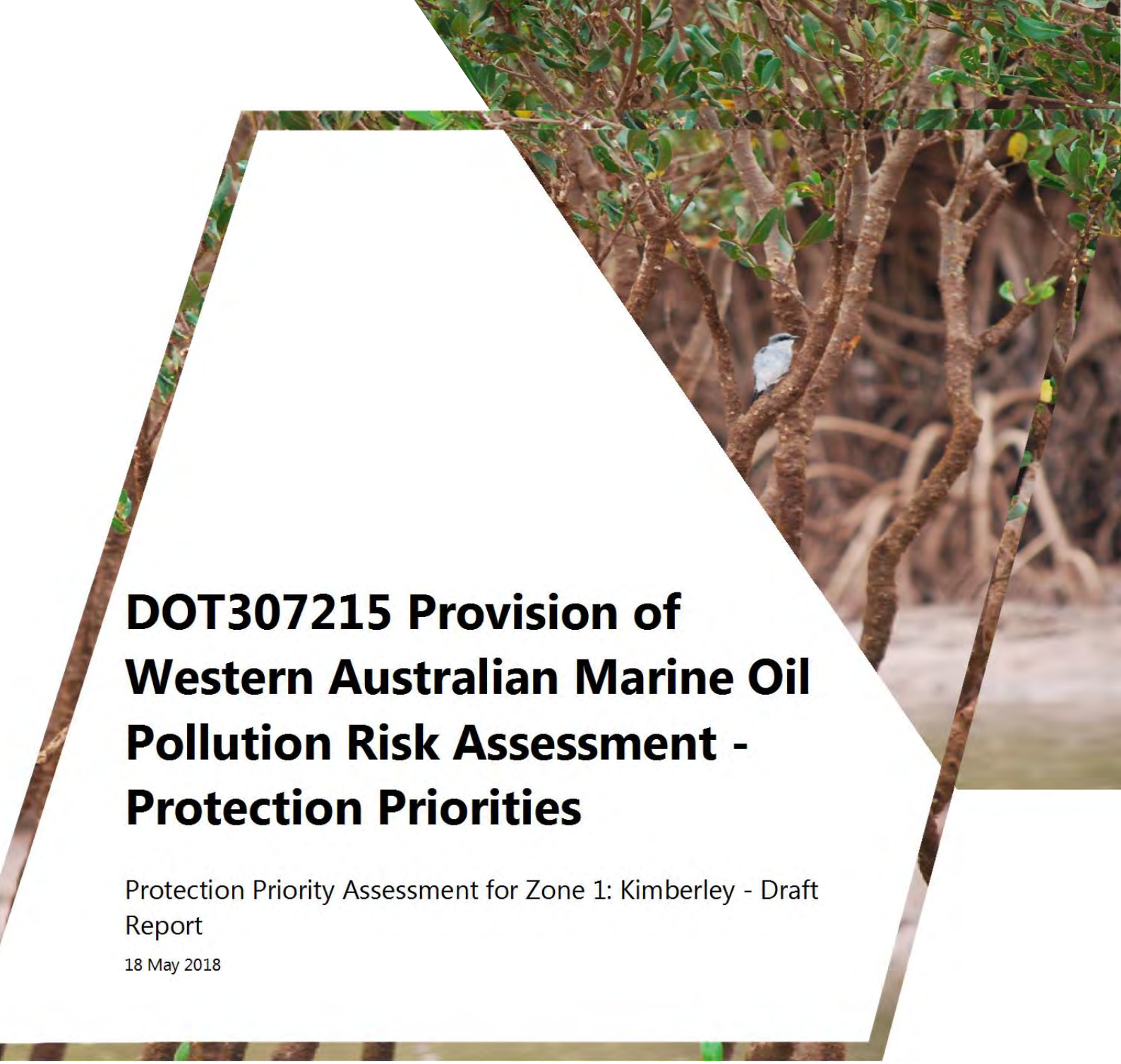

DOT307215 Provision of Western Australian Marine Oil Pollution Risk Assessment - Protection Priorities

Protection Priority Assessment for Zone 1: Kimberley - Draft Report

18 May 2018

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Rev	Description	Author	Review	Approved	Date
A	Issued for Internal Review	R Morgan	L Laver		10-Apr-2018
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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, DoT is conducting a state-wide marine oil pollution risk assessment. The risk assessment comprises 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 and Swan zones (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 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 data, and has been incorporated into the later assessments. This report presents the results of the assessment for the Kimberley zone (Zone 1) using this refined ranking method (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 Kimberley zone has demonstrated that there are many vulnerable and important receptors that will need to be considered in an oil spill. The cumulative ranking for all five categories, for both floating oil and dissolved oil impacts, sees 18 out of 115 shoreline cells ranked Very High and 95 out of 115 shoreline cells ranked High based on the cumulative assessment.

The key driver for the Very High ranking in the Kimberley zone is the presence of Ramsar wetlands (Ord River Floodplain, Roebuck Bay and Eighty Mile Beach) in the Protection Areas category, and Critically Endangered animal habitat and breeding areas for shorebirds, whales and turtles in the Protected Fauna category.

More than 80% of the shoreline cells in the Kimberley have been ranked High overall for protection from floating and dissolved oil due to the presence of Heritage Areas, Protection Areas and Protected Fauna. This High ranking is caused by the presence of the West Kimberley, which is on the National Heritage List and occupies a large area of the Kimberley zone. The Protection Areas creating the High ranking are Nature Reserves, Important Wetlands and various types of intertidal habitats. The Protected Fauna creating the High ranking are Critically Endangered and Endangered animal habitat and breeding areas for shorebirds, whales and turtles.

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 Biodiversity Conservation and Attractions (DBCA):
  - Stuart Field – Principal Policy Officer | Office of the Director General;
  - Ralph Talbot-Smith – WALIS Project Manager | Managing Coastal Vulnerability Project (now with Department of Transport);
  - Steve Rowlands – DBCA Data Manager;
  - Christopher Nutt – Marine Park Coordinator | Yawuru Nagulagun / Roebuck Bay & Rowley Shoals Marine Parks;
  - Scott Whiting – Project Leader | Western Australian Marine Sciences Institute (WAMSI) Kimberley Marine Research Program – Marine Turtles; and
  - Kathy Murray – Research Officer (Remote Sensing) | Marine Science Program.
- Woodside:
  - Denise McCorry – Senior Environment Advisor; and
  - Ben Malseed – Environment Advisor.
- Shell: Nathan Waugh – Environment Advisor;
- INPEX:
  - Jamie Carle – Senior Environment Advisor; and
  - Shannon Carter – Environmental Advisor.
- Kimberley Ports Authority:
  - Paul Taylor – Health, Safety and Environment Officer.

Kimberley Ports Authority: Veronica Mair – HSE Manager

Department of Primary Industries and Regional Development:

- Hans Kemps – Senior Management Officer | Strategy and Aquatic Resources; and
- Mike Travers – Research Scientist.

Northern Territory Environment Protection Authority: Jane Orr – Senior Environmental Officer | Environmental Operations

WAMSI Kimberley Marine Research Program researchers:

- Kelly Waples – Science Coordinator;
- Michaela Dommisse – WA Program Leader | AIMS;
- Thomas Holmes – Marine Monitoring Coordinator | DBCA;
- Peter Bayliss – Project Leader | Dugong Management Kimberley;

- Halina Kobryn – Academic Chair | Murdoch University;
- Jennifer Munro – East Kimberley Marine and Islands Coordinator;
- Simon Allen – Adjunct Research Fellow | University of Western Australia;
- Oliver Berry – Leader, Environomics Future Science Platform | CSIRO;
- Marji Puotinen – AIMS Spatial / Ecological Data Scientist;
- Joshua Smith – Cetacean Researcher | Murdoch University;
- Alex Brown – Cetacean Researcher | Murdoch University;
- Tony Tucker – Turtle Researcher | DBCA;
- Graham Loewenthal –Research Officer | DBCA;
- Lynnath Beckley – Professor Marine Science | Murdoch University;
- Lesley Gibson – Research Scientist | DBCA; and
- Blanche Danstas – Research Scientist | James Cook University.

PAWSEY: Luke Edwards – Data Specialist.

Indigenous groups:

- Balanggarra;
- Bardi Jawi;
- Wunambal Gaambera; and
- Dambimangari.

State Heritage Office: Bernhard Klingseisen – Senior Land Information Officer.

Department of Transport personnel:

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

CSIRO: Marlee Hutton.

Advisian team members and other Advisian personnel:

- Annette Jacobs – Project Manager and MCA Specialist;
- Raphael Morgan – Senior Environmental Specialist and Report Author;
- Kate Swain – Senior Environmental Specialist; and
- Jonathon Boeyen – GIS Specialist.

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Appendix A

Acronyms and Abbreviations

ACEAS	Australian Centre for Ecological Analysis and Synthesis
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
DAA	WA State Department of Aboriginal Affairs
DBCA	Department of Biodiversity Conservation and Attractions formerly WA State Department of Parks and Wildlife (DPaW)
DEC	WA State Department of Environment and Conservation (now called DBCA)
DoF	WA State Department of Fisheries (now called DPIRD)
DoT	WA State Department of Transport
DotEE	Commonwealth Department of the Environment and Energy
DPaW	Former WA State Department of Parks and Wildlife (now called DBCA)
DPIRD	WA Department of Primary Industries and Regional Development
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
FRMA	Fish Resource Management Act 1994
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
MHWM	Mean High Water Mark
MLWM	Mean Low Water Mark
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
PMST	Protected Matters Search Tool
SNES	Species of National Environmental Significance
SPRAT	Species Profile and Threats Database
TSA	Tourism Satellite Account
UNESCO	United Nations Educational, Scientific and Cultural Organization
VU	Vulnerable
WA	Western Australia
WAM	Western Australian Museum
WAMSI	Western Australian Marine Sciences Institute
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 mean high water mark, which includes the intertidal zone and the debris beach habitat
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.
Intertidal	The area between the mean high and low water mark, which is uncovered at low tide.
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 115 shoreline cells in Zone 1 *Kimberley* (Figure 1-3).
Zones	The WA state waters have been divided into seven 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).

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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 the 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, DoT also ensures the State's capacity 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 comprises two components. The first component evaluates protection priorities of the receiving environment in order to assess the 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), originally finalised in August 2016, which was followed by assessments of the Midwest and Swan (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 much of the shoreline cells being prioritised as High or Very High for protection in the event of an oil spill.

While the assessment demonstrates that the WA coastline has many receptors that are highly vulnerable 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, a State Wide Overview was undertaken to investigate the drivers for these High and Very High rankings. It was identified that a few key state-wide datasets were driving the majority of the 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 data. These revised rankings have been incorporated into the assessment of the Kimberley zone, and this report presents the results of that 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 to ensure appropriate rankings and processing.

