Importance:** The ranking is based on the amenity impact from floating oil being more socially unacceptable and more visually impacting than dissolved oil.
Beaches with >100,000 visitors a year	2	1	
Beaches with <100,000 visitors a year	1	1	

Data List

- Top ten beaches, Western Australia (www.westernaustralia.com, 2016)
- Surf Life Saving WA patrolled beaches (2016)
- DMP Coastal Landforms dataset (May 2016)

This page intentionally left blank.

4 Summary of Protection Priority Rankings

The following tables summarise the value indicators (e.g. threatened mammals, marine protection areas, commercial fishing areas, etc.) used for each of the five categories for floating hydrocarbons (Table 4-1) and dissolved hydrocarbons (Table 4-2). They illustrate the comparative protection priorities between the five categories for the shoreline cells.

Table 4-1: Summary of value indicators and their protection priority for floating hydrocarbons

	Very Low	Low	Medium	High	Very High
Protected Fauna	▪ CR species if extinct (birds, mammals, invertebrates, reptiles) ▪ Normal range for EN species (fish) ▪ Normal range for VU, Migratory or Marine species (mammals and fish) ▪ All areas Known for VU species (invertebrates) ▪ All other conservation codes (birds) ▪ Terrestrial species which do not use the intertidal zone for any instance of their lifecycle and do not use the coastal/ intertidal zone as any component of their habitat	▪ Known/migration area for CR species which are Very Certain or Moderately Certain (birds, mammals) ▪ Normal range for EN species (birds, mammals and terrestrial invertebrates) which are Moderately Certain ▪ Normal range for VU, Migratory or Marine species (birds, furry marine mammals) which is Certain or Moderately Certain ▪ Southern right whale: all calving areas ▪ Breeding/aggregation area for VU, CD and P1-P4 Migratory or Marine species and normal range for CR species (fish) Certain ▪ Foraging and inter-nesting for VU species (Certain) and all Migratory and Marine species and all CD, P1-P4 species (invertebrates, reptiles) Certain and Moderately Certain	▪ Likely/Moderately Certain habitat for CR species. Breeding areas for EN species (birds) if Moderately Certain ▪ Breeding/aggregation for VU species if sighting Very Certain (birds) ▪ Breeding/aggregation area for VU, normal range for CR species (mammals, furry marine mammals and terrestrial invertebrates) Certain and Moderately Certain ▪ Breeding/aggregation area for CR species (fish) Moderately Certain and EN species Very Certain or Certain ▪ Foraging and inter-nesting for EN species and nesting/breeding area for VU species (reptiles) Certain or Very Certain	▪ Known habitat for CR species breeding area/migration route for EN species (birds) and sighting is Certain ▪ Breeding/aggregation area for EN species (birds, mammals, furry marine mammals and terrestrial invertebrates) is caught/trapped or sighting Very Certain or Certain ▪ Breeding/aggregation area for CR species (fish) and caught, trapped or sighted is Certain/Very Certain ▪ Foraging and inter-nesting for CR species and nesting/breeding area for EN species (reptiles) Certain or Moderately Certain	▪ Breeding area for CR species (birds and terrestrial invertebrates) which are caught/trapped and sighting is Very Certain/WAM Vouchered/Certain ▪ Breeding/calving/ congregation, aggregation area for CR species (mammals) Certain and Very Certain ▪ Nesting/breeding area for CR species (reptiles) where sighting is Very Certain
Protection Areas	▪ ESI 1 and 2: 1A Exposed rocky shore; 1B Exposed, solid man-made structures; 1C Exposed rocky cliffs with boulder talus base; 2A Exposed wave-cut platforms in bedrock, mud or clay; 2B Exposed scarps and steep slopes in clay; 9A Sheltered tidal flats with <1,000 ha per shoreline cell ▪ All terrestrial and marine conservation areas and proposed conservation areas ranked IUCN VI: 5(1)(g) reserves; 5(1)(h) reserves; Miscellaneous Reserves which do not include the intertidal zone ▪ Shoreline types: Exposed rocky shore; Exposed, solid man-made structures; Exposed rocky cliffs with boulder talus base; Exposed wave-cut platforms in bedrock, mud or clay; Exposed scarps and steep slopes in clay	▪ ESI 3, 4, 5 and 6: 3A Fine- to medium-grained sand beaches; 3B Scarps and steep slopes in sand; 4 Coarse-grained sand beaches; 5 Mixed sand and gravel beaches; 6A Gravel beaches (granules and pebbles); 6B Riprap structures and gravel beaches (cobbles and boulders) ▪ CAMRIS marc, calcareous clay, gravel, sand silt, mud pelagic clay and volcanic grit; 10D Mangroves <1,000 ha per shoreline cell; 9A Sheltered tidal flats with between 1,000 ha and 3,000 ha per shoreline cell ▪ All terrestrial and marine conservation areas and proposed conservation areas ranked IUCN II, III, IV, V which do not include the intertidal zone ▪ All terrestrial and marine conservation areas and proposed conservation areas ranked IUCN VI: 5(1)(g) reserves; 5(1)(h) reserves; Miscellaneous Reserves which include the intertidal zone ▪ Seagrass ▪ Fish habitat protection areas	▪ ESI 7, 8 and 9: 7 Exposed tidal flats; 8A Sheltered scarps in bedrock, mud or clay and sheltered rocky shore; 8B Sheltered, solid man-made structures; 8C Sheltered riprap; 8D Sheltered rocky rubble shores; 8E Peat shorelines; 9A Sheltered tidal flats >3,000 ha per shoreline cell; 9B Vegetated low banks; 9C Hypersaline tidal flats; 10D Mangroves with between 1,000 and 3,000 ha per shoreline cell ▪ All terrestrial and marine conservation areas and proposed conservation areas IUCN IA, IB which do not include the intertidal zone ▪ All terrestrial and marine conservation areas and proposed conservation areas ranked IUCN II, III, IV, V which include the intertidal zone ▪ Coral	▪ ESI 10: 10A Salt and brackish water marshes; 10B Freshwater marshes; 10C Swamps; 10D Mangroves with >3,000 ha per shoreline cell ▪ All terrestrial and marine conservation areas and proposed conservation areas IUCN IA, IB which include the intertidal zone ▪ Nationally Important wetlands ▪ Areas closed under the *Fish Resource Management Act 1994*	▪ World Heritage areas ▪ Ramsar wetlands ▪ Shoreline types: Sheltered tidal flats; Vegetated low banks; Hypersaline tidal flats; Salt and brackish water marshes; Freshwater marshes; Swamps

	Very Low	Low	Medium	High	Very High
Cultural Heritage		▪ State protected shipwrecks	▪ National Indigenous and historic heritage places and Natural heritage places ▪ Commonwealth Maritime Cultural Heritage	▪ Commonwealth National and Indigenous and historic heritage places and Natural heritage places	▪ World Heritage areas
Economic	▪ Ports throughput <1 million tonnes annually ▪ <$20M (<0.01% State GDP) and recovery of species is <10 years ▪ Commonwealth managed fisheries ▪ Majority of State managed commercial fishing locations ▪ Tourism Region key population centre <5% of State income from tourism	▪ Ports throughput 1.1-10 million tonnes annually ▪ $21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years OR <$20M (<0.01% State GDP) and recovery of species is >11 years ▪ Aquaculture licence areas ▪ Water intake locations for aquaculture seawater intakes ▪ Tourism Region key population centre 5-10% of State income from tourism	▪ Ports throughput 11-100 million tonnes annually ▪ $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years OR $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years ▪ Cooling water intakes for power stations ▪ Tourism Region key population centre >10% of State income from tourism	▪ Ports throughput 101-400 million tonnes annually ▪ $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years OR $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years	▪ Reverse osmosis potable water plant seawater intakes ▪ Ports throughput >401 million tonnes annually ▪ >$1B (>0.5% of State GDP) OR $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years
Social, Amenity and Recreation	▪ Beaches with 100,000 visitors a year	▪ Marine Parks, Marine Management Areas and Marine Nature Reserve ▪ Coastal Landforms' 'fine- to medium-grained sand beaches ▪ Beaches with >100,000 visitors a year	▪ Beaches with >1 million visitors a year		

Table 4-2: Summary of value indicators and their protection priority for dissolved hydrocarbons

	Very Low	Low	Medium	High	Very High
Protected Fauna	▪ Other Known areas for VU, CR, EN species (birds) if Moderately Certain ▪ CR species if extinct (birds, mammals, invertebrates, reptiles, fish) ▪ Normal range for EN species and Normal range for VU, Migratory or Marine species (mammals and fish) ▪ Normal range for VU (furry marine mammals) ▪ All areas for terrestrial invertebrates ▪ Foraging and inter-nesting for VU species and all Migratory and Marine species (reptiles) ▪ Terrestrial species which do not use the intertidal zone for any instance of their lifecycle and do not use the coastal/ intertidal zone as any component of their habitat	▪ ESI 3, 4, 5 and 6: 3A Fine- to medium-grained sand beaches; 3B Scarps and steep slopes in sand; 4 Coarse-grained sand beaches; 5 Mixed sand and gravel beaches; 6A Gravel beaches (granules and pebbles); 6B Riprap structures and gravel beaches (cobbles and boulders) ▪ Known habitat for CR species Moderately Certain. Breeding area for VU, EN species Very Certain (birds) ▪ Normal range for CR species. Breeding area for VU species (mammals and fish) Certain or Moderately Certain ▪ Normal range for EN species. Breeding/aggregation areas for VU (furry marine mammals, fish) Certain or Moderately Certain ▪ Nesting/breeding area for VU species (reptiles, fish) Certain, Moderately Certain	▪ Known habitat for CR species. Breeding areas for EN species (birds) ▪ Breeding/aggregation area for EN species (mammals, furry marine mammals and fish) Very Certain, Certain ▪ Known habitat for CR species migration or foraging Moderately Certain to occur (Fish) ▪ Normal range for CR species (furry marine mammals) Known or Very Certain ▪ Foraging and inter-nesting for CR species and nesting/breeding area for EN species (reptiles) Certain or Very Certain	▪ Breeding and nesting area for CR species (birds, mammals, furry marine mammals and fish) which are Certain ▪ Breeding and Very Certain EN species (fish) ▪ Nesting/breeding area for CR species (reptiles) Certain or Very Certain	▪ Known habitat for CR species breeding, congregation caught or Certain (fish)
Protection Areas	▪ ESI 1 and 2: 1A Exposed rocky shore; 1B Exposed, solid man-made structures; 1C Exposed rocky cliffs with boulder talus base; 2A Exposed wave-cut platforms in bedrock, mud or clay; 2B Exposed scarps and steep slopes in clay; 9A Sheltered tidal flats with <1,000 ha per shoreline cell ▪ All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN VI (Managed Resource Protected Area) and all other types: 5(1)(g) reserves; 5(1)(h) reserves; Indigenous Protected Areas; Miscellaneous Reserves ▪ Shoreline types: Exposed rocky shore; Exposed, solid man-made structures; Exposed rocky cliffs with boulder talus base; Exposed wave-cut platforms in bedrock, mud or clay; Exposed scarps and steep slopes in clay	▪ All conservation areas and proposed conservation areas ranked IUCN II (National Park), III (National Monument), IV (Habitat/Species Management Area), V (Protected Landscape/Seascape) ▪ All conservation areas and proposed conservation areas as defined under the *WA Conservation and Land Management Act 1984* ranked IUCN VI (Managed Resource Protected Area) and all other types (existing and proposed): 5(1)(g) reserves; 5(1)(h) reserves; Indigenous Protected Areas; Miscellaneous Reserves ▪ Algae	▪ ESI 7, 8 and 9: 7 Exposed tidal flats; 8A Sheltered scarps in bedrock, mud or clay and sheltered rocky shore; 8B Sheltered, solid man-made structures; 8C Sheltered riprap; 8D Sheltered rocky rubble shores; 8E Peat shorelines; 9A Sheltered tidal flats >3,000 ha per shoreline cell; 9B Vegetated low banks; 9C Hypersaline tidal flats; 10D Mangroves with between 1,000 and 3,000 ha per shoreline cell ▪ All marine and terrestrial conservation areas and proposed conservation areas (conservation park, national park, nature reserve) ranked IUCN IA (Strict Nature Reserve) and IB (Wilderness Area) which include the intertidal zone ▪ All conservation areas and proposed conservation areas as defined under the WA *Conservation and Land Management Act 1984* ranked IUCN II (National Park), III (National Monument), IV (Habitat/ Species Management Area), V (Protected Landscape/Seascape), ▪ Fish habitat protection areas ▪ Seagrass	▪ ESI 10: 10A Salt and brackish water marshes; 10B Freshwater marshes; 10C Swamps; 10D Mangroves with >3,000 ha per shoreline cell ▪ All marine conservation areas and proposed conservation areas (marine nature reserve, marine park or marine management area) ranked IUCN IA (Strict Nature Reserve) and IB (Wilderness Area) which include the intertidal zone ▪ Nationally Important Wetlands ▪ Shoreline types: Sheltered scarps in bedrock, mud or clay and sheltered rocky shore; Sheltered, solid man-made structures; Sheltered riprap; Sheltered rocky rubble shores; Peat shorelines ▪ Coral ▪ Areas closed under the *Fish Resource Management Act 1994*	▪ World Heritage areas ▪ Ramsar wetlands ▪ Shoreline types: Sheltered tidal flats; Vegetated low banks; Hypersaline tidal flats; Salt and brackish water marshes; Freshwater marshes; Swamps