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

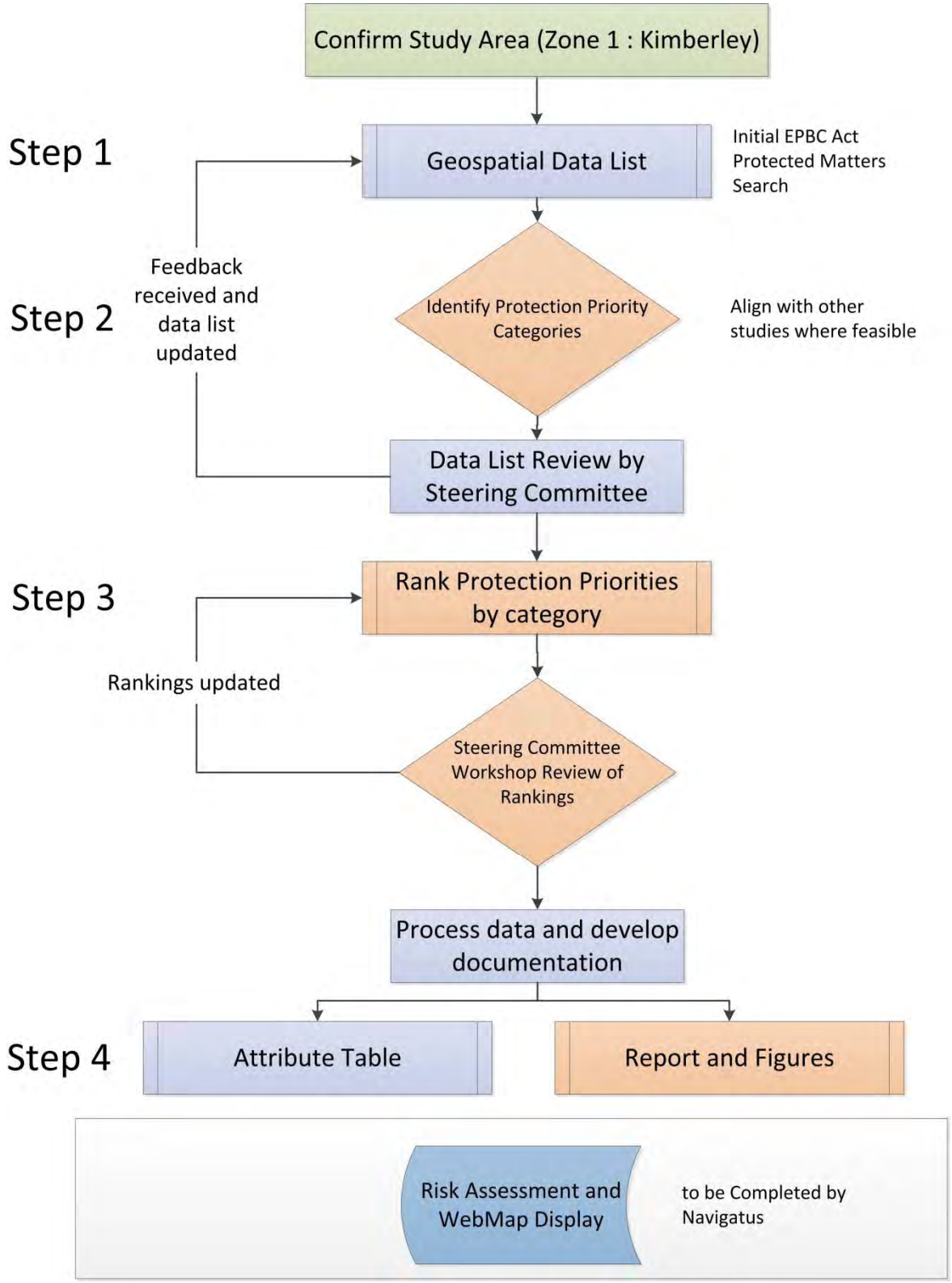

Figure 1-2 Protection priorities project component flowchart

1.2 Protection Priority Categories

The main outcome from step 1 was to develop a set of categories that group protection priorities, 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 cooperate 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 former 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 Biodiversity, Conservation and Attractions (DBCA) 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 Kimberley zone are illustrated in Figure 1-3. There are 115 shoreline cells in the Kimberley zone.

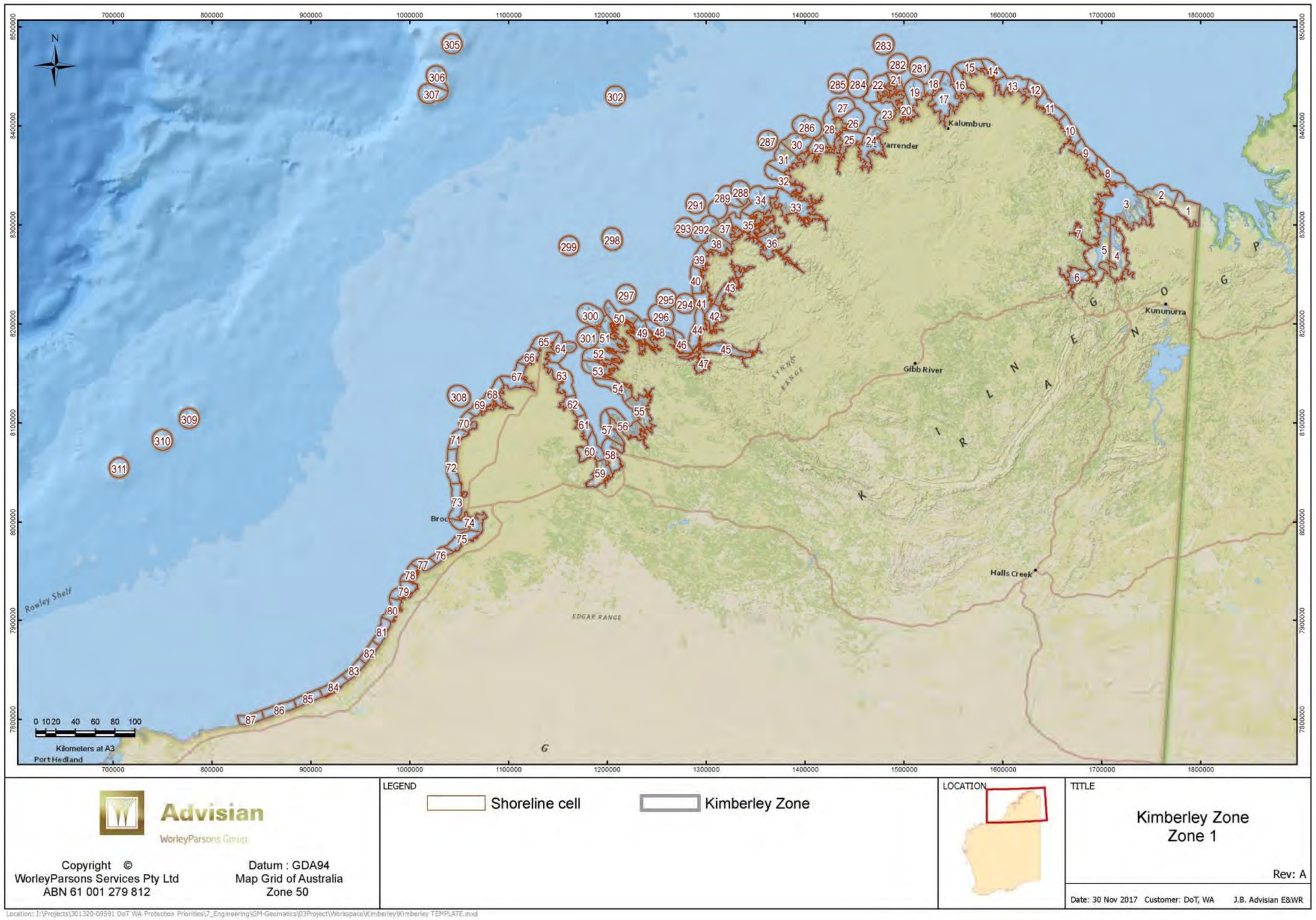

Figure 1-3: Kimberley Zone 1 shoreline cells

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1.4 Marine Oil Pollution Effects

The assessment to rank data (step 3) requires an understanding of vulnerability and susceptibility to marine oil pollution, for 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 (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.

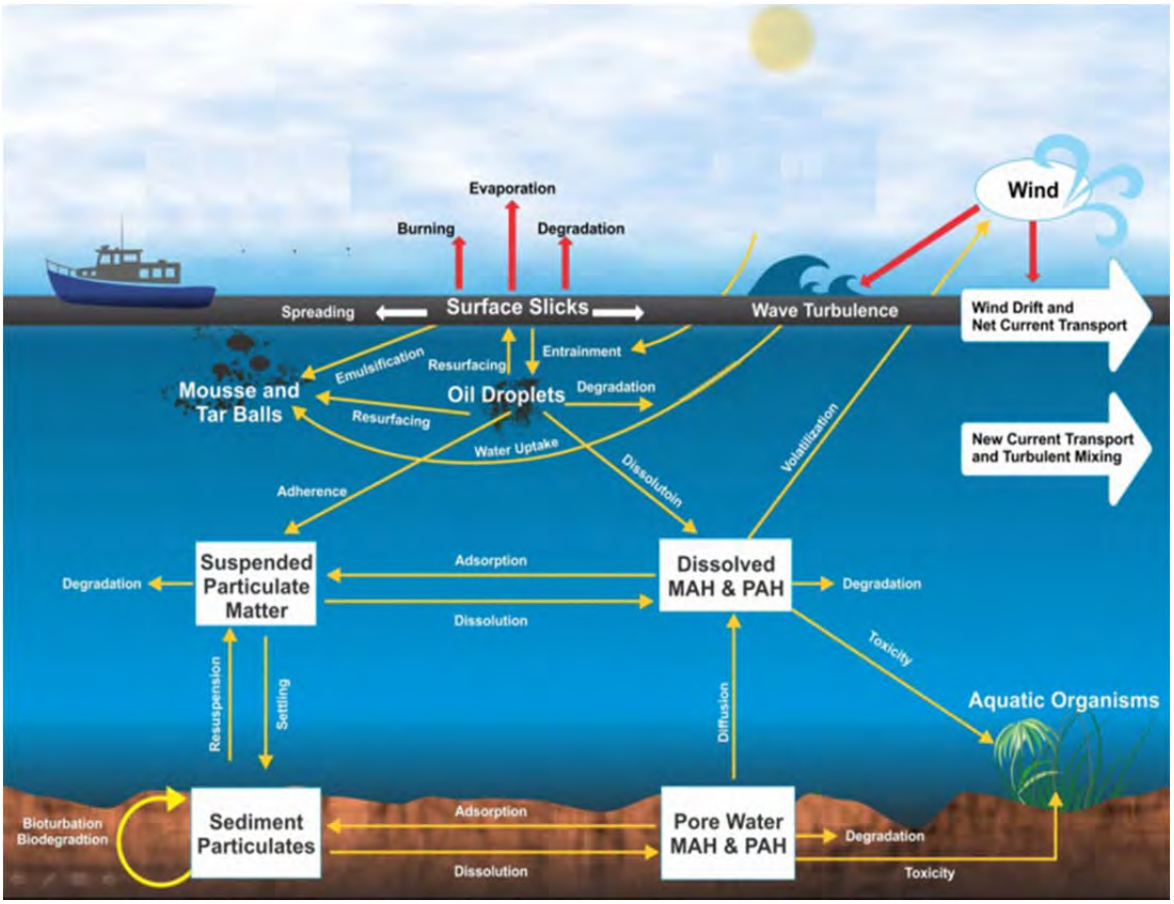

Figure 1-4: Hydrocarbon weathering and biodegradation processes

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 causes 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
- Indirect effects, such as losing habitat or shelter and consequently eliminating 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 reduced 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
- 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 to 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 comprised:

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

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

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

Department	Name	Title
Department of Transport	Emily Gifford	Team Leader Planning and Public Information | Marine Safety
Department of Biodiversity, Conservation and Attractions	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
	Kathy Murray	Marine Science Program | Research Officer (Remote Sensing)
	Scott Whiting*	Project Leader – WAMSI | Kimberley Marine Research Program – Marine Turtles
	Christopher Nutt	Marine Park Coordinator | Yawuru Nagulagun / Roebuck Bay & Rowley Shoals Marine Parks
	Steve Rowlands	Data Manager | DBCA
Woodside	Denise McCorry*	Senior Environment Advisor
	Ben Malseed	Environment Advisor
Shell	Nathan Waugh	Environmental Advisor
INPEX	Jamie Carle*	Senior Environmental Advisor – Oil Spill
	Shannon Carter	Environmental Advisor – Marine
Kimberley Ports Authority	Paul Taylor	Health, Safety and Environment Officer

*These members did not attend the Steering Committee workshop on 11 December 2017.

Kellie Pendoley from Pendoley Environmental, Paul Irving of AMSA, Gordon Motherwell from DWER and Hans Kemps from DPIRD were invited to participate in the Steering Committee, however were 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 each 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 26 October 2017);
- Interim Discussion Paper – Data Collection for Zone 1: Kimberley (301320-09591-EN-REP-K01) (sent 3 November 2017) to review and identify additional data; and
- Workshop Discussion Paper (301012-09591-EN-REP-0014) (sent 1 December 2017).

A workshop was held with the Steering Committee on 11 December 2017 to review the priority ranking process and the data collected up to that date. The agreed rankings being used for the Kimberley Zone are provided in Section 3. In the Steering Committee Workshop, a number of additional data requirements were also identified. These are 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.

In the workshop, the following issue was also discussed:

- How much data is too little – It was recognised that this could be an issue for the Kimberley Zone which has not been studied as extensively as other zones. The use of surrogates was discussed as a potential way to fill data gaps for sections of coastlines where data was lacking.

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

- Access and logistics (e.g. boat ramps, roads, mobile phone coverage), particularly in such a remote region as the Kimberley which includes large tidal ranges; and
- Potential dangers to personnel during a response (e.g. crocodile locations).

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

Additional outcomes of the workshop are discussed throughout this report in relevant sections.

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 and Energy (DotEE). 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 shoreline cells of the Kimberley (Figure 1-3).

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 publicly 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 publicly 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 Kimberley zone. These data layers were provided to the Steering Committee for review on 3 November 2017 and during the workshop on 11 December 2017. 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 Table 2-1 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 DotEE 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 and Energy (DotEE) Biologically Important Areas (BIA) for marine species	▪ Oct 2017
		▪ DotEE Species of National Environmental Significance (SNES)	▪ Oct 2017
		▪ WA Department of Biodiversity, Conservation and Attractions (DBCA) for fauna	▪ Nov 2017
		▪ INPEX data	▪ Jan 2018
		▪ WAMSI Kimberley node research project data on dolphins	▪ Feb 2018
		▪ Data on dugong distribution from Edith Cowan University	▪ 1985
		▪ WA Department of Primary Industries and Regional Development (DPIRD) Seasonally Protected and Totally Protected Fish	▪ Mar 2018
		▪ Atlas of Living Australia for distribution of Seasonally Protected and Totally Protected Fish	▪ Nov 2018
		▪ WAMSI Kimberley node research project data on turtles	▪ Feb 2018
		▪ WAMSI Kimberley node research project data on crocodiles	▪ Dec 2017
Protection Areas			
World Heritage Areas	3.2.1	▪ DotEE World Heritage Areas	▪ Oct 2017
Terrestrial Protection Areas	3.2.2	▪ DotEE Collaborative Australian Protected Areas Database (CAPAD) – terrestrial and DBCA update	▪ 2014 with 2016 update
		▪ DBCA legislated land and waters	▪ Nov 2017
Marine Protection Areas	3.2.3	▪ DotEE CAPAD – marine and DBCA update	▪ 2014 with 2016 update
		▪ DBCA legislated land and waters	▪ Nov 2017
Ramsar and Nationally Important Wetlands	3.2.4	▪ DotEE Ramsar Wetlands of Australia	▪ Oct 2017
		▪ DotEE Directory of Important Wetlands in Australia	▪ Mar 2016
Key Ecological Features	3.2.5	▪ DotEE Marine Key Ecological Features	▪ Feb 2016

Layer	Section	Data Source	Last Updated
Coastal and Intertidal Habitats	3.2.6	▪ DoT Oil Spill Response Atlas (OSRA) WA shorelines Environmental Sensitivities Index (ESI) ▪ Marine Futures Biodiversity (MFB) seamap project dataset ▪ Landgate Geonoma dataset ▪ DBCA historic mangroves dataset ▪ Geomorphology smartline dataset from GeoScience Australia	▪ Apr 2011 ▪ Nov 2017 ▪ Dec 2017 ▪ Nov 2017 ▪ Dec 2017
Coral, Seagrass, Algae and Filter Feeding Communities	3.2.7	▪ OSRA ESI – coral ▪ Coastal and Marine Resources Information System Seagrass ▪ Australian Centre for Ecological Analysis and Synthesis (ACEAS) seagrass dataset ▪ ReefKIM dataset ▪ Marine Futures Biodiversity (MFB) seamap project dataset	▪ Apr 2011 ▪ Oct 2017 ▪ Feb 2018 ▪ Dec 2017 ▪ Nov 2017
Fish Habitat Protection Areas (FHPAs) and Fisheries Prohibited Areas	3.2.8	▪ DPIRD Fish Habitat Protection Areas	▪ Oct 2017
Protected Areas for Aquaculture and Pearling	3.2.9	▪ Protection areas identified for pearling spat	▪ Dec 2017
Cultural Heritage			
World Heritage Properties	3.3.1	▪ DotEE World Heritage Areas	▪ Oct 2017
National Heritage	3.3.1	▪ DotEE National Heritage List	▪ Feb 2016
Commonwealth Heritage Places	3.3.1	▪ DotEE Commonwealth Heritage – Public	▪ Nov 2017
State Protected Heritage	3.3.2	▪ State Heritage Register ▪ Conservation Orders ▪ Heritage Agreements	▪ Nov 2017 ▪ Nov 2017 ▪ Nov 2017
Shipwrecks and Maritime Archaeology	3.3.3	▪ DotEE Australian National Shipwrecks ▪ WA Museum Recorded Shipwrecks ▪ WA Museum Maritime Archaeological Sites	▪ Oct 2017 ▪ Nov 2017 ▪ Nov 2017
Economic			
Aquaculture	3.4.1	▪ DPIRD aquaculture licence areas ▪ DPIRD Pearling leases	▪ Nov 2017 ▪ Nov 2017
State Managed Commercial Fisheries	3.4.2	▪ DPIRD Individual Fisheries shapefiles	▪ Nov 2017

Layer	Section	Data Source	Last Updated
Commonwealth Managed Fisheries	3.4.3	▪ Australian Fishing Management Authority (AFMA) areas of concentrated fishing effort	▪ Nov 2017
Other Commercial Operations	3.4.4	▪ None identified	▪ N/A
Tourism	3.4.7	▪ TRA 2015 for TSA boundaries and tourism statistics for 2015	▪ Oct 2017
Ports and Shipping	3.4.6	▪ DoT shipping and pilotage ports dataset ▪ DoT Port Authorities dataset	▪ Nov 2017
Water Intake Locations	3.4.7	▪ DoT seawater intake locations and types ▪ DPIRD aquaculture and research facility intake and outfall locations	▪ Feb 2016 ▪ Feb 2016
Social, Amenity and Recreation			
Recreational Fishing/Boating Zones	3.5.1	▪ DotEE CAPAD – marine and DBCA update ▪ Marine Parks draft zoning plan	▪ 2014 with 2016 update ▪ 2017
Beaches	3.5.2	▪ Top ten beaches, Western Australia ▪ Geomorphology smartline dataset from GeoScience Australia ▪ Landgate Geonoma dataset ▪ Surf Life Saving WA beach popularity information ▪ Department of Planning – Town location and population size ▪ DBCA Yacht clubs, jetties, marinas	▪ 2017 ▪ Dec 2017 ▪ Dec 2017 ▪ Nov 2016 ▪ Dec 2017 ▪ Nov 2017

2.4 Data Cut-Off and Summary of Inclusion

The Steering Committee's initial review of the data list for the Kimberley zone, and further discussion during the Steering Committee workshop, was intended to identify all data layers that could be used for the Kimberley zone. A data cut-off date of 15 January 2018 was initially applied to produce the final report. However, considering the time of year, some datasets could not be obtained by the cut-off date and therefore an extended period for some datasets were accepted.

It is useful to note that when gathering data and preparing this report, many WAMSI Kimberley research projects were being finalised. A number of these data layers have been incorporated into the final report and are listed in Table 2-1. However, it is anticipated that as more research takes place, additional datasets and/or information may become available for the Kimberley zone which may improve the identification and ranking of priority categories. It may be advisable to review the zones periodically to assess the need to include additional information as it becomes available.

2.5 Data Excluded

When assessing the Pilbara zone, the following datasets were identified but have been excluded for the reasons described below. This precedent has been carried into the remaining zones, including the Kimberley zone.

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 for the Kimberley on 16 May 2016, 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 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 Department of Mines and Petroleum 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.

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.

4. DBCA Marina Habitats dataset

The DBCA Marina Habitats dataset was not used as, apart from three offshore islands, it did not extend into the Kimberley zone.

5. WAMSI and other research project data

A number of datasets and/or reports were obtained from various projects completed in the Kimberley. After reviewing this information, it was determined that while these offered valuable information on the ecology, economy or social aspects of the Kimberley, these didn't add any value in identifying coastline portions needing protection when considering a state-wide ranking system. Therefore, they were omitted. They included:

- Biodiversity values on selected Kimberley islands, Australia. Lesley Gibson, Research Scientist at DBCA, advised that the surveys were terrestrial in nature, so this dataset was not included.
- Human values and aspirations for coastal waters of the Kimberley. This dataset and associated report described the social values people associated with the coastal waters of the western Kimberley, and identified and analysed people's aspirations regarding possible futures for the western Kimberley coastline. After analysing the data, it was determined that the values identified were generally reflected in current management practices and taken into account in priority categories included in this report (e.g. marine parks in protection area).
- The results of a habitat survey undertaken in 2016 in the Port of Broome, provided by Kimberley Ports. Due to the limited coverage of the survey area and because it did not provide more information compared to other datasets, this data was not used in the ranking process.

Other datasets were requested but were not obtained in the timeframe required to complete the report. However, it was considered that these datasets, taking into account other datasets that were being used, would offer limited additional value. These included:

- Data on sea snake distribution requested from Mick Guinea, Researcher at Charles Darwin University. However, there are no species of sea snakes listed as Threatened under the WA legislation, and only two species of sea snakes listed as Critically Endangered under the *EPBC Act*: the short-nosed (*Aipysurus apraefrontalis*) and leaf-scaled (*A. foliosquama*) sea snakes. Both are mostly found on Ashmore and Hibernia Reefs, with only very rare sightings of the former off the Kimberley coast in the last 15 years. These records and areas where the species may occur have been located through other databases (e.g. SNES).
- Data on shorebird distribution requested from Birds Australia. Extensive data on bird distribution is available from the DBCA Nature Map and the EPBC Species of National Environmental Significance, which has allowed shoreline cells to be appropriately ranked.