	Very Low	Low	Medium	High	Very High
Cultural Heritage		▪ State protected maritime archaeology	▪ National Heritage Properties, Indigenous and historic heritage places ▪ Commonwealth heritage places, Indigenous and historic heritage places ▪ Commonwealth Maritime Cultural Heritage	▪ National Heritage Properties, natural heritage places ▪ Commonwealth heritage places, natural heritage	▪ World Heritage areas
Economic	▪ Ports throughput <1 million tonnes annually ▪ <$20M (<0.01% State GDP) and recovery of species is <10 years ▪ Commonwealth managed fisheries ▪ Majority of State managed commercial fishing locations ▪ Many State and all Commonwealth managed fisheries locations ▪ Tourism Region key population centre <5% of State income from tourism	▪ Ports throughput 1.1-10 million tonnes annually ▪ $21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years OR <$20M (<0.01% State GDP) and recovery of species is >11 years ▪ Aquaculture licence areas ▪ Water intake locations for aquaculture seawater intakes ▪ Tourism Region key population centre 5-10% of State income from tourism	▪ Ports throughput 11-100 million tonnes annually ▪ $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years OR $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years ▪ Cooling water intakes for power stations ▪ Tourism Region key population centre >10% of State income from tourism	▪ Ports throughput 101-400 million tonnes annually ▪ $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years OR $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years ▪ Reverse osmosis potable water plant seawater intakes	▪ Ports throughput >401 million tonnes annually ▪ >$1B (>0.5% of State GDP) OR $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years
Social, Amenity and Recreation	▪ All town sites ▪ Beaches with >100,000 visitors a year ▪ Beaches with 100,000 visitors a year	▪ Recreational fishing/boating zones ▪ Marine Parks, Marine Management Areas and Marine Nature Reserve ▪ Beaches with >1 million visitors a year ▪ Coastal Landforms' fine- to medium-grained sand beaches			

5 Analysis Method

5.1 Overview of Multi-Criteria Analysis

Using a multi-criteria analysis approach, the data layers identified for inclusion have been assigned a ranking from one (Very Low priority) to five (Very High priority) for protection from the effects of both floating and dissolved hydrocarbons, as outlined in Section 3. These rankings have then been used to produce a map showing Very Low (dark green) to Very High (red) priorities of the shoreline cells for each category, for protection from both floating and dissolved hydrocarbons. Figure 5-1 illustrates the process. Each layer has been ranked, then combined to give an overall shoreline cell map showing the highest priority areas for protection.

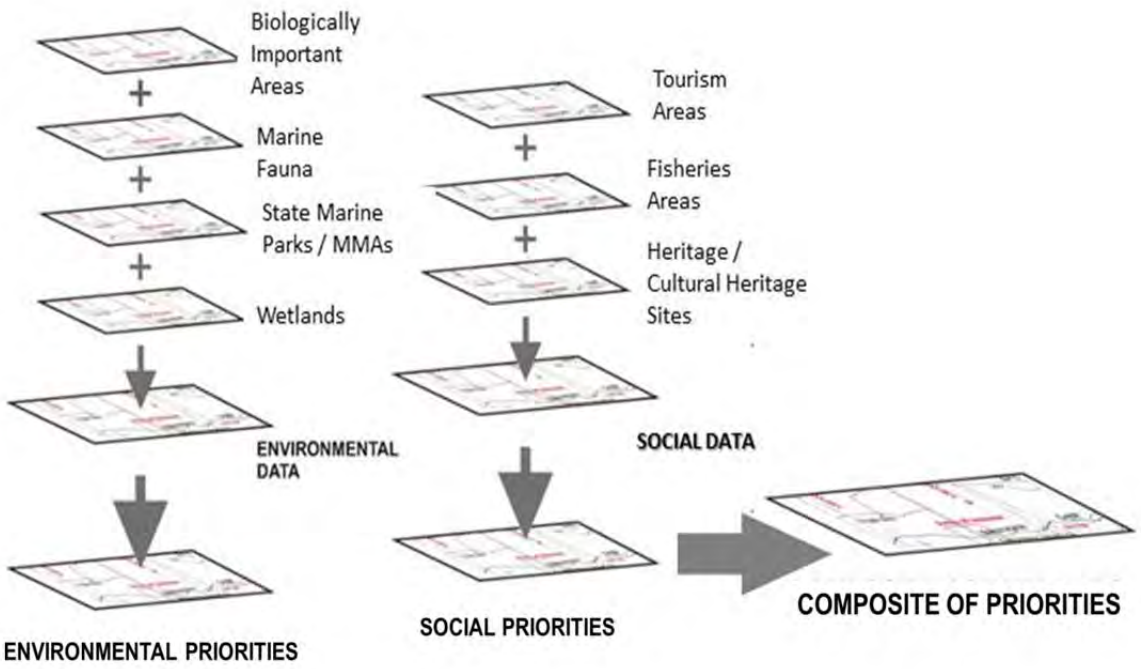

Figure 5-1: Example illustration of composite of ranked geospatial data

The map has been derived from the ranking information developed when weighting the criteria, including revised rankings developed during the State Wide Overview assessment. These define more detailed criteria for assigning protection priority rankings for Protected Fauna and Protection Areas data, to include more criteria. While the original weightings were agreed by the Steering Committee in the workshop held on 16 May 2016, the revised rankings have also been reviewed by the key Steering Committee members.

The weighted importance of all criteria has been ranked from Very Low to Very High, and the shoreline cell layer has been overlain and "clipped" or "cookie cut" to each shoreline cell, with the information extracted from the overall weighted layer and put into an attribute table (see Section 5.2).

The reasons that this method was selected for this project were:

- Known and standard method previously used with success;
- Produces a single output for each overall highest priority ranking of 'floating oil', 'dissolved oil' and 'overall';
- Produces data identifying the shoreline cells with highest protection priority, and details what aspect caused the highest ranking; and
- No scripting in the geoprocessing is required to achieve this output.

The geoprocessing which occurred to collate the multiple shapefile attributes and assign the weightings identified were as follows:

1. For each of the shapefiles in a sub-category (e.g. all the shapefiles comprising 'Protected Fauna'), the weighting has been assigned in a new column and appended to each of the shapefiles.
2. The data in each of the sub-categories has been clipped to the shoreline cells' outlines, and processed per category (i.e. protected fauna, protection areas, etc.).
3. All the sub-categories contained in Protected Fauna have been combined into a newly created single Protected Fauna category shapefile, which is the same shape as the shoreline cell, and assigned the weighting equal to the highest weighting.
4. The categories have all been treated this way until six new shapefiles were created in each shoreline cell representing Protected Fauna, Protection Areas, etc., all being categorised from Very Low to Very High.
5. This process has been repeated for floating and dissolved oil rankings for each category.
6. The overall ranking for each shoreline cell is the highest ranking value of any of the categories in each shoreline cell, identified for protection from 'floating oil' and 'dissolved oil'.

This has been used to create the map outputs as contained in Appendix A, as well as the attribute table containing the data pertaining to the highest ranked aspect from each category in each shoreline cell.

Three rankings for each category, for each cell, will be provided in the form of an attribute table to the Risk Consultant for inclusion in a WebMap Application. An extract from the first two shoreline cells in the attribute table is presented in Section 5.2.

5.2 Analysis Output: Attribute Table

The attribute table will be provided in Microsoft Excel format, with nine columns containing the following headings and information:

1. Shoreline Cell ID – Each shoreline cell has a unique identification number. This has been provided by Navigatus as an attribute in the 'WAMOPRA Coast Cells' shapefile dataset.
2. Category ID – There are six category rankings that will be provided for each shoreline cell. These are: Protected Fauna; Protection Areas; Cultural Heritage; Economic; Social, Amenity and Recreation; and Overall. These have been given a number from one to six.

3. Category Name – There are six categories: Protected Fauna; Protection Areas; Cultural Heritage; Economic; Social, Amenity and Recreation; and Overall.
4. Floating Ranking – This is the overall ranking from 1-5 of the single highest ranked protection priority at risk from being impacted by floating hydrocarbons in each shoreline cell. This ranking has been assessed and a ranking assigned for each category.
5. Dissolved Ranking – This is the overall ranking from 1-5 of the single highest ranked protection priority at risk from being impacted by dissolved hydrocarbons in each shoreline cell. This ranking has been assessed and a ranking assigned for each category.
6. Overall Ranking – This is the overall highest ranking for each category between the 'Floating Ranking' and the 'Dissolved Ranking'.
7. Brief Description Floating Oil – This is a brief description of the priority(ies) identified that have given the category its highest ranking for priority from assessment of floating hydrocarbons. NOTE: Limit is 256 characters.
8. Brief Description Dissolved Oil – This is a brief description of the priority(ies) identified that have given the category its highest ranking for priority from assessment of dissolved hydrocarbons. NOTE: Limit is 256 characters.
9. Data Source – This is the source of the data for that category that has given the cell it's ranking either for floating or dissolved hydrocarbons.

An extract from the attribute table is provided in Table 5-1.

Table 5-1: Attribute table format (Extract, Shoreline Cell number 88)

Shoreline Cell ID	Category ID	Category Name	Floating Ranking	Dissolved Ranking	Overall Ranking	Brief Description Floating Oil	Brief Description Dissolved Oil	Data Sources
88	1	Protected Fauna	4	3	4	Birds: curlew sandpiper (*Calidris ferruginea*) (CR) Known in area, eastern curlew (*Numenius madagascariensis*) (CR) Known in area	Birds: curlew sandpiper (*Calidris ferruginea*) (CR) Known in area, eastern curlew (*Numenius madagascariensis*) (CR) known in area. Fish: dwarf sawfish (*Pristis clavata*) (VU) Breeding known in area, green sawfish (*Pristis zijsron*) (VU) Breeding known in area	DotE SNES (22 February 2017), DPaW Protected Fauna (2 March 2017), DotE BIA (26 April 2016)
88	2	Protection Areas	5	5	5	Ramsar Wetland (Eighty Mile Beach)	Ramsar Wetland (Eighty Mile Beach)	DotE Ramsar Wetlands of Australia (22 April 2015)
88	3	Cultural Heritage	NA	NA	NA	NA	NA	NA
88	4	Economic	2	3	3	Eighty Mile Beach Pearling	Eighty Mile Beach Pearling	Department of Fisheries, FRDC Project No. 2000/127
88	5	Social, Amenity and Recreation	2	2	2	Marine Park, (Eighty Mile Beach) Multiple Use Zone (IUCN VI)	Marine Park, (Eighty Mile Beach) Multiple Use Zone (IUCN VI)	DotE SNES (22 February 2017), DPaW Protected Fauna (2 March 2017), DotE BIA (26 April 2016)
88	6	Overall	5	5	5	Ramsar Wetland, Eighty Mile Beach, Mangroves, Sheltered tidal flats	Ramsar Wetland, Eighty Mile Beach, Mangroves, Sheltered tidal flats	DotE Ramsar Wetlands of Australia (22 April 2015)

6 Oil Spill Risk Assessment

The attribute table containing the protection priorities information for each shoreline cell will be input into the Oil Spill Risk assessment by Navigatus for the DoT. This step will occur once an Oil Spill Risk ranking has been produced for floating and dissolved oil for each shoreline cell. The combination of the 'likelihood' (the oil spill risk) and the 'consequence' (the protection priority) for each of the protection categories (Protected Fauna, Protection Areas, Cultural Heritage, etc.) will be displayed in a WebMap Application.

A sample of this WebMap output of the combined efforts of this project and that of the oil spill risk modelling, as presented on the New Zealand Marine Oil Spill Risk Assessment website accessed via http://mosra15.navigatusconsulting.com/login, is shown in Figure 6-1.

The data created by this project will be used to populate the entries against each of the shoreline cells under each category (Protected Fauna, Protection Areas, etc.), and the corresponding colour of the cell according to its ranking in each category, from Very High to Very Low.

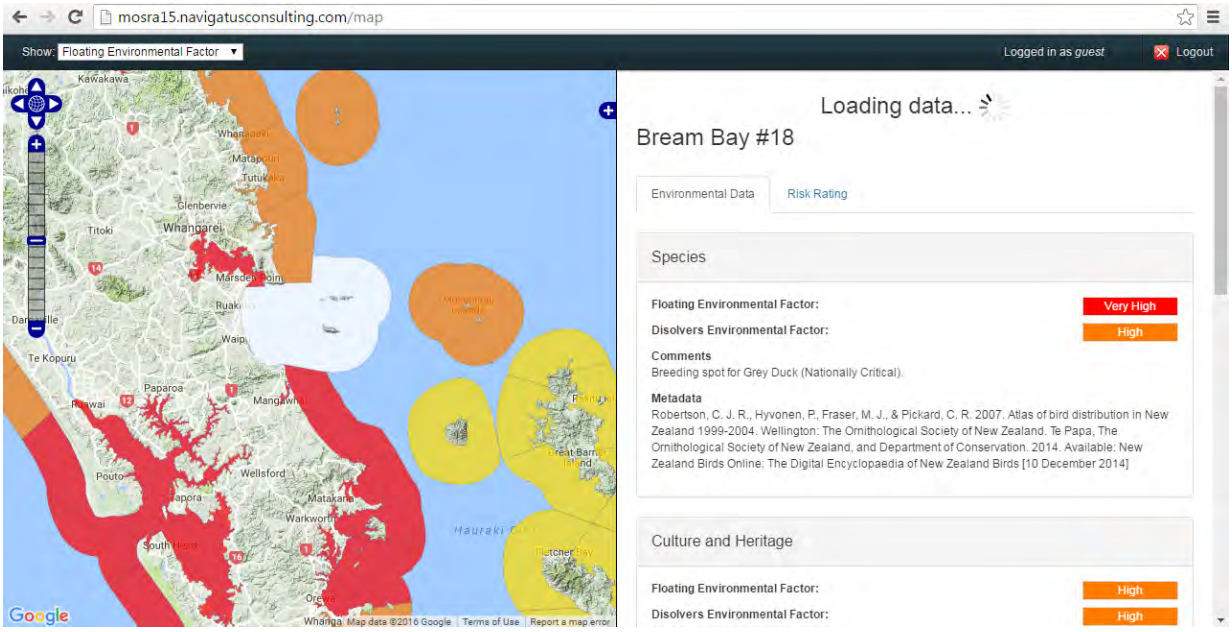

Figure 6-1: Marine Oil Spill Risk Assessment WebMap sample by Navigatus for New Zealand (accessed 31 July 2016)

This page intentionally left blank.