Furthermore, the WAMSI Kimberley dugong research project dataset could not be obtained in time to finalise this report, as we did not receive approval from all Aboriginal custodians. It is recommended that this dataset be reviewed and, if required, included in any updates of the report and/or used in any response planning situation when it is made available.

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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 priority for protection in 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 sensitivity.

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 in the Steering Committee Workshop (see Section 1.5) regarding these points, and the overall consensus is 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. 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 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 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 found for these species.

[2] Under the WC Act, 11 conservation categories exist. In addition to those listed in the EPBC Act, there are seven more used, including CD. The other six are Other specially protected fauna (OS), migratory (IA) 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. 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 can be greatly impacted by oil, whales are less likely to be affected at an individual level due to a number of factors. This is discussed more in the sections below.

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 ranked 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). Seventeen of these species are endemic to Western Australia, while many others migrate annually to feed, breed, and escape the northern winter. The zone plays an important role in providing habitat for both endemic species and migratory birds which are protected under JAMBA and CAMBA. The Kimberley contains two of only a dozen areas in the world with huge intertidal flats rich in shorebirds. Roebuck Bay and Eighty Mile Beach Ramsar wetlands are summer refuges to hundreds of thousands of internationally protected migratory waders that fly from as far afield as Siberia. Both are at the receiving end of the world's most species-rich shorebird flyways. These Ramsar wetlands have been considered in the Protection Area category (Section 3.2.4).

Bird distribution, species and conservation status (legislated) data was obtained as discrete observation locations from the following sources:

- DBCA's NatureMap database;
- The DotEE Species of National Environmental Significance (SNES) dataset; and

- Generalised distribution polygon information from the DotEE Biologically Important Areas (BIA) database.

Key bird species in the Kimberley zone include:

- Critically Endangered (CR) birds: curlew sandpiper (*Calidris ferruginea*), great knot (*Calidris tenuirostris*), northern Siberian bar tailed godwit (*Limosa lapponica menzbieri*) and eastern curlew (*Numenius madagascariensis*);
- Endangered (EN) birds: Australian lesser noddy (*Anous tenuirostris melanops*), Australasian bittern (*Botaurus poiciloptilus*), red knot (*Calidris canutus*) and its subspecies red knot (north-eastern Siberia) (*Calidris canutus rogersi*), lesser sand plover (*Charadrius mongolus*), Abbott's booby (*Papasula abbotti),* Hutton's shearwater (*Puffinus huttoni*) and Australian painted snipe (*Rostratula australis*); and
- Vulnerable (VU) birds: greater sand plover (*Charadrius leschenaultii*) and its subspecies greater sand plover (Mongolian) (*Charadrius leschenaultii leschenaultii*), bar tailed godwit (*Limosa lapponica*) and its subspecies (*Limosa lapponica baueri*), and the fairy tern (*Sterna nereis nereis*).

There are also 71 more migratory (IA), Priority (P1 to P4) and Other Specially Protected (OS) bird species in the Kimberley zone.

Distribution

The CR curlew sandpiper is known or likely to occur within Shoreline Cells 3 to 7, 16, 24, 25, 56 to 60, 63 to 66, 70 to 77, 79, 81 to 87, 282, 296, 299 and 308. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 87 and 281 to 292).

The CR great knot is known or likely to occur within Shoreline Cells 16, 64, 72 to 76, 79, 81 to 87 and 308.

The CR northern Siberian bar tailed godwit is known or likely to occur within Shoreline Cells 71 to 87. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 5, 8, 16 to 20, 23 to 26, 29 to 48, 51 to 71, 79, 282, 287, 294, 295, 299, 301 and 308).

The CR eastern curlew is known or likely to occur within Shoreline Cells 1 to 7, 10, 13, 17, 18 to 20, 22, 24, 25, 28 to 31, 33, 36, 38, 39, 41 to 46, 48, 53, 56 to 60, 63 to 68, 70 to 87, 282, 296, 299 and 308. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 87, 281 to 302 and 305 to 311).

The EN Australian lesser noddy may occur on some of the islands off the Kimberley coast (Shoreline Cells 302, 305 and 306).

The EN Australasian bittern is moderately certain to occur in Shoreline Cells 4 and 5.

The EN red knot is likely to occur or is known to occur within Shoreline Cells 58, 66, 71 to 76, 80 to 87, 294 to 296, 299 and 308. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 5, 8 to 87, 281 to 302 and 305 to 311). The subspecies red knot (north-eastern Siberia) is known to occur in Shoreline Cells 73 and 74.

The EN lesser sand plover is known or likely to occur within Shoreline Cells 17, 58, 64, 67, 72 to 76, 78, 79, 81 to 87, 299, 307 and 308.

The EN Hutton's shearwater is likely to or is known to occur within Shoreline Cells 73 and 308.

The EN Abbott's booby may occur within Shoreline Cells 48 to 84, 296 to 302 and 305 to 311.

The EN Australian painted snipe is likely to or is known to occur within Shoreline Cells 1 to 7, 57 to 60, 73 to 76 and 308. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 87).

The VU greater sand plover is known or likely to occur within Shoreline Cells 2, 4, 13, 16 to 18, 24, 30, 34, 42, 45, 58, 64 to 66, 68, 71 to 76, 78, 79, 81 to 87, 294, 296, 299, 302, 307 and 308. The subspecies greater sand plover (Mongolian) is also known to occur in Shoreline Cells 50, 74, 75, 83, 85 and 299.

The VU bar tailed godwit including its subspecies bauera is known or likely to occur within Shoreline Cells 2, 4, 16, 18, 24, 33, 45, 56 to 58, 60, 64, 65, 68, 71 to 87, 294, 299, 302 and 308. It also may occur in numerous other locations along the Kimberley coast (Shoreline Cells 1 to 5, 8, 16 to 20, 23 to 26, 29 to 48, 51 to 56, 58 to 71, 282, 287, 294, 295, 299, 301 and 308).

The VU fairy tern is likely to occur within Shoreline Cell 308.

Discussion

The bird protection priority ranking considers the threatened status of a species and its biological use of the area, as well as the certainty of the data available. For the SNES data, species that are 'known', 'likely' and 'may be' in an area have been given different weightings, while for the DPaW data, the survey method and certainty of identification have been used (e.g. caught, trapped or sighted and 'Very Certain, 'WAM Vouchered' or 'Certain', which were provided in the dataset). For the threatened status of a species, its highest protection 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. This process ensures species that are protected only at a state level under the *WC Act* are included in the assessment.

The ranking also takes into account the biological importance of an area to a species, elevating the priority of an area that could contain high numbers of that species, and activities associated with breeding, which is when the species is most vulnerable. This reflects the possible long term consequences the spill can have at a species level if a spill occurred at critical sites during breeding season. The steering committee also discussed the important habitat the Kimberley provides, including feeding grounds, for long distance migratory species which are critical to their lifecycle, and that this should be considered in the ranking of migratory species. However, a decision was made not to change the ranking for these migratory species. This was to retain the same approach used for other zones which also include migratory species. Furthermore, important habitats for migratory species are protected within Ramsar wetlands, particularly Roebuck Bay and Eighty Mile Beach, which have been ranked Very High for protection from both floating and dissolved oils (Section 3.2.4).

The ranking also considers the major impact heavy oiling can have on fauna, especially birds (French-McCay *et al.*, 2002; 2004; 2006). When oiled, birds' feathers lose their waterproofness and their insulation, which can lead to hypothermia, dehydration, drowning and starvation. Birds

coming into contact with layers of 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 through feeding on contaminated prey such as benthic invertebrates.

The rankings for protection priority for birds are presented in Table 3-3. The table includes details about data confidence, reliability, survey method type, accuracy and geospatial extent.

Based on Table 3-3, Shoreline Cells 17, 24, 73, 74, 75, 79, 82, 85, 86, 296 and 308 have been ranked Very High for protection from floating oil and High for protection from dissolved oil, because of the verified presence of the CR eastern curlew, curlew sandpiper, bar tailed godwit (northern Siberian) and great knot.

Shoreline Cells 1 to 7, 9, 10, 13, 16, 20, 25, 29 to 31, 33, 35 to 39, 42, 43, 45, 46, 48 to 51, 53, 56 to 60, 63 to 68, 70 to 72, 76 to 78, 80, 81, 83, 84, 87, 282, 292 and 299 have been ranked High for protection from floating oil and Medium for protection from dissolved oil, for the presence of the CR eastern curlew, curlew sandpiper, north-eastern Siberian bar tailed godwit and great knot, the EN red knot, including the subspecies north-eastern Siberia, lesser sand plover, Hutton's shearwater and the Australian painted snipe, and the VU greater sand plover and bar tailed godwit.

Shoreline Cells 8, 11, 12, 14, 15, 18, 19, 21 to 23, 26 to 28, 32, 34, 40, 41, 44, 47, 52, 54, 55, 61, 62, 69, 283 to 291, 293 to 295, 297, 298, 300 to 302, 305 to 307 and 309 to 311 have been ranked Medium for protection from floating oil and Low for protection from dissolved oil, due to the presence of the CR eastern curlew, curlew sandpiper, bar tailed godwit (northern Siberian) and great knot, the EN red knot, lesser sand plover, Hutton's shearwater and the Australasian bittern.

A total of 15 terrestrial species were identified through the database searches as occurring within the coastal zone (Table 3-2). However, a review of their ecology revealed these would not use the intertidal zone during their lifecycle. In accordance with the ranking criteria in Table 3-3, these have therefore been ranked Very Low for protection from both floating and dissolved oil. .

All other cells of the Kimberley zone have been ranked Very Low for protection from both dissolved and floating oil due to various bird species.

Table 3-2: Terrestrial species

Species	Listing
Crested shrike tit (*Falcunculus frontatus whitei*)	EPBC: VU WA: P4
Gouldian finch (*Erythrura gouldiae*)	EPBC: EN WA: P4
Masked owl (northern) (*Tyto novaehollandiae kimberli*)	EPBC: VU WA: P1
Night parrot (*Pezoporus occidentalis*)	EPBC: EN WA: CR
Patridge pigeon (eastern) (*Geophaps smithii smithii*)	EPBC: VU WA: P4
Patridge pigeon (western) (*Geophaps smithii blaauwi*)	EPBC: VU WA: VU
Princess parrot (*Polytelis alexandrae*)	EPBC: VU WA: P4
Purple-crowned fairy wren (western) (*Malurus coronatus coronatus*)	EPBC: EN WA: EN
Red goshawk (*Erythrotriorchis radiatus*)	EPBC: VU WA: VU
Barn swallow (*Hirundo rustica*)	EPBC: / WA: IA
Black grasswren (*Amytornis housei*)	EPBC: / WA: P4
Fork-tailed swift (*Apus pacificus*)	EPBC: / WA: IA
Grey falcon (*Falco hypoleucos*)	EPBC: / WA: VU
Letter-winged kite (*Elanus scriptus*)	EPBC: / WA: P4
Oriental cuckoo (*Cuculus optatus*)	EPBC: / WA: IA

Table 3-3: 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 DotEE 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	2	1	
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			

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

- DotEE Species of National Environmental Significance (SNES)
- DotEE Biologically Important Areas (BIAs)
- DBCA's NatureMap database

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:

- DBCA's NatureMap database;
- The DotEE Species of National Environmental Significance (SNES) dataset;
- Data provided by INPEX;
- WAMSI Kimberley node research project data on dolphins;
- Data on dugong distribution from Edith Cowan University; and
- Generalised distribution polygon information from the DotEE Biologically Important Areas (BIA) database.

Key mammal species in the Kimberley zone include:

- Endangered (EN) mammals: sei whale (*Balaenoptera borealis*), blue whale (*Balaenoptera musculus*), pygmy blue whale (*Balaenoptera musculus brevicauda*), fin whale (*Balaenoptera physalus*); and
- Vulnerable (VU) mammals: humpback whale (*Megaptera novaeangliae*).

There are also 16 more migratory (IA), Priority (P1 to P4) and Other Specially Protected (OS) mammal species in the Kimberley zone, which include the dugong (*Dugong dugon*), Indo-Pacific humpback dolphin (*Sousa sahulensis*) and Australian snubfin dolphin (*Orcaella heinsohni*).

Distribution

In terms of marine mammals which occur in the Kimberley zone, the EN sei whale is known or likely to occur within Shoreline Cells 30, 302, 305 to 307 and 309 to 311. It also may occur in numerous other locations (Shoreline Cells 12, 13, 15, 16, 21, 22, 50, 281 to 283, 285, 287, 289 to 293, 296 to 300 and 302).

The EN blue whale is known or likely to occur within Shoreline Cells 12 to 40, 50, 64 to 87, 281 to 300, 302 and 305 to 311. It also may occur in numerous other locations (Shoreline Cells 1 to 5 and 7 to 12).

The EN pygmy blue whale is known or likely to occur within Shoreline Cells 69 to 87 and 305 to 311.

The EN fin whale is known or likely to occur within Shoreline Cells 39, 302, 305 to 307 and 309 to 311. It also may occur in numerous other locations (Shoreline Cells 12, 13, 15, 16, 21, 22, 50, 281 to 283, 285, 287, 289 to 293, 296 to 300 and 302).

The VU humpback whale is known or likely to occur within Shoreline Cells 11 to 87, 281 to 302 and 305 to 311. It also may occur in numerous other locations (Shoreline Cells 1 to 5, 9 to 14, 16 to 21, 23 to 26, 28 to 33, 38 to 40, 50, 67 to 69, 71 to 74, 286, 292, 300 and 305 to 307).

Discussion

Marine mammals in the Kimberley zone could come in direct contact with floating oil, or potentially ingest hydrocarbons that are dissolved. Physical oiling can burn and irritate the 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.

The rankings for protection priority for mammals are presented in Table 3-5. The table incorporates data confidence, reliability, survey method type, accuracy and geospatial extent.

Shoreline Cells 30 and 39 have been ranked High for protection from floating oil and Medium for protection from dissolved oil, for the presence of the EN sei whale and fin whale.

Shoreline Cells 24, 27, 29, 31 to 32, 34, 35, 37 to 38, 40 to 42, 44, 48 to 52, 63 to 87, 285 to 302, 305 to 311 have been ranked Medium for protection from floating oil and Low for protection from dissolved oil, due to the presence of the VU blue whale, pygmy blue whale and humpback whale.

A total of 17 terrestrial species were identified through the database searches as occurring within the coastal zone (Table 3-4). However, a review of their ecology revealed these would not use the intertidal zone during their lifecycle. In accordance with the ranking criteria in Table 3-5, these have therefore been ranked Very Low for protection from both floating and dissolved oil.

All other cells of the Kimberley zone have been ranked Very Low for protection from dissolved and floating oil due to various mammal species.

Table 3-4: Terrestrial species

Species	Listing
Bare-rumped sheathtail bat (*Saccolaimus saccolaimus nudicluniatus*)	EPBC: VU WA: P3
Yellow-lipped cave bat (*Vespadelus douglasorum*)	EPBC: / WA: P2
Ghost bat (*Macroderma gigas*)	EPBC: VU WA: VU
Northern leaf nosed bat (*Hipposideros stenotis*)	EPBC: / WA: P2
Orange leaf-nosed bat (*Rhinonicteris aurantius*)	EPBC: / WA: P4
North-western free-tailed bat (*Mormopterus lumsdenae*)	EPBC: / WA: P1
Black-footed tree rat (*Mesembriomys gouldii gouldii*)	EPBC: EN WA: EN
Brush-tailed rabbit rat (*Conilurus penicillatus*)	EPBC: VU WA: VU
Golden-backed tree rat (*Mesembriomys macrurus*)	EPBC: VU WA: P4
Golden bandicoot (*Isoodon auratus auratus*)	EPBC: VU WA: VU
Greater bilby (*Macrotis lagotis*)	EPBC: VU WA: VU
Scaly-tailed possum (*Wyulda squamicaudata*)	EPBC: / WA: P4
Kimberley brush-tailed phascogale (*Phascogale tapoatafa kimberleyensis*)	EPBC: VU WA: VU
Nabarlek (Kimberley) (*Petrogale concinna monastria*)	EPBC: E WA: E
Monjon (*Petrogale burbidgei*)	EPBC: / WA: P4
Northern marsupial mole (*Notoryctes caurinus*)	EPBC: / WA: P4
Northern quoll (*Dasyurus hallucatus*)	EPBC: EN WA: EN

Table 3-5: 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 DotEE 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			
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 ▪ Caught, trapped or sighted Very Certain/WAM	2	1	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
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

- DotEE Species of National Environmental Significance (SNES)
- DotEE Biologically Important Areas (BIAs)
- DBCA's NatureMap database
- Data provided by INPEX
- WAMSI Kimberley node research project data on dolphins
- Data on dugong distribution from Edith Cowan University

3.1.3 Invertebrates

Description

Invertebrates are all animals that lack a backbone. They include marine invertebrates such as crustaceans, corals, sponges, jellyfish and octopi (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). However, as some protected terrestrial invertebrates have habitats along the coast, a protection priority ranking has been adopted for terrestrial invertebrates only.

Terrestrial invertebrate distribution, species and conservation status (legislated) data was obtained as discrete observation locations from the following sources:

- DBCA's NatureMap database;
- The DotEE Species of National Environmental Significance (SNES) dataset; and
- Generalised distribution polygon information from the DotEE Biologically Important Areas (BIA) database.

Several protected invertebrate species were identified in the Kimberley zone. These were various species of Camaenid land snails including the CR Laurie camaenid land snail (*Ningbingia laurina*), the VU *Amplirhagada astute* and five other camaenid land snails with Priority (P1 to P4) ranking.

Distribution

The Caemenid land snail is known or likely to occur in Shoreline Cells 3, 16, 27, 50, 285, 286, 300. The CR Laurie camaenid land snail is known to occur in Shoreline Cell 3 and VU *Amplirhagada astute* in Shoreline Cell 50.

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 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 3-6.

The Camaenids are exclusive to limestone occurrences in pockets of open and closed deciduous vine thicket, with additional scattered boab trees (*Adansonia gregorii*), and therefore do not use the intertidal zone. In accordance with the ranking criteria in Table 3-6, the shoreline cells have been ranked Very Low for protection from both floating and dissolved oil.

Table 3-6: 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 DotEE 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 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 ▪ DotEE Species of National Environmental Significance (SNES) ▪ DotEE Biologically Important Areas (BIAs) ▪ DBCA's NatureMap database			

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 following sources:

- DBCA's NatureMap database;
- The DotEE Species of National Environmental Significance (SNES) dataset;
- Generalised distribution polygon information from the DotEE Biologically Important Areas (BIA) database; and
- Information on Totally Protected fish species from the DPIRD, and geospatial information from the Atlas of Living Australia to determine previous records within the Kimberley zone.

Key fish species in the Kimberley zone include:

- Endangered (EN) fish: northern river shark (*Glyphis garricki*); and
- Vulnerable (VU) fish: great white shark (*Carcharodon carcharias*), dwarf sawfish (*Pristis clavata*), freshwater sawfish (*Pristis pristis*), green sawfish (*Pristis zijsron*) and whale shark (*Rhincodon typus*).

There are also five more migratory (IA), Priority (P1 to P4) and Other Specially Protected (OS) fish species which occur in the Kimberley zone which include the Prince Regent hardyhead (*Craterocephalus lentiginosus*) and the large scale grunter (*Leiopotherapon macrolepis*).

'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 Kimberley zone, this includes humphead Maori wrasse (*Cheilinus undulatus*), the whale shark (*Rhincodon typus),* all sawfish species and the potato cod (*Epinephelus tukula*).

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 EN northern river shark is known or likely to occur within Shoreline Cells 2 to 9 and 52 to 64. It also may occur in numerous other locations (Shoreline Cells 1 to 3, 5, 9 to 52, 64, 65, 281 to 302 and 305 to 307).

The VU great white shark may occur in numerous shoreline cells within the Kimberley zone including Shoreline Cells 1 to 5, 8 to 87, 281 to 302 and 305 to 311.

The VU dwarf sawfish is known or likely to occur within Shoreline Cells 1 to 87, 281 to 301 and 308.

The VU freshwater sawfish is known or likely to occur within Shoreline Cells 1 to 87, 281 to 301 and 308.

The VU green sawfish is known or likely to occur within Shoreline Cells 1 to 87, 281 to 302 and 308.

The VU whale shark is known or likely to occur within Shoreline Cells 50, 285, 287, 291, 297 to 300 and 302. It also may occur in numerous other locations (Shoreline Cells 1 to 5, 7 to 87, 281 to 302 and 305 to 311).

Discussion

Fish are affected by hydrocarbons through physical smothering impacting 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 3-7. The rankings also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent.

Shoreline Cells 3, 4, 5, 55 to 58 and 60 have been ranked Medium for protection from dissolved oil and Low for protection from floating oil, due to the presence of the EN northern river shark.

Shoreline Cells 2, 6 to 9, 52 to 54, 59, 61 to 64, 68, 73 to 76 and 79 to 87 have been ranked Low for protection from dissolved oil, and Very Low for protection from floating oil due to the presence of the EN northern river shark, the VU green sawfish, freshwater sawfish and dwarf sawfish, the P2 Prince Regent hardyhead and the large scale grunter.

All other cells of the Kimberley zone have been ranked Very Low for protection from dissolved and floating oil due to various fish species.

Table 3-7: 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 DotEE 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

- DotEE Species of National Environmental Significance (SNES)
- DotEE Biologically Important Areas (BIAs)
- DBCA's NatureMap database
- Totally Protected fish from the DPIRD, with geospatial information from the Atlas of Living Australia

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 following sources:

- DBCA's NatureMap database;
- DotEE Species of National Environmental Significance (SNES) dataset;
- Data provided by INPEX;
- WAMSI Kimberley node research project data on turtles;
- WAMSI Kimberley node research project data on crocodiles; and
- Generalised distribution polygon information from the DotEE Biologically Important Areas (BIA) database.