7 Results

Shoreline cell maps which display the cumulative effect of all the protection priorities are included in Figure 7-1 to Figure 7-3. These maps summarise the protection priorities that have been identified as a result of this project.

Included in Appendix A are a series of maps which provide additional granularity which underpins the results of the assessment. The maps are grouped for each category (i.e. Protected Fauna; Protection Areas; Cultural Heritage; Economic; and Social, Amenity and Recreation). Summary maps depict the shoreline cells in the Pilbara zone, ranked (and coloured) based on the highest ranking of any aspect present in that shoreline cell, irrespective of its spatial coverage in that shoreline cell. Two summary maps are included for each category, one each for floating oil and dissolved oil protection priority rankings.

When the protection priorities are reviewed for the cumulative effect of the rankings of floating oil, dissolved oil and overall oil effects for each of the categories, the following is apparent:

- Three shoreline cells in the Pilbara zone are ranked Very High for protection from floating oil impacts on protected fauna. These cells are located in the Exmouth Gulf, Roebourne and Barrow Island. These areas are known breeding areas for the short-nosed sea snake which is Critically Endangered. Thirty-two shoreline cells are ranked High for protection due to known habitat for the Critically Endangered eastern curlew and curlew sandpiper (birds); and known habitat for mammals including the endangered pygmy blue whale and humpback whale which are known in the area. The shoreline cells are also ranked High due to the presence of breeding areas for reptiles like the loggerhead and leatherback turtles (Endangered). The Pilbara zone is ranked High for protection from dissolved oil impacts to protected fauna in the same three shoreline cells. These rankings are for the protection of the same fauna, but ranked lower due to the lesser expected impacts on these fauna due to the oil being in a dissolved form (Appendix A: Figure A1 and Figure A2);
- Fourteen shoreline cells are ranked Very High for protection of Protection Areas from floating oil, a further 36 are ranked High; and 11 are ranked Medium and Low. For protection from dissolved oil, 14 are ranked Very High, and 26 are ranked High priority protection. These Very High and High rankings for Protection Areas cover 40 of the Pilbara zone of 62 shoreline cells. The Very High rankings for protection from both floating and dissolved oil are due to a Ramsar wetland (Eighty Mile Beach) in Shoreline Cells 88 and 89, and the Ningaloo Coast World Heritage Area which stretches across 12 shoreline cells, from 121 to 131 and 329 (Appendix A: Figure A3 and Figure A4). The shoreline cells ranked High include Nature Reserves and Important Wetlands;
- The effect of the ranking of economic impacts in the Pilbara zone sees six shoreline cells ranked Very High for protection from floating and dissolved oil. These are due to the ports of Port Hedland (Shoreline Cells 93 to 95) and Barrow Island (Shoreline Cells 319 to 321) (Appendix A: Figure A7 and Figure A8). The other economic protection priorities are for the other active ports in the Pilbara zone which have a ranking of High in 15 shoreline cells, including Port Walcott, Dampier Port, Port of Onslow and Ashburton Port;
- Twelve shoreline cells have a Very High Cultural Heritage ranking in the Pilbara zone. These cells are associated with the Ningaloo coast. There are 12 shoreline cells ranked High for Cultural Heritage and they include the Burrup Peninsula (Shoreline Cells 103 to 107) and Barrow Island (Shoreline Cells 318 to 322). There are 14 shoreline cells ranked Medium for

Cultural Heritage due to the presence of Commonwealth protected shipwrecks (Appendix A: Figure A5 and Figure A6);

- The Social, Amenity and Recreation rankings in the Pilbara zone are never higher than a Low (Appendix A: Figure A5, Figure A6, Figure A7 and Figure A8); and
- The cumulative ranking for all categories for both floating oil and dissolved oil effects, results in the majority of the Pilbara zone being ranked High (33 out of 62 shoreline cells). The remainder are ranked Very High or Medium based on the above cumulative assessment (Figure 7-3).

Protected Fauna

The **Protected Fauna** category had the most comprehensive dataset coverage of all the categories. The datasets incorporated into this category included the DotE SNES and BIA polygons, while the DPaW dataset comprised discrete points.

The majority of the Pilbara zone has been ranked High for protection from floating oil and Medium for protection from dissolved oil. This is due to the entire coastline being identified as habitat for Critically Endangered species, including birds and reptiles. The key species which use the majority of the coastline and are driving this High classification in the Protected Fauna category are the Endangered loggerhead and leatherback turtles, the southern right whale and the Critically Endangered curlew sandpiper and eastern curlew.

Protection Areas

There were 13 datasets used to identify **Protection Areas** across all zones in WA, including the Pilbara zone. The most comprehensive of these is the DotE compiled CAPAD datasets for marine and terrestrial areas and the updated dataset by the WA DPaW. Other key datasets were for internationally and nationally important wetlands (Ramsar wetlands and Nationally Important Wetlands datasets). These are Commonwealth provided datasets and identify key areas for protection in the event of an oil spill. The key dataset identified for future improvement was the OSRA ESI dataset. This is a state-wide dataset but it has a portion of areas 'unclassified' and others classified as 'island'. The DPaW Marine Habitats dataset was extremely useful as it is highly detailed and well classified, however it is only for marine and coastal areas under DPaW management. Whilst this covers a significant portion of state waters, it is still recognised as a limited dataset.

The Protection Areas which have been ranked Very High are associated with important habitat protection zones around Ningaloo, and the areas which have been ranked High are those with habitat protected under Commonwealth and Federal legislation. Where the coastline has been ranked High for protection from dissolved oil, these are the areas which contain important wetlands and IUCN type IA Nature Reserves. The majority of the coastline has been ranked High for protection from floating oil, with the exceptions being those shoreline cells which have been classified as exposed tidal flats.

Cultural Heritage

The key state-wide datasets used in this category were the DotE provided World Heritage Areas dataset, National Heritage Areas dataset, Commonwealth Heritage Places and the Australian National Shipwrecks Database, and the State provided Cultural Heritage datasets for the same heritage. These are comprehensive and cover the Commonwealth and State protected **Cultural Heritage** values of WA.

The impact on Cultural Heritage including maritime shipwrecks is the same for dissolved oil and floating oil for all shoreline cells in the Pilbara zone. 38 shoreline cells have been ranked for Heritage; of these, 12 have been ranked Very High due to the presence of the Ningaloo coast World Heritage Area. 12 have been ranked High due to DotE National Heritage-listed places (Appendix A: Figure A5 and Figure A6).

In the other 14 Medium ranked shoreline cells, there are a total of 109 Nationally-protected shipwrecks. Shoreline Cells 94 (Port Hedland) and 104 (Dampier, Delambre Island) have the most shipwrecks.

Economic

The key datasets used to identify the key **Economic** priorities for protection were the Ports and Shipping datasets and State and Commonwealth Managed Fisheries datasets. These datasets are comprehensive and state-wide. Individual geospatial shapefiles for the fisheries took a long time to incorporate into the rankings due to the different management of species under each fishery. It made this process quite complicated.

The priority for protection from floating oil on Economic aspects has resulted in a ranking of Very High in seven shoreline cells. There are 14 ports in the Pilbara zone; six fall in the jurisdiction of Pilbara Ports Authority. The largest is Port Hedland, which exports iron ore and is the world's largest bulk export port. It had 5,800 ship movements in 2014 (Pilbara Ports, 2016).

The protection priority in another 15 shoreline cells has been ranked High due to other ports being present; the presence of so many ports in the Pilbara zone has resulted in clusters of Very High and High at five key points along the coast, covering a total of 22 shoreline cells which is 35% of the Pilbara zone. The State managed fisheries have been ranked Low in the Pilbara due to their large extent over the coastline, and therefore do not contribute to any of the Medium or higher rankings.

Social, Amenity and Recreation

Three state-wide datasets were key to identifying **Social, Amenity and Recreation** values in the Pilbara zone. These were the multi-use zones of the marine parks and reserves in the DotE CAPAD Marine and DPaW updated CAPAD datasets (2016). The other key data was popularity information for WA beaches, sourced from Surf Life Saving WA and the DMP's Coastal Landforms dataset for sandy beaches, which was used as a proxy for potentially popular beaches. This is because there was no data from Surf Life Saving WA in the Pilbara zone.

The results for the assessment of protection priority for Social, Amenity and Recreation aspects have indicated that the Pilbara zone has an overall Low risk ranking for protection from floating and dissolved oil.

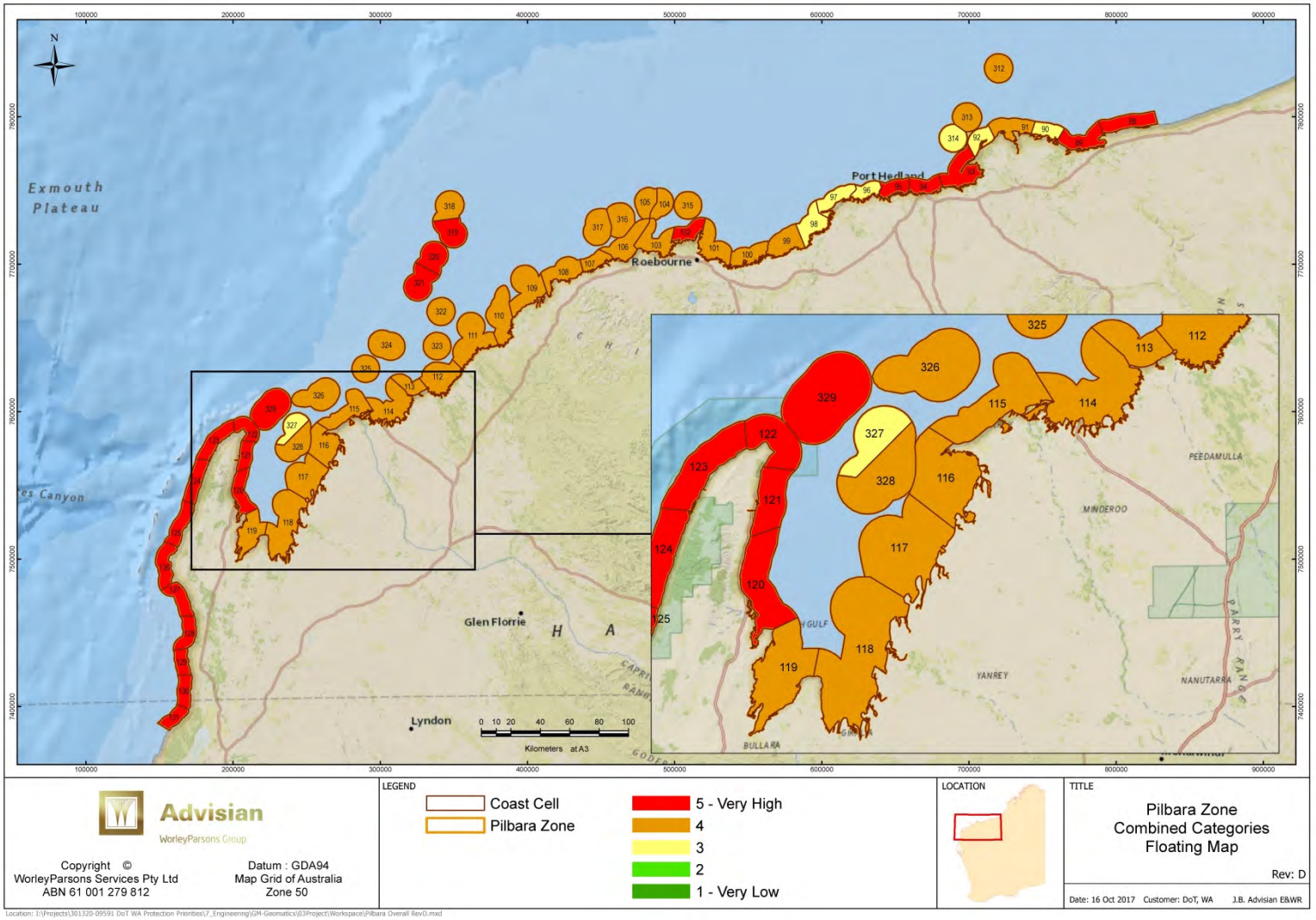

Figure 7-1: Cumulative (including all category rankings) shoreline cell protection priority ranking for floating hydrocarbons effects

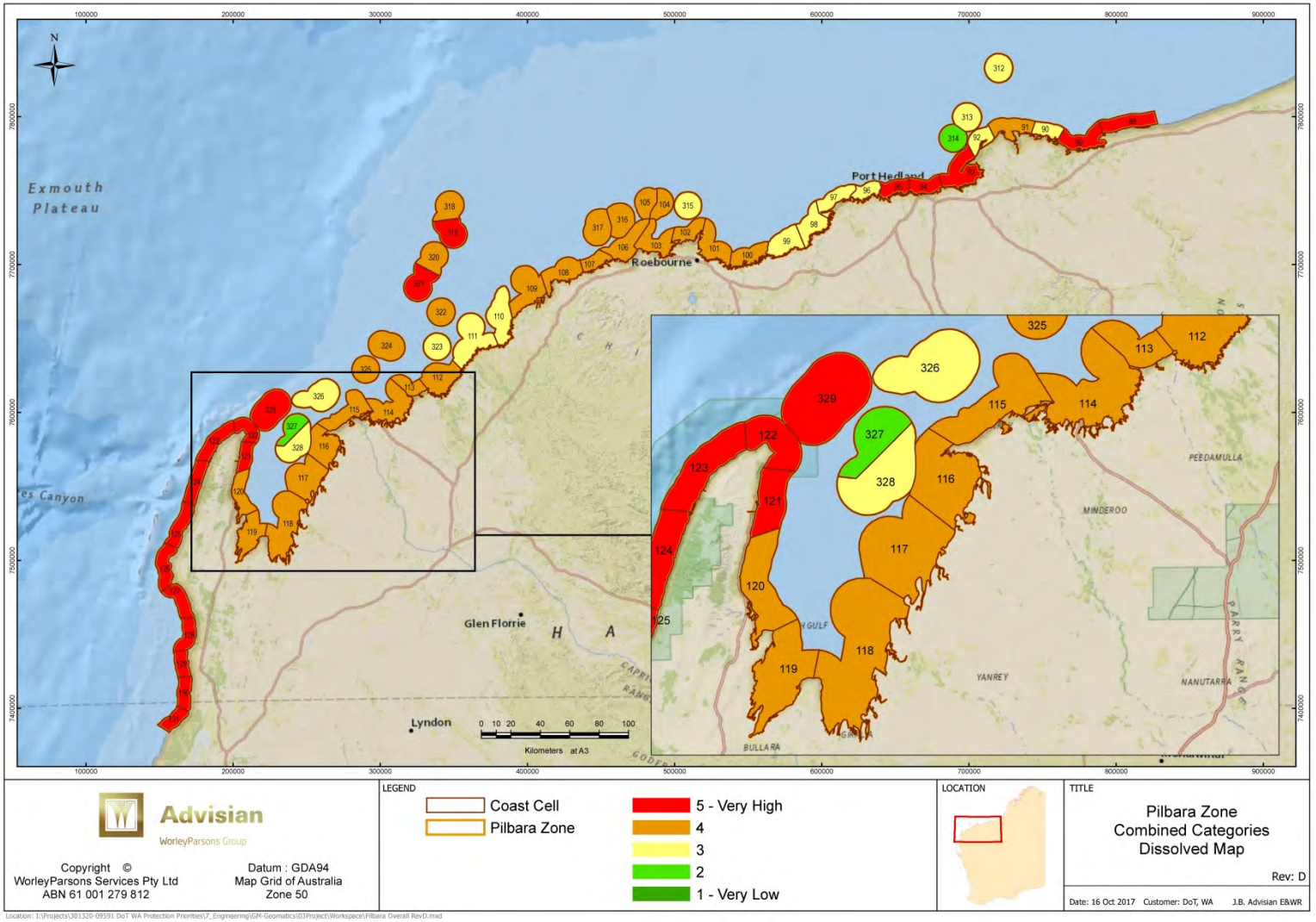

Figure 7-2: Cumulative (including all category rankings) shoreline cell protection priority ranking for dissolved hydrocarbons effect

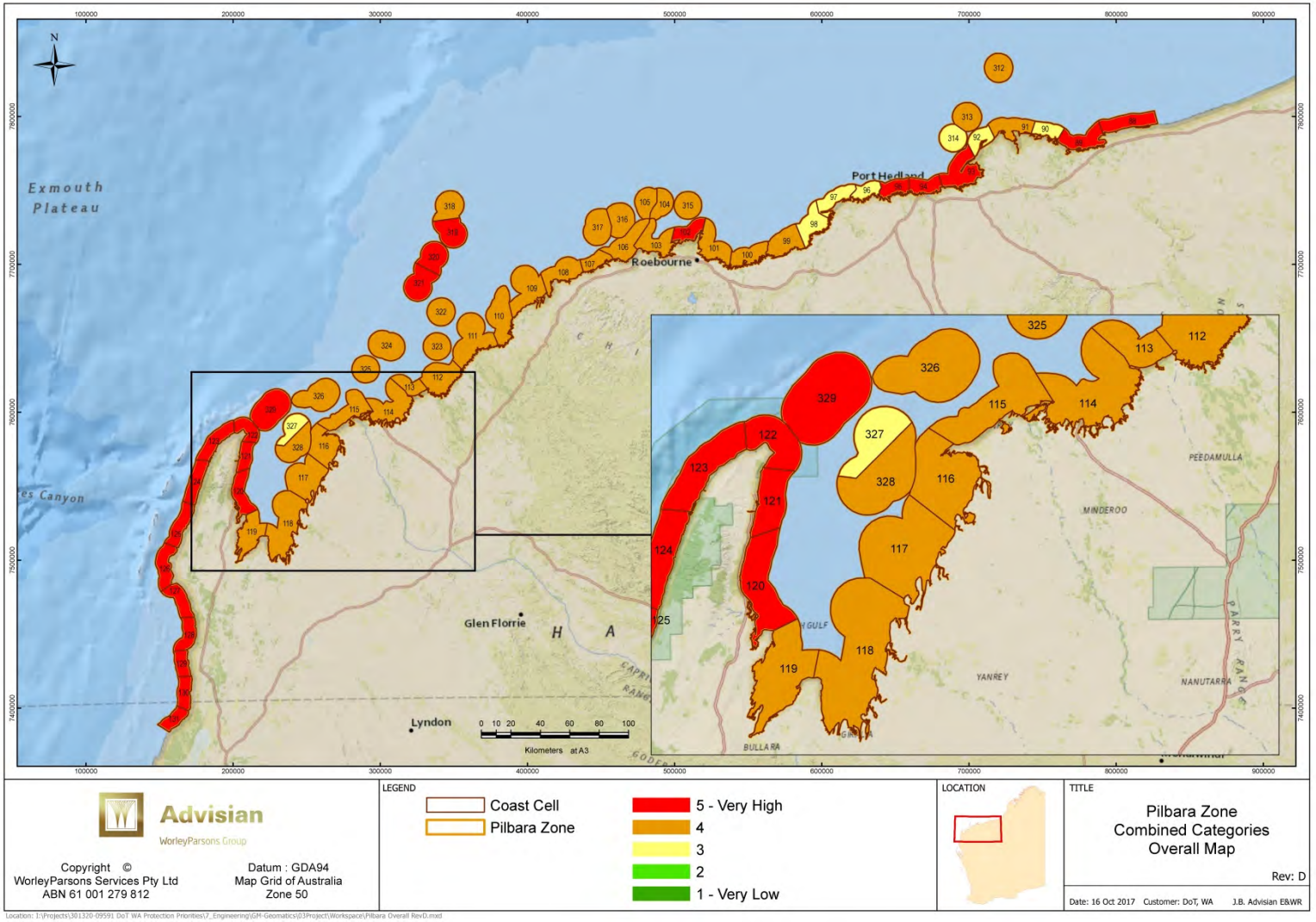

Figure 7-3: Cumulative (including all category rankings) shoreline cell protection priority ranking, for both floating and dissolved effects

8 Discussion

The key discussion points from the Pilbara zone are:

1. Dataset Comparison;
2. Multi-Criteria Analysis;
3. Very High Cumulative Ranking Analysis;
4. Consultation;
5. Timeframes;
6. Attribute Table; and
7. Terrestrial fauna data treatment.

8.1 Dataset Comparison

In the absence of the DPaW dataset, for example in the case of reptiles (i.e. turtles and skinks), the BIA dataset ranks the majority but not all of the shoreline cells at the same level as the discrete points. The DPaW point data however covers more of the area, so it is feasible that the DPaW dataset be used in place of the SNES and BIA datasets for the rest of the zones under assessment, once it is confirmed that the coverage is better.

On closer inspection, the SNES dataset has mapped the entire coastline as potential habitat for the Critically Endangered short-nosed seasnake, which is only recorded in two locations in the DPaW dataset. This indicates that, despite the DPaW dataset's comprehensive coverage of the individual species' recorded locations, it does not result in a ranking for protection of *potential* habitats.

It is therefore reasonable that the SNES and BIA datasets be incorporated despite overlaps, to allow potential habitats to be considered and reviewed as part of the attribute table input into the broad coverage datasets.

The port areas are concentrated, while fishing areas are hugely extensive. When comparing the geospatial areas alone, it is difficult to assign a high value on such an extensive fishing area. In the event of an oil spill, an entire fishing area will not be affected as the areas are so large. However when compared to fish habitat protection area, an oil spill has the potential to affect the whole area and affect the species, by wiping out a whole generation, which is why the habitat areas are given a higher priority ranking.

Regarding economic considerations, by ranking priority based on the economic value per year in relation to WA gross state product, the value of fisheries is smaller when compared against the economic value of ports. However, an alternative approach to assess this has not been identified.

It was also discussed in the Steering Committee Workshop whether, in the event of an oil spill, an environmental priority with a lower rating than an economic one, would result in the environment not being protected in favour of the economic priority. While this assessment has included economic factors, in the event of a spill, the decisions made regarding the appropriate response will be based on situational best judgement and likely environmental impacts, not economic ones.

Economics has been included, as the Incident Controller will want to know what the potential economic impacts may be, as well as other impacts, so they are considered holistically.

8.2 Multi-Criteria Analysis

The approach for the Multi-Criteria Analysis (MCA) initially intended to use the sum of the rankings for each of the aspects in a shoreline cell on a cell-by-cell basis. The shoreline cells were overlain by a grid of 2 km x 2 km and when the project started, the intention was to combine the rankings of every layer to obtain a total weighting for each category, i.e. Protected Fauna, Protection Area, Cultural Heritage, etc.

When the layers had all been ranked and their suitability for inclusion in the assessment had been confirmed, it was apparent that the cumulative ranking where they are summed would unintentionally prioritise Protected Fauna above all other categories. This was because of the abundance of data and incorporation of the same data (e.g. migratory bird observed distribution and bird habitat shapefile areas in the BIA dataset).

Similarly, where the highest ranking of any category in a cell was ranked as Very High, the overall ranking for that cell was Very High. At the shoreline cell level, the presence of any instance of Very High automatically elevated the ranking of the entire coastal compartment to Very High, regardless of the proportion of the shoreline cell. This is an acknowledgement that the management unit for the assessment of the risk of an oil spill at a shoreline cell level, and the sub-level assessment at 2 km x 2 km grids, was simply a function of the process to extrapolate the weighting from point data to the shoreline cell level.

A key advantage of processing the data to the sub level at 2 km x 2 km grid spacing is the potential to produce detailed information for a shoreline cell, depicting the relative location and ranking of the data in the category. This is not a deliverable from this project, but could be a potential deliverable in the future.

8.3 Very High Cumulative Rankings Result

Initially, in 2016, the cumulative rankings for all categories showed that the majority of the Pilbara zone is a high priority for protection in the event of a marine oil pollution event. When explored further, the majority of the Pilbara's coastline supports dense and sparse mangroves, as well as sheltered intertidal flats, both of which were ranked Very High for susceptibility to marine oil pollution.

When the analysis for Zone 3 *Midwest* was completed in mid-2017, it was apparent that there were datasets in the Protection Areas and Protected Fauna categories which were driving High and Very High rankings. These rankings now covered most of the state coastline. The DoT asked Advisian to evaluate the certainty of the fauna sighting, the reliability of the record, and the coverage of the shoreline ESI habitat layers for mangroves and sheltered intertidal flats.

The revised rankings take into account the presence of Marine Protection Areas, Ramsar wetlands and other protected areas which have already been recognised and protected as important areas of higher biodiversity. The coastal habitats from these datasets were ranked lower than previously, to ensure areas of high biodiversity and ecosystem function would be prioritised and highlighted by the Protection Areas database.

This is also the case with the mangroves and sheltered intertidal flats, which are found in most of the shoreline cells along the Pilbara and Kimberley coasts. In a similar oil spill risk assessment undertaken in Victoria, mangroves and other habitat types were ranked in accordance with abundance in the shoreline cell, where higher abundance was given a higher ranking. Whilst it has been previously discussed during this WA Protection Priority Project, this method was not adopted, as it was noted that less abundance did not necessarily equate to lower importance. For example, in Bunbury there are small stands of mangroves, but these represent unique and highly biodiverse areas that are formally recognised and protected under State legislation. However, as these mangroves are also ranked for protection as a legislatively protected area, this gives these shoreline cells a High ranking in the Protection Areas category. A ranking based in abundance was deemed appropriate to distinguish between mangrove areas of varying value. The abundance based approach does not preclude small or isolated stands of mangroves from being given a higher rating as protection areas or potential protection areas.

Mangroves and sheltered intertidal flats were revised and analysed to consider the percentage coverage in the shoreline cells.

8.4 Consultation

Consultation with the Steering Committee was crucial to determine firstly the suitability of the datasets identified, and secondly the suitability of the rankings proposed for the aspects in each of the categories. The consultation process however created time delays compared to the planned timeframes.

The consultation in subsequent assessments should be able to be completed with greater efficiency, since the Steering Committee membership should remain reasonably constant and there is an existing familiarity with the ranking process.

8.5 Timeframes

The project timeframes were negatively impacted as a result of two key changes to the source data: firstly as a result of late changes to the shoreline cell numbering in April 2016; and secondly updates to the input data after the Steering Committee Workshop. This necessitated three separate rounds of data processing and increased the timeframe.

In subsequent zones this should not be a concern, as the above changes were a direct result of this zone being a 'prototype'.

8.6 Attribute Table

The attribute table produced by this process is a compromise between including minimal data entries for all aspects in each category in a shoreline cell; and including moderate amounts of meaningful data for only the highest ranked aspects from each category in a shoreline cell. The WebMap Application has a data entry restriction of 256 characters, so some categories which had many aspects in a cell (e.g. Protected Fauna, Cultural Heritage) had to be truncated with the intent that the user has access to OSRA, or a similar database, to determine the balance of the data found in that shoreline cell.