Key reptile species in the Kimberley zone include:

- Critically Endangered (EN) reptiles: short-nosed sea snake (*Aipysurus apraefrontalis*);
- Endangered (EN) reptiles: loggerhead turtle (*Caretta caretta*), leatherback turtle (*Dermochelys coriacea*) and Olive Ridley turtle (*Lepidochelys olivacea*); and
- Vulnerable (VU) reptiles: hawksbill turtle (*Eretmochelys imbricata*), flatback turtle (*Natator depressus*), green turtle (*Chelonia mydas*) and Airlie Island ctenotus (*Ctenotus angusticeps*).

There are also eight more Priority (P1 to P4) and Other Specially Protected (OS) reptile species in the Kimberley zone which include the salt-water crocodile (*Crocodylus porosus*).

Distribution

The CR short-nosed sea snake is known or likely to occur within Shoreline Cells 3, 4, 21 to 87, 283 to 289, 291 to 296 and 305 to 311. It also may occur in numerous other locations (Shoreline Cells 27 to 30, 34, 38, 39, 41, 44, 48, 284 to 291, 293, 295, 296, 305 to 307 and 309 to 311).

The EN loggerhead turtle is known or likely to occur throughout the Kimberley zone within Shoreline Cells 1 to 87, 281 to 302 and 305 to 311.

The EN leatherback turtle is known or likely to occur throughout the Kimberley zone within Shoreline Cells 1 to 87, 281 to 302 and 305 to 311.

The EN Olive Ridley turtle is known or likely to occur within Shoreline Cells 1 to 55, 59 to 73, 281 to 302 and 305 to 307. It also may occur in numerous other locations (Shoreline Cells 4 to 7, 15 to 50, 282, 285, 286, 288, 292, 293, 296 to 299, 302, 305 and 306).

The VU hawksbill turtle is known or likely to occur throughout the Kimberley zone within Shoreline Cells 1 to 87, 281 to 302 and 305 to 311.

The VU flatback turtle is known or likely to occur throughout the Kimberley zone within Shoreline Cells 1 to 87, 281 to 302 and 305 to 311.

The VU green turtle is known or likely to occur throughout the Kimberley zone within Shoreline Cells 1 to 87, 281 to 302 and 305 to 311.

The VU Airlie Island ctenotus is known or likely to occur within Shoreline Cells 73 to 75 and 78 to 80.

Discussion

The assessment for impacts on reptiles considered that physical oiling by floating oil irritates 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.

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 3-9. The rankings also incorporate data confidence, reliability, survey method type, accuracy and geospatial extent.

In the protection priority ranking for reptiles (Table 3-9), 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.

Shoreline Cell 292 has been ranked High for protection from floating oil and Medium for protection from dissolved oil, for the presence of the EN Olive Ridley turtle.

All remaining Shoreline Cells 1 to 87, 281 to 291, 293 to 302 and 305 to 311 have been ranked Medium for protection from floating oil and Low for protection from dissolved oil, for the presence of the CR short-nosed seasnake, EN Olive Ridley turtle, loggerhead turtle, leatherback turtle, the VU green turtle, hawksbill turtle and Airlie Island ctenotus.

The Airlie Island ctenotus is considered a terrestrial species. It 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). Based on 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 and has been ranked Medium for protection from floating oil and Low for protection from dissolved oil.

A total of two additional terrestrial species were identified through the database searches as occurring within the coastal zone (Table 3-4). However, a review of their ecology revealed these would not use the intertidal zone during their lifecycle. In accordance with the ranking criteria in Table 3-5, these have therefore been ranked Very Low for protection from both floating and dissolved oil.

Table 3-8 Terrestrial species

Species	Listing
Plains death adder (*Acanthophis hawkei*)	EPBC: VU WA: /
Buccaneer burrowing skink (*Lerista praefrontalis*)	EPBC: / WA: VU

The other species and/or the data confidence and use of the area of a species have been given lower rankings for protection from floating and dissolved oil.

Table 3-9: 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 DotEE 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 database ▪ Secondary signs Very Certain/WAM Vouchered/Certain ▪ Caught, trapped or sighted Moderately Certain, Not Defined or Not Sure Vulnerable species, if:	3	2	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
▪ 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 ▪ 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	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 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 ▪ DotEE Species of National Environmental Significance (SNES) ▪ DotEE Biologically Important Areas (BIAs) ▪ DBCA's NatureMap database ▪ Data provided by INPEX ▪ WAMSI Kimberley node research project data on turtles ▪ WAMSI Kimberley node research project data on crocodiles			

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. Protection areas include both areas formally protected through State or Commonwealth legislation, and important habitats identified through ecological and scientific literature. For example, seagrass, mangroves and coral.

When assessing the Pilbara zone, 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 as 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. This process has also been applied to the Kimberley zone.

3.2.1 World Heritage Areas

Description

Australia has 19 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 DotEE World Heritage Areas dataset was used to delineate the World Heritage areas in the Kimberley zone.

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

There are no World Heritage Area in the Kimberley zone. No additional proposed or nominated evidence for the Kimberley 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.

The protection priority ranking listed in Table 3-10 are provided for information only, as the Kimberley zone does not include any World Heritage areas.

Table 3-10: 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

- DotEE 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 (DotEE, 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 (DotEE, 2013). Most of this land is managed by DBCA.

Terrestrial protection areas have been identified through the DotEE Collaborative Australian Protected Areas Database (CAPAD). The dataset is updated every two years and, while the previous version is dated 2014, DBCA 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.

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 DBCA 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 DBCA 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 DBCA. 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.

'A Representative Marine Reserve System for Western Australia', a report by the Marine Reserves Selection Working Group (the Wilson report) (Wilson *et al.*, 1994) was also used to identify proposed protected areas. The report was used to visually identify which cells these proposed areas were in, and assign an appropriate conservation category as per the CALM Act. If the conservation category could not be determined through background research, the proposed area was assigned to 5(1)(g) Reserves.

The DBCA legislated land and waters database was also used. This database shows all lands and waters defined under Acts which are applicable to DBCA. These include the *CALM Act 1984*, *Swan and Canning Rivers Management Act 2006* and lands identified under the *Land Administration Act 1997* such as Crown reserve vested in Botanical Gardens and Parks, Crown reserve vested in the Zoological Gardens Board and Crown reserve vested in the Rottnest Island Authority. Tenure categories include national park, nature reserve, conservation park, marine park, marine nature reserve, marine management area, section 5(1)(g) reserves, state forest and timber reserves. It is noted there is some duplication between this database and the CAPAD database.

Distribution

In the Kimberley zone, there are 39 listed or proposed conservation areas:

- Fifteen Strict Nature Reserves (IUCN IA) in Shoreline Cells 2, 3, 4, 5, 13, 22, 50, 64 to 67, 71, 81, 296, 299, 302 and 308. These include one proposed Nature Reserve as identified in the Wilson report (Borda Nature Reserve in Shoreline Cells 66 and 67);
- Three National Parks (IUCN II) in Shoreline Cells 24, 25 and 33 to 36; and
- Twenty-three other 5(1)(g) Reserves, 5(1)(h) Reserves, Indigenous Protected Areas, Miscellaneous Reserves and Regional Parks in Shoreline Cells 2, 3, 5 to 13, 17 to 43, 45, 46, 48 to 52, 63 to 67, 73 to 81, 84 to 87, 281, 282, 284 to 290, 292 to 294, 299, 300, 302, 307 and 308.

The better known ones include the Browse Island Nature Reserve and Lacepede Islands Nature Reserve.

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 3-11. As noted in Section 3.2, it has been recognised that due to 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 first zone assessed (i.e. Pilbara), it was highlighted that the designated boundary of a terrestrial protection area may be either to the mean high water mark, or to the mean low water mark. If the boundary was to the mean low water mark, the area for protection included the intertidal zone. Therefore the effects of marine pollution in the intertidal zone needed to be considered in the Terrestrial Protection Area assessment. In response, the terrestrial parks have been divided into parks that include the intertidal zone and those that have a boundary to the mean high water mark (terrestrial only), and the potential impacts ranked accordingly. The

methodology used to define the intertidal, subtidal and terrestrial zones for the Kimberley zone is discussed in Section 8.4.

The majority of terrestrial protection areas include the intertidal zone except for unnamed reserves in Shoreline Cell 13 (WA44677 5(1)(h) Reserve), Shoreline Cell 74 (WA51932 5(1)(h) Reserve), Shoreline Cell 299 (WA44674 Nature Reserve), Shoreline Cell 300 (WA28968 5(1)(h) Reserve), Shoreline Cell 302 (WA41775 5(1)(h) Reserve) and Shoreline Cell 308 (WA37168 5(1)(h) Reserve).

The majority of the shoreline cells of the Kimberley zone have been ranked due to the presence of various terrestrial protection areas. A total of 17 shoreline cells have been ranked High for protection from floating oil and Medium for protection from dissolved oil due to the presence of 15 strict nature reserves. Six cells have been ranked Medium for protection from floating oil and Low for protection from dissolved oil due to the presence of three national parks. Cells which contained other reserves as identified above have been ranked Low for protection from floating oil and Very Low for protection from dissolved oil.

Table 3-11: 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 ▪ DotEE CAPAD with DBCA update ▪ DBCA legislated land and waters ▪ Wilson report			

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 conserve aquatic biodiversity and contribute to a sustainable marine environment. 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 DotEE CAPAD Marine dataset. This dataset provides both spatial and text information about government, Indigenous and privately protected areas for continental Australia. State and Territory conservation agencies supplied DotEE with data current to 30 June 2014 for inclusion. It is updated by the DotEE every two years, however DBCA was able to provide an updated marine and terrestrial dataset for lands vested in its department. The WA DPIRD also provided updated datasets for areas managed for fisheries.

Marine Protection 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 as described above in Section 3.2.2 for terrestrial protection areas. It should be noted that different areas within the same reserve can receive a different IUCN category. For example, the Rowley Shoals Marine Park sanctuary zone is assigned an IUCN category of IA while the recreation zone and general use zone is classified as II.

Fish Habitat Protection areas, along with Closed Waters areas, are described in Section 3.2.8.

As per terrestrial protection areas, 'A Representative Marine Reserve System for Western Australia' report (Wilson et al 1994) and the DBCA legislated land and waters database were also used to identify additional existing and/or proposed marine protection areas.

Distribution

In the Kimberley zone, there are 20 listed or proposed marine conservation areas. Some of these have been divided into smaller zones for management purposes and each zone may have a different IUCN classification:

- Three IUCN IA reserves and/or zones. This includes Scott Reef Nature Reserve (Shoreline Cells 306 and 307), the sanctuary zones of the Mermaid Reef Commonwealth Marine Reserve (Shoreline Cell 309) and the Rowley Shoals Marine Park (Shoreline Cells 310 and 311).