8.7 Terrestrial Fauna Data Treatment

Terrestrial fauna has been considered for re-ranking after identifying that certain species were being ranked as Very High or High where they are unlikely to use the coastal zone. In this context, the coastal zone is defined as the area of the sea, including the water up to the high water mark, which includes the intertidal zone and the debris beach habitat (e.g. dried seagrass).

In all zones, the terrestrial fauna data was interrogated further including a review of all birds, mammals, reptiles and invertebrates data. The fauna habitat information from secondary credible sources was evaluated to determine if they spend any part of their lifecycle in the coastal zone. The secondary sources evaluated included the Species Profile and Threats (SPRAT) database (http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl), Commonwealth and State Recovery Plans (http://www.environment.gov.au/biodiversity/threatened/recovery-plans, https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals) and published EPA reports and records (http://www.epa.wa.gov.au/).

This review resulted in the following amendments to the treatment of data records for terrestrial birds, mammals, reptiles and invertebrates.

Any fauna which was found to use the coastal zone retained its ranking in accordance with the ranking system according to classification, habitat use and record certainty. Any fauna which was found to not use the coastal zone was given a ranking of Very Low for protection from both floating and dissolved oil. This ranking was assigned because the fauna is highly unlikely to be impacted by an oil spill, as it does not use the coastal zone. By giving it the lowest ranking possible, the data is still considered in the assessment but does not influence the planning of an oil spill response.

9 Conclusions

The following are key conclusions of this study:

- The Pilbara zone is highly vulnerable to marine oil pollution, both from floating and dissolved hydrocarbons;
- The prevalence of mangrove habitat and sheltered intertidal flats along the majority of the coastline is still a driver for key vulnerability areas in the Pilbara zone, despite the revised rankings;
- The Steering Committee provided invaluable input and advice regarding dataset suitability and ranking of criteria, while also addressing the desire to be robust and transparent in the identification of protection priorities;
- This is a static assessment and further data, information, locations and priority rankings can change in the future;
- This assessment will not replace the role of the Environmental Scientific Coordinators (ESCs) in an oil spill. The ESCs will still be called upon in the event of an oil spill, with full information required to be sought by the Incident Commander in the spill; and
- This report and assessments are intended as a guide only, and are intended to enhance the process and reduce the response time in the event of an oil spill off the Pilbara coast.

This page intentionally left blank.

10 References

AHC (2009). Guidelines for the Assessment of Places for the National Heritage List, Australian Heritage Council, published by the Department of the Environment, Water, Heritage and the Arts, Canberra, February 2009.

AFMA (2016). Australian Fisheries Management Authority Annual Report 2015-16. Published by the Commonwealth of Australia, ACT. [http://www.afma.gov.au/wp-content/uploads/2016/10/AFMA-Annual-Report-2015-16-Accessible.pdf]

AMSA (2016). National Plan for Maritime Environmental Emergencies. Website managed by the Australian Maritime Safety Authority, accessed 15 March 2016. [https://www.amsa.gov.au/environment/national-plan/]

Aquaculture Council of WA (2016). Information on Aquaculture Species in Western Australia. Online website accessed 4 May 2016. [http://www.aquaculturecouncilwa.com/how-get-aquaculture/species/]

Beeton RJS, Buckley KI, Jones GJ, Morgan D, Reichelt RE, Trewin D (2006). Independent report to the Australian Government Minister for the Environment and Heritage, 2006 Australian State of the Environment Committee, Australia. [http://www.environment.gov.au/topics/science-and-research/state-environment-reporting/soe-2006/soe-2006-report/9-natural-and-0]

BLM (1979), Western Gulf of Alaska Draft Environmental Impact Statement, Oil and Gas Lease Sale 46 – Kodiak. Prepared by the Bureau of Land Management, Alaska.

Car C, Short M, Huynh C and Harvey MS (2013). The millipedes of Barrow Island, Western Australia (Diplopoda) Records of the Western Australian museum Volume 83: 209-219 http://museum.wa.gov.au/sites/default/files/11.%20Car,%20Short,%20Huynh,%20Harvey.pdf

Dambacher JM, Rochester W and Dutra L, (2009). Addendum to ecological indicators for the exclusive economic zone waters of the South-west Marine Region. Report for the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

DEC (2007). Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-2017, Management Plan No. 55. Department of Environment and Conservation. Available at http://www.dec.wa.gov.au/management-and-protection/marine-environment/marine-parks-and-reserves/plans-and-policies.html.

DoEE (2017). *Petrogale lateralis lateralis* – Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby, in Species Profile and Threats Database, by Department of the Environment and Energy. Accessed October 2017. [http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66647]

DoEE (2017). Dasyurus hallucatus – Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] Species Profile and Threats Database. Accessed October 2017 [http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=331]

DoF (2011). Abalone Fact Sheet. Published by the Department of Fisheries, July 2011. [http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_abalone.pdf]

DoF (2013a). Pearl Oyster, Webpage managed by the Department of Fisheries Western Australia, accessed 1 Aug 2016. Last updated 24 April 2013. [http://www.fish.wa.gov.au/Species/Pearl-Oyster/Pages/default.aspx]

DoF (2013b). Prawn. Webpage managed by the Department of Fisheries Western Australia, accessed 1 Aug 2016. Last updated 9 April 2013. [http://www.fish.wa.gov.au/Species/Prawn/Pages/default.aspx]

DoF (2015a). Blue Swimmer Crabs. Webpage managed by the Department of Fisheries Western Australia, accessed 1 Aug 2016. Last updated 17 March 2015. [http://www.fish.wa.gov.au/Species/Blue-Swimmer-Crabs/Pages/default.aspx]

DoF (2015b). Pink Snapper. Webpage managed by the Department of Fisheries Western Australia, accessed 1 Aug 2016. Last updated 15 Dec 2015. [http://www.fish.wa.gov.au/Species/Pink-Snapper/Pages/default.aspx]

DoF (2015c). Status of the fisheries and aquatic resources of Western Australia 2014/15: State of the fisheries. Report prepared by the WA Department of Fisheries, Perth WA. [http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2014-15.pdf]

DoF (2015d). Status of the fisheries and aquatic resources of Western Australia 2014/15: State of the fisheries. Report prepared by the WA Department of Fisheries, Perth WA.

DoF (2015e). Department of Fisheries Annual Report to Parliament 2014/15. Report prepared by the WA Department of Fisheries, Perth WA. [http://www.fish.wa.gov.au/Documents/annual_reports/Annual%20Report%202014-15.pdf]

DoF (2016a). Aquaculture. Webpage maintained by the Department of Fisheries WA, accessed 15 Dec 2016. Last updated 26 Oct 2016. [http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Aquaculture/Pages/default.aspx]

DoT (2016). Ports Handbook, Western Australia 2016. Online resource published by the WA Department of Transport, accessed 20 Jan 2017. [http://www.transport.wa.gov.au/mediaFiles/projects/MAC_B_WAPortsHandbook2016.pdf]

DoT (2012). A vision of Western Australia's Ports. Online publication by the WA Department of Transport, accessed 2 May 2016. [http://www.transport.wa.gov.au/mediaFiles/marine/mar_AVisionFWesternAustraliasPortsReport.pdf]

DotE (2013). Ownership of protected areas, webpage maintained by the Commonwealth Department of the Environment, accessed 3 Feb 2017. Last updated 13 February 2013. [http://155.187.2.69/parks/nrs/about/ownership.html]

DPaW (2013). Recovery plan for five species of rock wallabies: Black-footed rock wallaby (*Petrogale lateralis*), Short-eared rock wallaby (*Petrogale brachyotis*), Monjon (*Petrogale burbidgei*), Nabarlek (*Petrogale concinna*) and Rothschild rock wallaby (*Petrogale rothschildi*), Western Australian Wildlife Management Program No. 55, Bentley, WA. [http://www.environment.gov.au/biodiversity/threatened/publications/recovery/recovery-plan-five-species-rock-wallabies]

DPaW proposed Marine Parks as depicted on the Map current at November 2014, accessed 30 July 2016. [https://www.dpaw.wa.gov.au/management/marine/marine-parks-and-reserves]

DSD (2015). Western Australia Economic Profile, November 2015. A report prepared by the Government of Western Australia, Department of State Development, November 2015. [http://www.dsd.wa.gov.au/docs/default-source/default-document-library/wa-economic-profile---november-2015?sfvrsn=4]

Eliot I, Nutt C, Gozzard B, Higgins M, Buckley E and Bowyer J (2011). Coastal Compartments of Western Australia: A Physical Framework for Marine & Coastal Planning. Report to the Departments of Environment & Conservation, Planning and Transport. Damara WA Pty Ltd, Geological Survey of Western Australia and Department of Environment & Conservation, Western Australia.

FAO (2008) Toral-Granda V, Lovatelli A and Vasconcellos M (eds) *Sea Cucumbers: A global review of fisheries and trade*. Fishes and Aquaculture Technical Paper 516, Rome.

EPA (1991). Shark Bay Salt pond expansion Useless Loop Inlet Shark Bay Salt Joint Venture. Report and recommendations of the Environmental Protection Authority.

Freedonia (2014). World Salt – Industry Market Research, Market Share, Market Size, Sales, Demand Forecast, Market Leaders, Company Profiles, Industry Trends Study 3199.

French-McCay, DP (2002). Development and Application of an Oil Spill Toxicity and Exposure Model, OilToxEx. Environmental Toxicology and Chemistry 21(10): 2080-2094.

French-McCay, DP (2004). Oil spill impact modelling: Development and validation. Journal of Environmental Toxicity and Chemistry, vol. 23, issue 10, October 2004 pp. 2441-2456.

French-McCay DP and Payne JR (2001). *Model of Oil Fate and Water Concentrations With and Without Application of Dispersants*. In: Proceedings of the Twenty-fourth Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Emergencies Science Division, Environment Canada, Ottawa, ON, pp. 611-645.

French-McCay DP, Mueller C, Payne J, Terrill E, Otero M, Kim SY, Carter M, Nordhausen W, Lampinen M, Longval B, Schroeder M, Jayko M, Ohlmann C (2006). *Dispersed Oil Transport Modeling Calibrated by Field-Collected Data Measured Fluorescien Dye Dispersion*. Paper 393 presented at the International Oil Spill Conference May 2008.

Gilbert, TD (1999). *Oil Spills in the Australian Marine Environment: Environmental Consequences and Response Technologies*. Proceedings of the Australian Oil and Gas Conference 22-23 April 1999. Perth, Western Australia. [https://www.amsa.gov.au/forms-and-publications/environment/publications/NP-Reports/documents/Oil-Spills-in-ME.pdf]

Hayes M, Hoff R, Michel J, Scholz D and Shigenaka G (1992). An introduction to Coastal Habitats and Biological Response to an Oil Spill. Report prepared by the Hazardous Materials Response and Assessment Division National Oceanic and Atmospheric Administration.

David K. Holley, Ivan R. Lawler and Nicholas J. Gales (2006). Summer survey of dugong distribution and abundance in Shark Bay reveals additional key habitat area. Journal of Wildlife Research. Vol. 33, issue 3, pages 243-250. [http://www.publish.csiro.au/wr/WR05031]

ITOPF (2011). Effects of Oil Pollution on the Marine Environment – Technical Information Paper. Published by the International Tanker Owners Pollution Federation Limited, London UK. [http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiivsDHt8LMAhVWwGMKHQXUCH0QFggbMAA&url=http%3A%2F%2Fwww.itopf.com%2Ffileadmin%2Fdata%2FDocuments%2FTIPS%2520TAPS%2FTIP13EffectsofOilPollutiontheMarineEnvironment.pdf&usg=AFQjCNFkZXzESta0xb1rXJST20nCW0JCOQ&sig2=AD753iy4QcnHBrAC6mHD7w&bvm=bv.121421273,d.cGc]

IPIECA/IMO/OGP (2012). Sensitivity mapping for oil spill response. Joint publication from the global oil and gas industry association for environmental and social issues, International Maritime Organisation (UK) and the International Association of Oil & Gas Producers, London, UK, July 2012.

Kangas M, McCrea J, Fletcher W, Sporer E and Weir V (2006). Exmouth Gulf Prawn Fishery, Published by the Department of Fisheries, WA, January 2006. [http://www.fish.wa.gov.au/Documents/esd_reports/esd001.pdf]

Kobryn HT, Wouters K, Beckley LE and Heege T (2013). Ningaloo Reef: Shallow Marine Habitats Mapped Using a Hyperspectral Sensor. PLoS ONE 8(7): e70105. doi:10.1371/journal.pone.0070105.

Lobban C and Harrison P (1994). Seaweed Ecology and Physiology, Cambridge University Press.

McClatchie S, Middleton J, Pattiaratchi C, Currie D and Kendrick G, (Eds), (2006). The South-west Marine Region: ecosystems and key species groups., Australian Government Department of the Environment and Water Resources, Canberra.

Navigatus Consulting Ltd (2011). Victorian Marine Pollution Risk Assessment. Report prepared for the Victorian Department of Transport, in association with Seer Consulting, Auckland, NZ, July 2011.

NOAA (2016). How Oil Spills Affect Fish and Whales, Accessed 30 July 2016. [http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/how-oil-spills-affect-fish-and-whales.html]

Oakwood, M (2008). Northern quoll *Dasyurus hallucatus*. In: Van Dyck S and Strahan R, eds. *The Mammals of Australia (3rd ed)*. Page(s) 57-59. Sydney, NSW: Reed New Holland.

Oakwood, M. (2008). Northern quoll Dasyurus hallucatus. In: Van Dyck S and Strahan R, eds. The Mammals of Australia (3rd ed). Page(s) 57-59. Sydney, NSW: Reed New Holland.

Quadrant Energy (2016). Production Facilities. Webpage by Quadrant Energy Ltd, accessed 6 May 2016. [http://quadrantenergy.com.au/our-business/production-facilities/]

Shire of Exmouth and CALM (1999). Management Plan: Jurabi and Bundegi Coastal Parks and Muiron Islands for the National Parks and Nature Conservation Authority, Perth, Western Australia.

Taylor H and Rasheed M (2011). Impacts of a fuel oil spill on seagrass meadows in a subtropical port, Gladstone, Australia – The value of long-term marine habitat monitoring in high risk areas. Marine Pollution Bulletin 63:431-437.

Tourism WA (2016). Economic Contribution. Webpage for Tourism WA, accessed 16 December 2016. [http://www.tourism.wa.gov.au/Research-Reports/Latest_Visitor_Facts_and_Figures/Pages/Economic-Contribution-of-Tourism-to-WA.aspx]

TRA (2016). Local Government Area Profiles website maintained by Tourism Research Australia. Accessed 4 December 2016. [http://tra.gov.au/Tourism_in_Local_Government_Areas_2016/LGA_Profiles/index.html]

UNESCO (2008). World Heritage Information Kit, UNESCO World Heritage Centre, Paris, France. [http://whc.unesco.org/en/activities/567/]

UNESCO (2017). World Heritage List Nominations. Website maintained by the World Heritage Council, accessed 3 Feb 2017. [http://whc.unesco.org/en/nominations/].

Wilson *et al. (*1994). A Representative Marine Reserve System for Western Australia. Report of the Marine Reserves Selection Working Group, Dept. of Conservation and Land Management, June 1994.

This page intentionally left blank.

Appendix A Shoreline Cell Maps

This page intentionally left blank.

Protected Fauna

This page intentionally left blank.

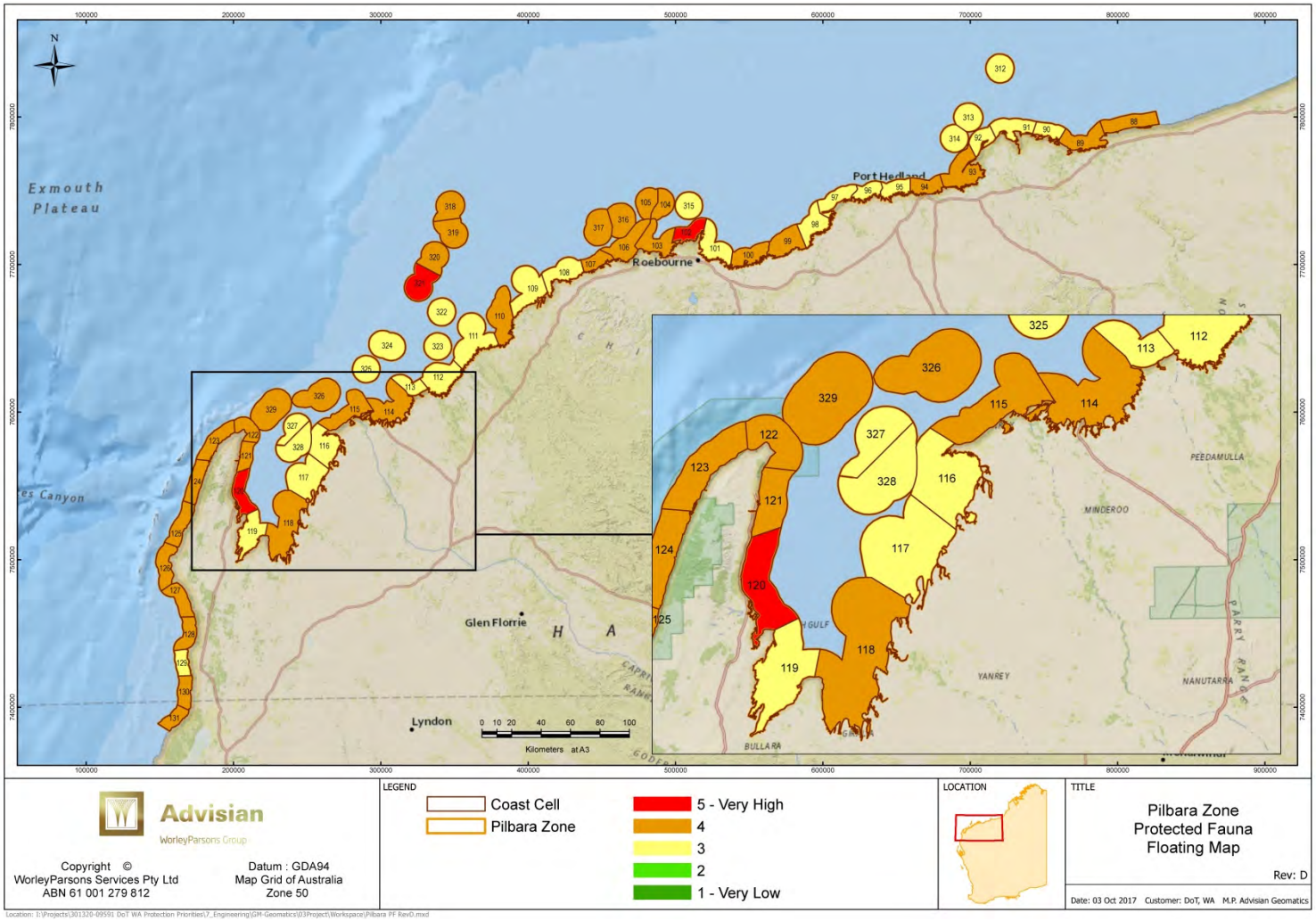

Figure A1: Protected Fauna shoreline cell protection priority ranking for floating hydrocarbons effects

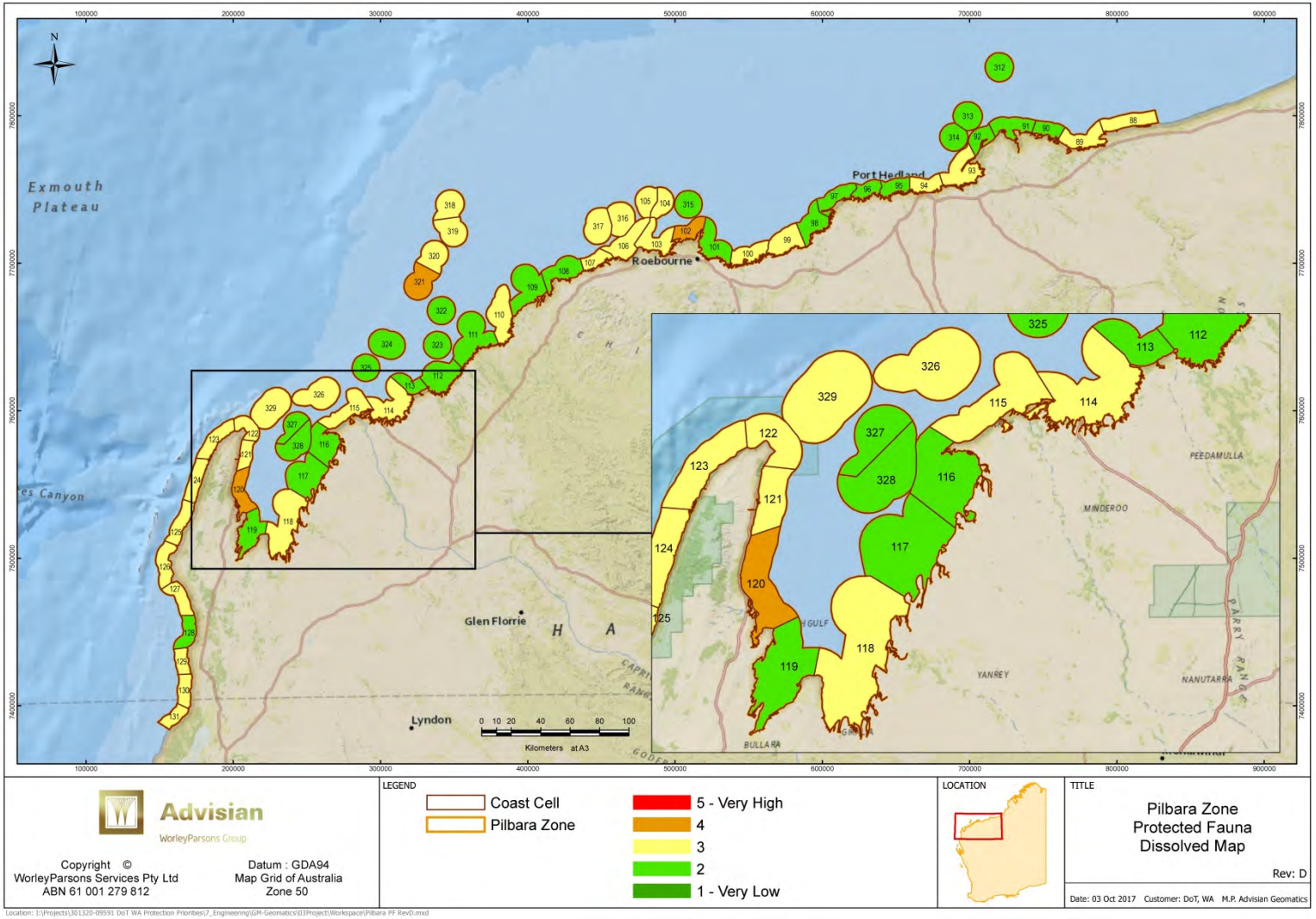

Figure A2: Protected Fauna shoreline cell protection priority ranking for dissolved hydrocarbons effects

Protection Areas

This page intentionally left blank.

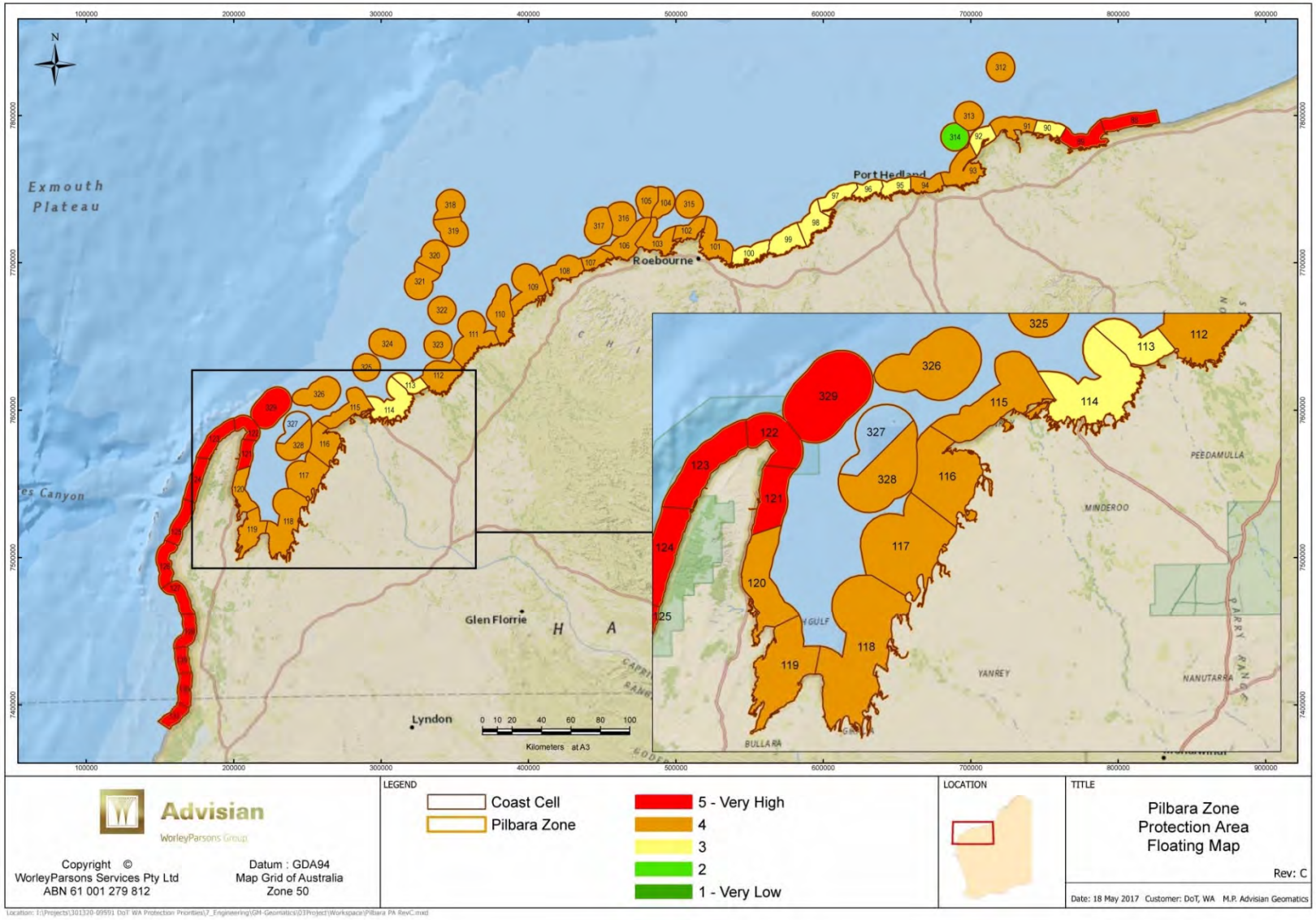

Figure A3: Protection Areas shoreline cell protection priority ranking for floating hydrocarbons effects