- Four IUCN II reserves and/or zones. This includes the Kimberley Commonwealth Marine Reserve Marine National Park zone (Shoreline Cell 65), the Rowley Shoals Marine Park recreation zone and general use zone (Shoreline Cells 310 and 311) and as part of the Australian Marine Parks draft zoning, the Kimberley Commonwealth Marine Reserve National Park zone (Shoreline Cells 293 and 298) and the Mermaid Reef Commonwealth Marine Reserve National Park zone (Shoreline Cell 309).
- Two IUCN IV reserves and/or zones. This includes the Rowley Shoals Marine Park unassigned zone (Shoreline Cell 310) and the Kimberley Commonwealth Marine Reserve Habitat Protection zone (Shoreline Cells 65 and 299).
- Eleven IUCN VI reserves and/or zones. The Joseph Bonaparte Gulf Commonwealth Marine Reserve Multiple Use zone (Shoreline Cells 8 and 9), the Lalang-garram/Camden Sound Marine Park (Shoreline Cells 35 to 41, 44 and 292 to 297), the Kimberley Commonwealth Marine Reserve Multiple Use zone (Shoreline Cells 65 to 69, 281 to 283, 285, 291, 298, 299 and 308), the Roebuck Commonwealth Marine Reserve Multiple Use zone (Shoreline Cells 73 to 76), Unnamed WA51046 5(1)(h) Reserve Unassigned zone (Shoreline Cells 74 to 76), Eighty Mile Beach Commonwealth Marine Reserve (Shoreline Cells 80 to 87) and the Eighty Mile Beach Marine Park (Shoreline Cells 81 to 87), the Argo-Rowley Terrace Commonwealth Marine Reserve Multiple Use zone (Shoreline Cells 309 to 311), the North Kimberley Marine Park (Shoreline Cells 1 to 3, 8 to 34 and 281 to 290), the North Lalang-garram Marine Park (Shoreline Cells 34, 35, 37 and 289 to 293) and the Lalang-garram/Horizontal Falls Marine Park (Shoreline Cells 41 to 50, 294 and 296).

The Wilson report also identified a number of proposed reserves including:

- Montgomery Islands Reserve (Shoreline Cells 41, 294 and 295);
- Walcott Inlet Reserve (Shoreline Cell 45);
- Adele Island Reserve (Shoreline Cell 299);
- Buccaneer Archipelago Reserve (Shoreline Cells 49 to 53, 63 to 65, 300 and 301);
- Lacepede Islands Reserve (Shoreline Cell 308); and
- Lagrange Bay Reserve (Shoreline Cells 77 to 80).

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 3-12. 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 mean high water mark, or to the mean 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 mean high water mark) and those that only go to the mean low water mark (i.e. subtidal only). This is reflected in the rankings in Table 3-12. The methodology used to define the intertidal, subtidal and terrestrial zones in the Kimberley is discussed in Section 8.4. The marine protection areas include the intertidal zone.

Where there were inconsistencies between various datasets in terms of the IUCN classification, the highest IUCN classification was selected. For example, the Rowley Shoals Marine Park was an IUCN type VI reserve within the DBCA legislated lands and waters dataset but a type IA, II or IV,

depending on the zoning, within the CAPAD dataset. The higher classification was selected for ranking purposes.

For the proposed reserves from the Wilson report, there are currently no details on how these will be classified under the IUCN system. Therefore, all reserves have been assigned a ranking of Low for protection from floating and dissolved oil.

Kingfisher Island was discussed at the Steering Committee workshop and asked to be included in the ranking. Kingfisher Island is located within the Lalang-garram/Horizontal Falls Marine Park boundary and therefore has been ranked accordingly.

Five shoreline cells covered by the three IUCN-type IA reserve areas have been ranked High for protection from both dissolved and floating oil. Four shoreline cells have been ranked Medium for protection from both dissolved and floating oil due to the presence of IUCN II and IV reserves/ zones (i.e. Kimberley Commonwealth Marine Reserve). Ninety-three shoreline cells have been ranked Low for protection from both dissolved and floating oil due to IUCN VI reserves/zones.

Table 3-12: 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 ▪ DotEE CAPAD with DBCA update ▪ DBCA legislated land and waters ▪ Wilson report			

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
6. It is of outstanding historical or cultural significance.

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

Distribution

There are three Ramsar wetlands in the Kimberley zone. These are the Ord River Floodplain (Shoreline Cells 3 and 4), Roebuck Bay (Shoreline Cells 74 to 76) and Eighty Mile Beach (Shoreline Cells 81 to 87).

There are six nationally important wetlands in the Kimberley zone. These are Ord Estuary System (Shoreline Cells 3 and 4), the Parry Floodplain (Shoreline Cells 4 and 5), the Mitchell River System (Shoreline Cell 25), the Prince Regent River System (Shoreline Cell 35 and 36), Yampi Sound Training Area (Shoreline Cell 50), Bunda-Bunda Mound Springs (Shoreline Cell 70), the Willie Creek

Wetlands (Shoreline Cells 73), Roebuck Bay (Shoreline Cells 74 and 75) and Mermaid Reef (Shoreline Cell 309).

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 3-13.

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 3-13).

Twelve shoreline cells have been ranked Very High for protection from both floating and dissolved oils as a result of the presence of three Ramsar wetlands as indicated in the distribution above. The higher number of shoreline cells ranked very high due to the presence of Ramsar wetlands compared to other zones is mostly driven by Eighty Mile Beach where the wetland stretches across seven shoreline cells. As discussed in Section 3.1.1, Ramsar wetlands in the Kimberley, in particular Roebuck Bay and Eighty Mile Beach, play an important role in providing habitat for both endemic species and migratory birds which are protected under JAMBA and CAMBA.

Additionally, eight Shoreline Cells (5, 25, 35, 36, 50, 70, 73, 309) have been ranked High for protection from both floating and dissolved oils as a result of the presence of three nationally important wetlands (Parry Floodplain, Mitchell River System, Prince Regent River System, Yampi Sound Training Area, Bunda-Bunda Mound Springs, Willie Creek Wetlands and Mermaid Reef).

Table 3-13: 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

- DotEE Ramsar Wetlands of Australia
- Directory of Important Wetlands in Australia

3.2.5 Key Ecological Features

Description

Marine Key Ecological Features (KEFs) are elements of the marine environment that are considered regionally important based on current scientific understanding, 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 DotEE. While all KEFs are in Commonwealth waters, the shoreline cell boundaries may overlap with some Commonwealth waters.

Distribution

There are five KEFs in the Kimberley zone. These are the carbonate bank and terrace system of the Sahul Shelf (Shoreline Cells 3, 8 and 11 to 14), ancient coastline at 125 m depth contour (Shoreline Cell 302), continental slope demersal fish communities (Shoreline Cells 302 and 305 to 307), Seringapatam Reef and Commonwealth waters in the Scott Reef Complex (Shoreline Cells 305 to 307) and Mermaid Reef and Commonwealth waters surrounding Rowley Shoals (Shoreline Cells 309 to 311).

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 3-14.

Table 3-14: 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

- DotEE Marine Key Ecological Features

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 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 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. It is widely accepted around the world as the standard for sensitivity rating, used when planning a response to shoreline contact from an oil spill.

The Marine Futures Biodiversity project (Government of Australia, 2008) mapped the biodiversity of nine key regions along the WA coastline including Abrolhos Island, Broke Inlet, Geographe Bay, Jurien Bay, Middle Island (Recherche Archipelago), Mount Gardner, Point Ann (Fitzgerald National Park), Rottnest Island and Southwest Cape. This data is available online through the Seamap Australia project, and hosted on the Australian Ocean Data Network (aodn.org.au) which is maintained by the University of Tasmania.

Additional datasets used included:

- The Landgate Geonoma dataset which contains road, topographic (place/feature), cultural, administrative boundary and points of interest names. It identifies the correct spelling and position of official geographic names for Western Australia. This dataset includes locations of freshwater springs, swamps/marshes, beaches and additional features which were able to be assigned to one of the ESI features.
- The DBCA historical mangrove dataset which was the most comprehensive dataset about the distribution of mangroves.
- The geomorphology smartline dataset from Geoscience Australia. The 'Smartline' is a representation of the geomorphic features located within 500 m of the shoreline, denoted by the high water mark. The service includes geomorphology themes and stability classes. It includes features such as tidal flats, saltpans and rocky shores which were able to be assigned to one of the ESI features.

The Department of Mines and Petroleum 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 dataset above.

Kimberley Ports provided the results of a habitat survey completed in 2016 in the Port of Broome. However, due to the limited coverage of the survey area and that it did not provide additional information compared to other datasets, this data was not used in the ranking process.

The DBCA Marina Habitats dataset was not used as, apart from three offshore islands, it did not extend into the Kimberley zone.

Distribution

The coastal characteristics of the Kimberley zone are dominated by mangroves, sheltered and exposed tidal flats and sand beaches in a continuous stretch along the coastline. Additional features scattered along the coastline include saltmarsh and freshwater springs.

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 one (low sensitivity) to ten (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.

Multiple datasets in addition to the OSRA were used to identify habitats. The description of the habitats from each dataset was aligned to correspond to an ESI feature as described in Table 3-15.

Table 3-15: Dataset habitat features used and corresponding value measure from Table 3-14

Value measure	DoT OSRA ESI Dataset	MFB Project Dataset (Primary NAT_HAB_CL)	MFB Project Dataset (Secondary Hab_ORIG)	Geonoma Dataset	DBCA Historic Mangroves Dataset	Geomorphology Smartline Dataset (Back Proximal)	Geomorphology Smartline Dataset (Intertidal)
ESI 10: 10A Salt and brackish water marshes; 10B Freshwater marshes; 10C Swamps; 10D Mangroves with >3,000 ha per shoreline cell	Marsh, swamp, saltmarsh	Saltmarsh	Saltpan, saltmarsh/ saltflat	Swamp, marsh, morass, spring	Mangroves	Marshy muddy sediment flats	
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	Exposed tidal flats, sheltered rocky shores, sheltered seawalls, sheltered tidal flats, coastal hillocks	Tidal sand banks	Intertidal flats		Mangroves	Saltpans or saline mud flats/to below sea level	Tidal flats, tidal sediment flats, muddy tidal flats

Value measure	DoT OSRA ESI Dataset	MFB Project Dataset (Primary NAT_HAB_CL)	MFB Project Dataset (Secondary Hab_ORIG)	Geonoma Dataset	DBCA Historic Mangroves Dataset	Geomorphology Smartline Dataset (Back Proximal)	Geomorphology Smartline Dataset (Intertidal)
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) 10D Mangroves <1,000 ha per shoreline cell; 9A Sheltered tidal flats with between 1,000 ha and 3,000 ha per shoreline cell	Fine to medium-grained sand beaches, sandhills, dunes, mixed sand and gravel beaches, area of sand and mud with patches of stones or gravel, sheltered tidal flats	Sand, Sand shoal	Sandshoal	Beach, dune, claypan	Mangroves	Sand deposits, sandy alluvium, dune undiff, Aeolian sand-sheets on sediment to below sea level, Aeolian sand-sheets depth uncertain, Alluvial sediment undiff/to below sea level, muddy sediments, sediment deposits, sediment plain	Beach (sediment type undiff), sandy beach undiff, sandy shore undiff, fine-medium sand beach, mixed sandy shore undiff
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	Rocky area, exposed seawalls, exposed rocky cliffs, exposed wave cut platform, sheltered tidal flats			Cliff	Mangroves	Cliff (>5 m) undiff	Artificial shoreline undiff (jetty)

Shorelines of sheltered tidal flats incorporating mangrove and swamp habitats are more susceptible to long term impacts from a spill of both floating and dissolved oil, while rocky exposed shorelines are the least susceptible. Shorelines which include beaches and sandy areas are considered moderately difficult to rehabilitate, moderately ecologically sensitive, and also 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 Kimberley. 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 was 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 first zone (i.e. 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 on 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.

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 highest, with High for protection from both dissolved and floating oil). A graduated scale was then applied, modelled on the Victorian example, with sheltered tidal flats >3,000 ha and mangroves of 1,000 to 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 to 3,000 ha sheltered tidal flats, these have been ranked Low for protection from both floating and dissolved oil.