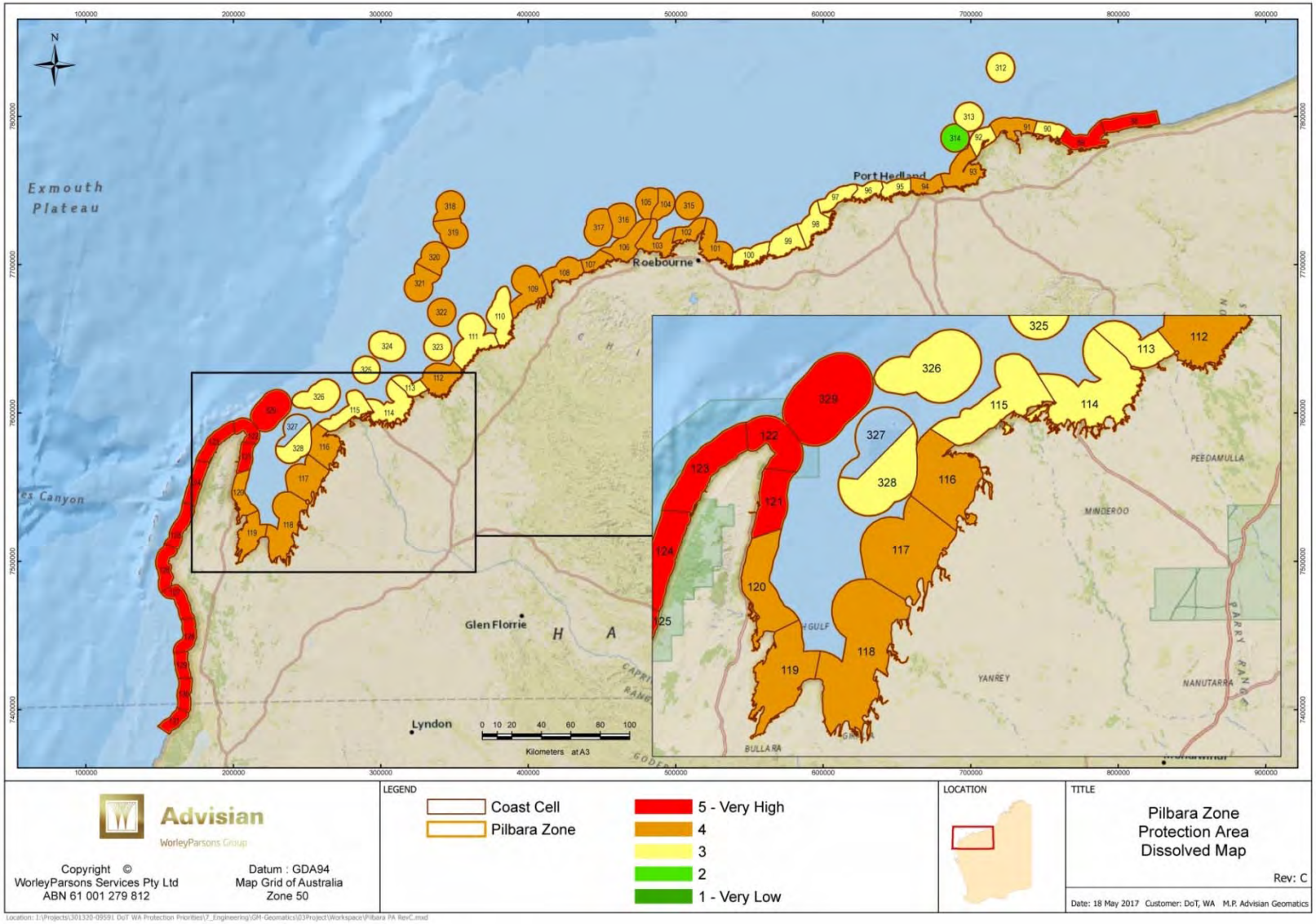

Figure A4: Protection Areas shoreline cell protection priority ranking for dissolved hydrocarbons effect

Cultural Heritage

This page intentionally left blank.

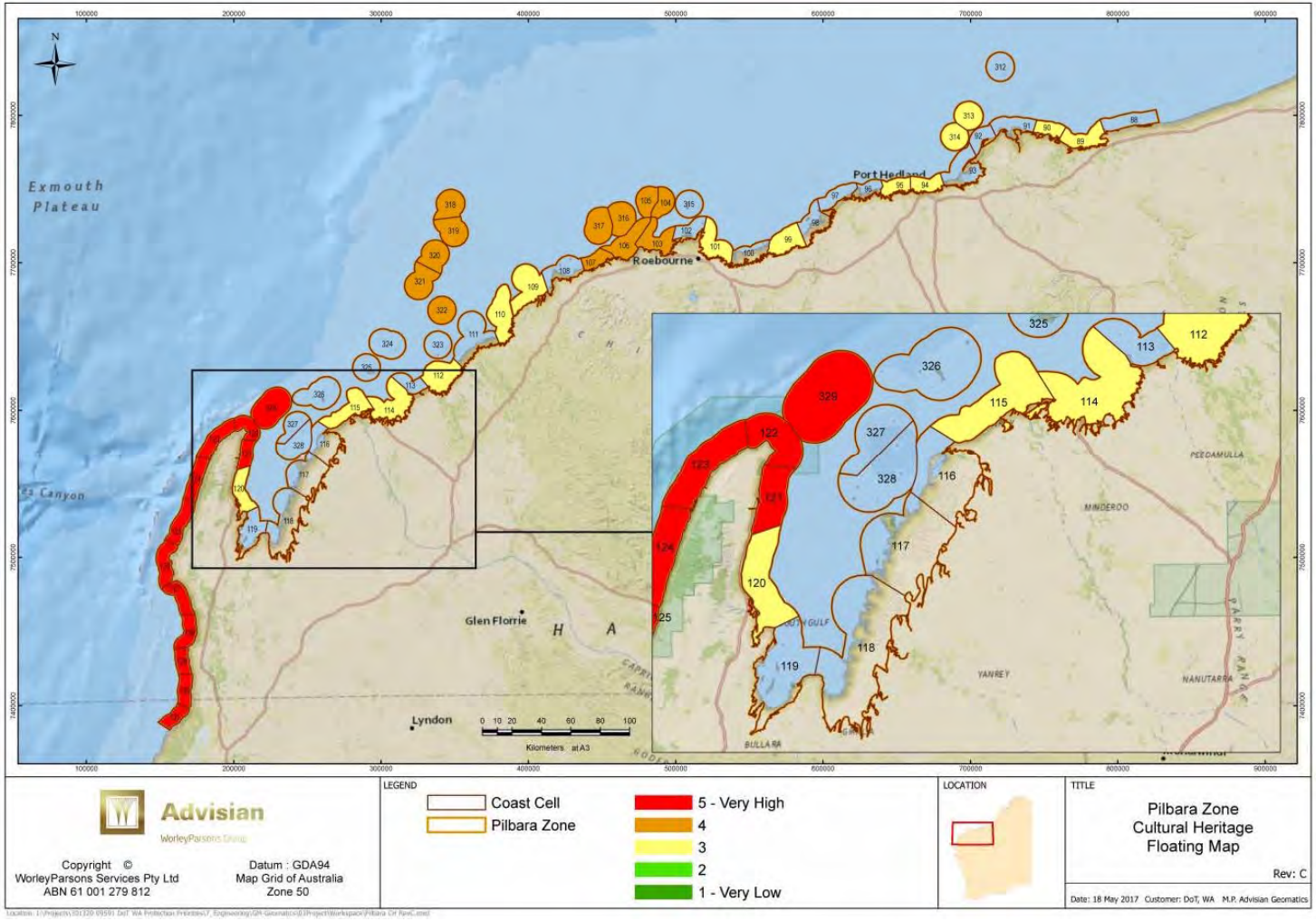

Figure A5: Cultural Heritage shoreline cell protection priority ranking for floating hydrocarbons effects

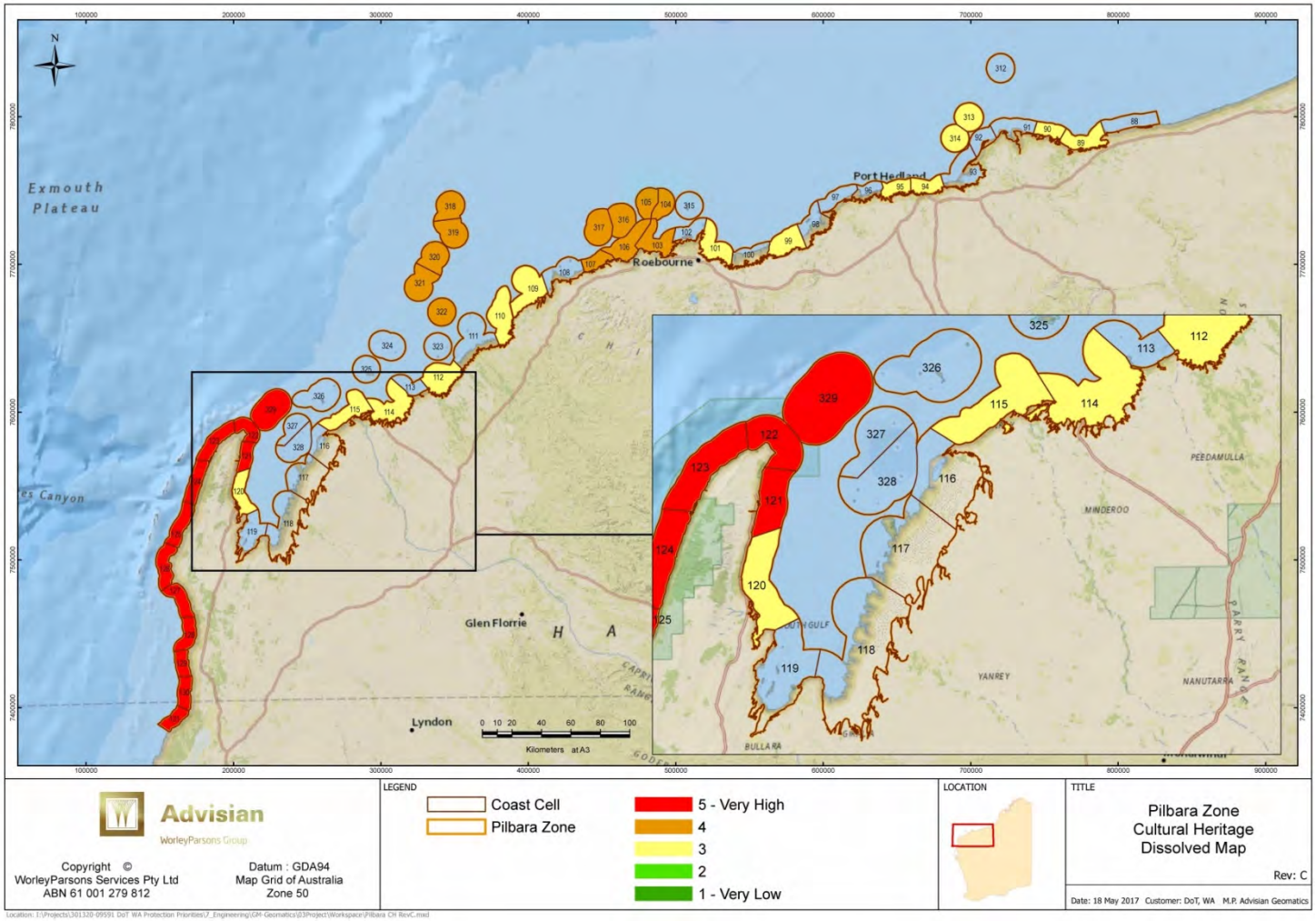

Figure A6: Cultural Heritage shoreline cell protection priority ranking for dissolved hydrocarbons effects

Economic

This page intentionally left blank.

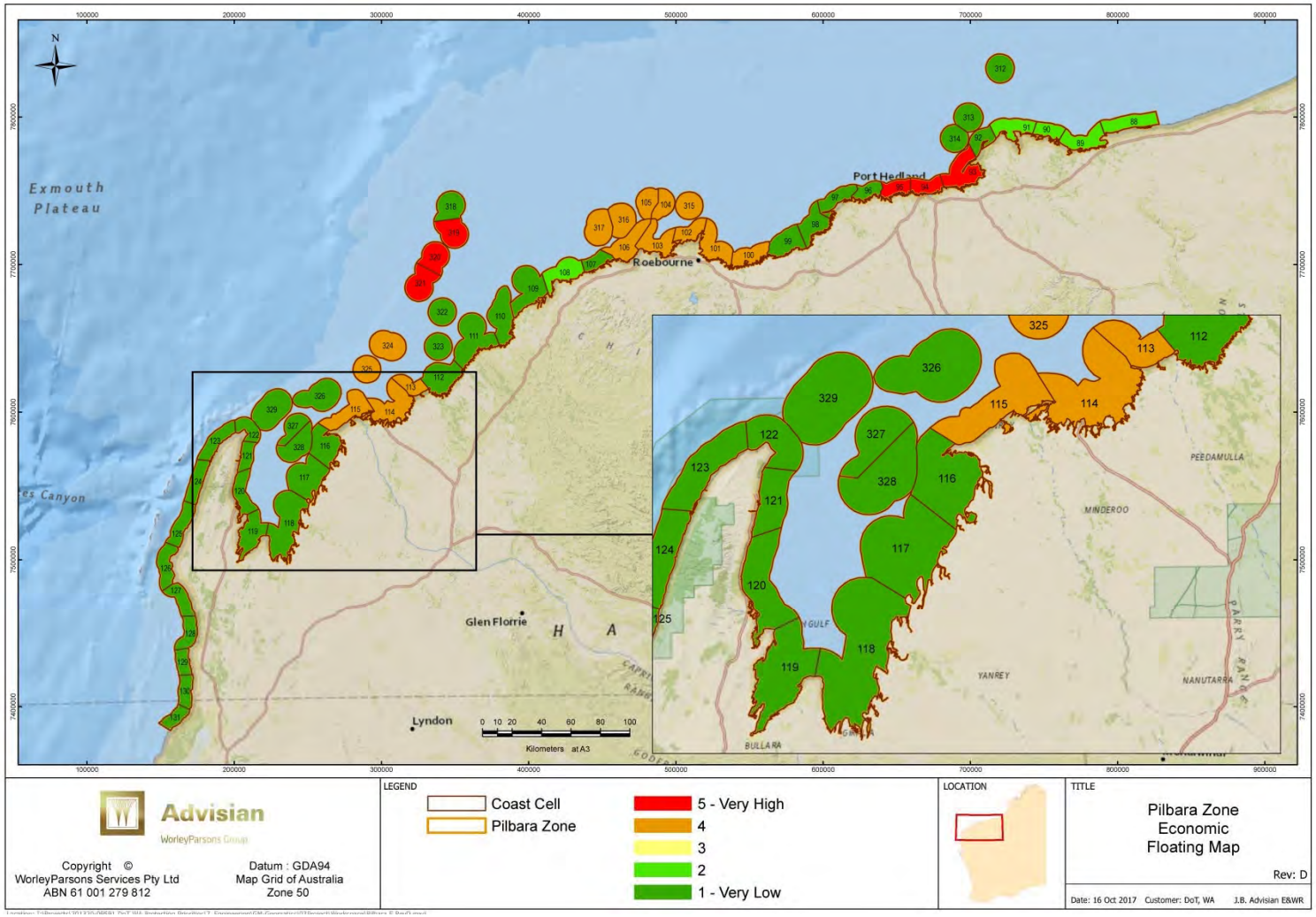

Figure A7: Economic shoreline cell protection priority ranking for floating hydrocarbons effects

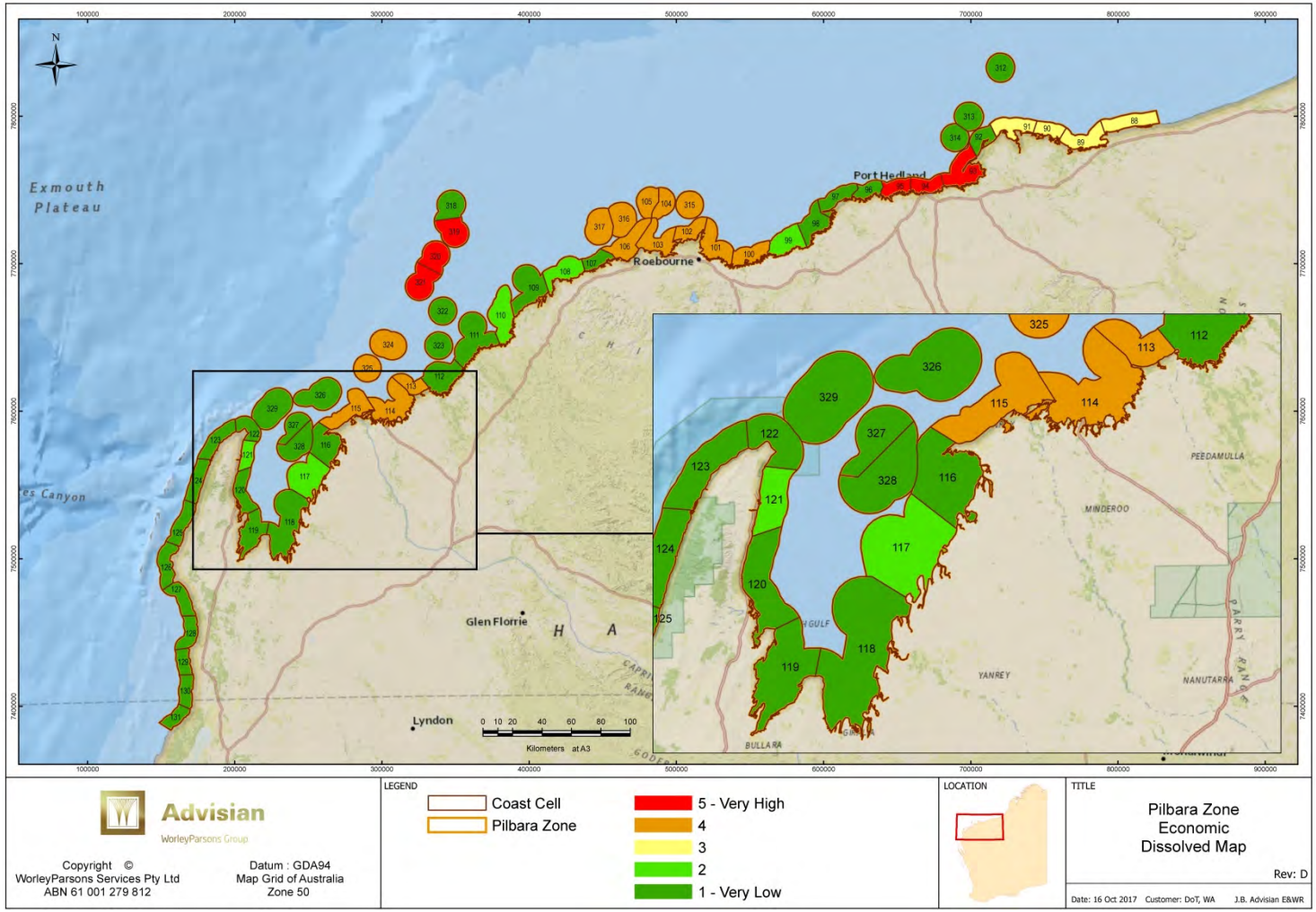

Figure A8: Economic shoreline cell protection priority ranking for dissolved hydrocarbons effect

Social, Amenity and Recreation

This page intentionally left blank.

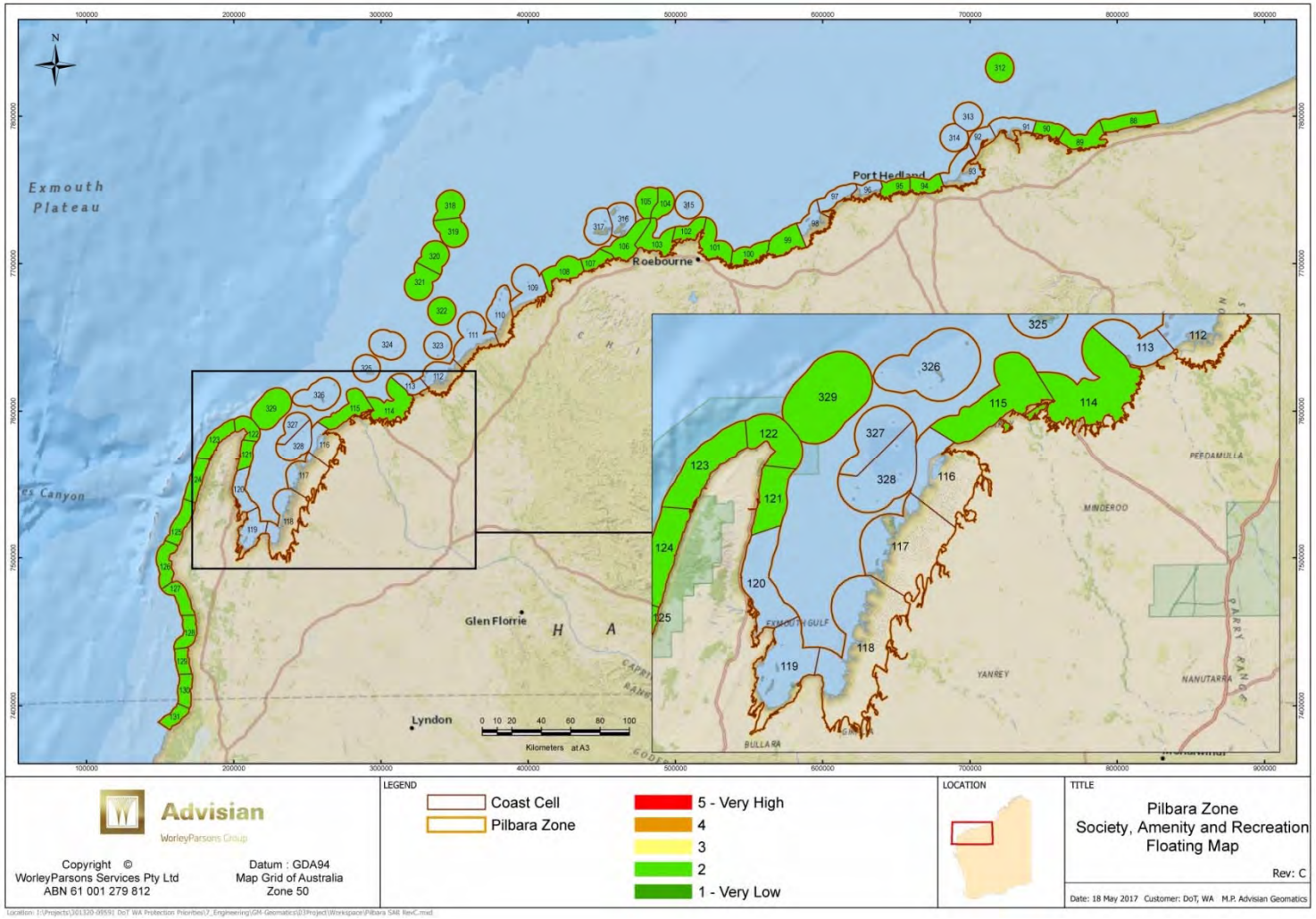

Figure A9: Social, Amenity and Recreation shoreline cell protection priority ranking for floating hydrocarbons effects

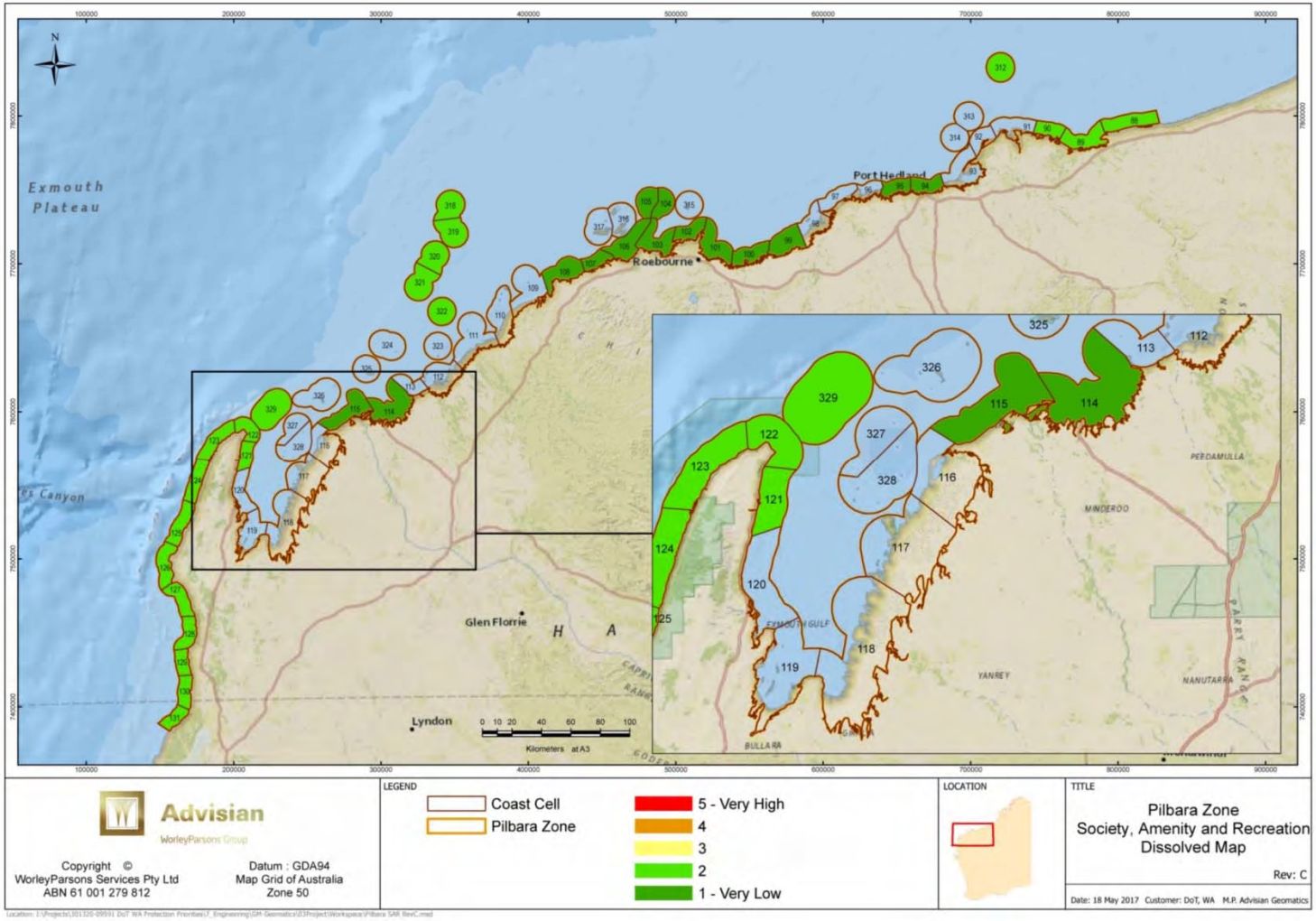

Figure A10: Social, Amenity and Recreation shoreline cell protection priority ranking for dissolved hydrocarbons effects