A ranking of High for protection from both floating and dissolved oil has been given to Shoreline Cells 1 to 7, 9, 16, 17, 24, 25, 33, 35, 36, 40, 42 to 47, 49, 51 to 56, 58 to 63, 68, 70, 71, 74 and 301 due to the presence of mangroves (>3,000 ha), freshwater marshes, salt and brackish water marshes, and swamps.

A Medium ranking for protection from both floating and dissolved oils has been given to most of the remaining Shoreline Cells 8, 10 to 15, 18 to 23, 26 to 32, 34, 37 to 39, 41, 48, 50, 57, 64 to 67, 69, 72, 73, 75 to 87, 281 to 300, 302 and 306 to 308 due to the presence of mangroves (1,000 ha to 3,000 ha), sheltered tidal flats (>3,000 ha), exposed tidal flats, sheltered rocky shores, sheltered seawalls and saline tidal flats.

The remaining Shoreline Cells 309 to 311 have been ranked Low for protection from both floating and dissolved oils due to the presence of beaches.

Table 3-16: 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 ESI, 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; 9A Sheltered tidal flats with <1,000 ha per shoreline cell	1	1	

Data List

- DoT OSRA ESI dataset
- MFB project data set
- Geonoma data set
- DBCA historic mangroves data set
- Geomorphology smartline dataset

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 therefore rely 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.

Coral reefs are well developed in the Kimberley and are one of the region's most important marine values. They fall into two distinct groups, the fringing coral reefs around coastal islands and the mainland shore and large platform coral reefs, banks and shelf edge atolls offshore.

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.

Filter feeding communities play important roles in purifying water, creating habitat and controlling shoreline erosion. Examples of filter feeders are sponges, soft and whip corals and sea squirts and can be found at depth below 40 metres.

Coral, seagrass, algae and filter feeding community distribution has been determined from the following datasets:

- OSRA ESI data layer;
- CAMRIS Seagrass dataset from the CSIRO – contains information about the distribution of seagrass around the Australian coastline;
- ReefKIM dataset from WAMSI – contains an inventory of Kimberley reefs;
- The Australian Centre for Ecological Analysis and Synthesis (ACEAS) seagrass dataset – compiles information on the distribution of seagrass along the WA coastline from various studies, including CAMRIS; and
- Seamap Australia database – contains information about the distribution of filter feeding communities and coral reefs around the Australian coastline.

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 extensively within the Kimberley zone, both in the intertidal and subtidal zones. Coral reefs are in Shoreline Cells 14 to 35, 37 to 41, 44, 46, 48 to 53, 64, 65, 281 to 301 and 309 to 311.

Seagrass is found in both the intertidal and subtidal zones in Shoreline Cells 12, 13, 64 to 87, 294, 295, 306 to 308, 310 and 311. It should be noted that most seagrass surveys that have been undertaken only extend up to Derby. Therefore, seagrass may be present north of this but their presence is still unknown.

No data was available for algae. In previous zones, the DBCA marine habitats database was used to locate algae within the zones. This dataset does not extend to the Kimberley and therefore could not be used.

Similar to algae, there was limited data available on the distribution of filter feeding communities. However, some surveys undertaken in the Kimberley revealed that filter feeding communities occur in the areas associated with fringing biogenic reefs. In these areas, filter feeders tend to occur where the substratum is hard and steeply sloping and/or where light availability is limiting for hard corals. A generally repeating pattern that has been observed around fringing coral reefs is that benthic cover gradually shifts from a predominance of hard corals to filter feeders with increasing depth (DEC 2009). Filter feeding communities are in Shoreline Cells 309 to 311, which also contain coral reefs, but are likely to also be found in shoreline cells where coral reefs have been recorded.

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 to 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 3-17. Intertidal coral reefs also receive a higher ranking (High) for floating oil compared to subtidal coral reefs (Medium).

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 it provides important habitat for threatened turtles, fish and invertebrates. Intertidal seagrass also receives a higher ranking (Medium) for floating oil compared to subtidal seagrass (Low).

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 supports fauna species and provides 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 Low, below coral and seagrass, except for subtidal algae where they are ranked Very Low for protection from floating oil. However, as not enough spatial data could be collected on the distribution of algae in the Kimberley, algae has not been ranked in this zone.

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. For these reasons, filter feeders, as algae, have been ranked below coral and seagrass and are ranked Low, except for subtidal filter feeders where they are ranked Very Low for protection from floating oil.

Based on the above, Shoreline Cells 14 to 35, 37 to 41, 44, 46, 48 to 53, 64, 65, 281 to 301 and 309 to 311 have been ranked High for protection from both floating and dissolved oils due to the presence of intertidal coral reefs.

Shoreline Cells 66 to 75, 77 to 81, 87, 306 and 307 have been ranked Medium for protection from both floating and dissolved oils due to the presence of intertidal seagrass. Furthermore, Shoreline Cells 76, 82 to 86 and 308 have been ranked Low for protection from floating oil and Medium for protection from dissolved oil due to the presence of subtidal seagrass.

Table 3-17: Coral, Seagrass and Algae protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Coral, Seagrass and Kelp			
Coral *Intertidal*	4	4	**Importance:** Corals are particularly sensitive to dissolved hydrocarbons.
Coral *Subtidal*	3	4	
Seagrass *Intertidal*	3	3	**Importance:** Seagrasses are grazed by protected animals and provide refuge areas for fish and invertebrates.
Seagrass *Subtidal*	2	3	

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Algae and filter feeding communities *Intertidal*	2	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.
Algae and filter feeding communities *Subtidal*	1	2	

Data List

- Coral Reef data in the OSRA ESI data layer
- ReefKIM dataset
- CAMRIS seagrass dataset
- ACEAS seagrass dataset

3.2.8 Fish Habitat Protection Areas and Closed Waters

Description

The WA DPIRD 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 specially protected and managed 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
- 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 DPIRD habitat protection areas.

In addition, areas can be closed to fishing 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'. This assessment only takes into account 'closed waters/Marine Reserves'.

Distribution

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

There are four areas in the Kimberley zone which are considered 'closed waters/Marine Reserves' under section 43 of the FRMA (1994). These are:

- Rowley Shoals Marine Park prohibition on recreational fishing (Shoreline Cells 310 and 311);
- Rowley Shoals Marine Park prohibition on commercial fishing (Shoreline Cells 310 and 311); and
- Roebuck Bay prohibition on commercial fishing (Shoreline Cells 73 to 81).

Netting prohibition in the Kimberley region (Shoreline Cells 4 to 6, 59 and 74) is also included in 'closed waters/Marine Reserves' under section 43 of the FRMA (1994). However, this has not been included in the ranking process as it only applies at certain times of the year and/or for certain fauna groups. It also does not apply to certain types of nets, nor does it apply to fishing for non-commercial purposes.

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 3-18.

The Rowley Shoals Marine Park and Roebuck Bay shoreline cells are ranked High for protection from floating and dissolved oil due to these being 'closed waters/Marine Reserves' under the FRMA (1994).

Table 3-18: Fish Habitat Protection Areas protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Fish Habitat Protection Areas			
Closed waters/Marine Reserves under section 43 of the *Fish Resource Management Act 1994*	4	4	**Importance:** Areas closed under section 43 of this Act prohibit fishing.
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
- DPIRD Closed waters/Marine Reserves under section 43 of the *Fish Resource Management Act 1994*

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 DPIRD. Note that the economic assessment of aquaculture licenced areas is included in Section 3.4.

Distribution

The Western Australian pearl oyster fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. The pearling industry relies almost exclusively on harvesting pearl oysters from a section of Eighty Mile Beach south of Broome (Shoreline Cells 75 to 87) and a fishing patch off the Lacepede Islands (Shoreline Cell 308). Further details of this fishery, including its economic importance, are provided in Section 3.4.

All other wild aquaculture stocks for fish, prawns, crayfish, trout and yabbies could be resourced from a number of areas and even from other aquaculture farms.

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.

The pearling harvest areas at Eighty Mile Beach and around the Lacepede Islands have been ranked Low for protection from floating and Medium from dissolved oil (Table 3-19).

Table 3-19: 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 including in 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 3-20 (taken from AHC, 2009).

Table 3-20: 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 3-21. These are discussed further in each section below.

Table 3-21: 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:

1. World Heritage Areas
2. National Heritage Areas

3. Commonwealth Heritage Places.

The datasets used to determine the distribution of Commonwealth protected heritage properties included the DotEE'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

There are no World Heritage Areas in the Kimberley zone.

The West Kimberley occurs in Shoreline Cells 3, 5 to 76, 79, 281, 282, 284 to 297, 300, 301 and 308.

The Yampi Defence Area (Shoreline Cells 46, 47, 49 and 51 to 55), Scott Reef and surrounds (Shoreline Cells 306 and 307) and Mermaid Reef-Rowley Shoals (Shoreline Cell 309) are listed on the Commonwealth Heritage Register.

Discussion

World Heritage Areas

In 2018, Australia had 19 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).

There are no World Heritage Areas in the Kimberley zone.

National Heritage Places

National Heritage Properties data has been sourced from the DotEE. This data provides location and attribute information for places nominated to and included in the National Heritage List, as determined by the Australian Government. As described in Table 3-21, 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.

Heritage areas which comprise 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.

The West Kimberley has been ranked High for protection from both floating and dissolved oil. The West Kimberley is on the National Heritage List because it is a vast area of dramatic and relatively undisturbed landscapes of great biological richness and important geological and fossil evidence of Australia's evolutionary history. The region is home to a rich and dynamic Aboriginal culture and a proud pastoral and pearling tradition. Furthermore, the intertidal zone along the Dampier Peninsula coastline from Roebuck Bay to Cape Leveque (excluding the area from Dampier Creek to Entrance Point) was included on the West Kimberley National Heritage List on August 31 2011 in recognition of the outstanding heritage values associated with the dinosaur tracks.

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 3-21, Commonwealth Heritage Places are protected for their significant heritage value to the nation, so they are considered to be 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 comprise 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.

Yampi Defence Area is in Shoreline Cells 46, 47, 49 and 51 to 55. The shoreline cells covering the Yampi Defence Area also cover the West Kimberley National Heritage Place classification. Therefore, the shoreline cells retain their higher ranking of High for protection from floating and dissolved oil, instead of the lesser ranking created by the Commonwealth Heritage Place listing.

The shoreline cells covering Scott Reef and surrounds have been ranked Medium for protection from both floating and dissolved oil.

The shoreline cell covering Mermaid Reef–Rowley Shoals has been ranked Medium for protection from both floating and dissolved oil.

Table 3-22: 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

- DotEE World Heritage Areas
- DotEE National Heritage List
- DotEE Commonwealth Heritage Areas

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 many 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 3-23.

Table 3-23: Western Australian 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

The 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. Places that are currently being assessed for inclusion on the State Register of Heritage Places were not included.

As described in Section 2.5, the DAA Aboriginal Heritage Listed Places dataset is excluded from the first zone assessed (Pilbara zone) and subsequent zones including the Kimberley, 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 five sites listed on the State Register. These are Bungarun (Leprosarium) in Derby (Shoreline Cell 57), Lombadina Mission in Lombadina (Shoreline Cell 66) and Chinatown Conservation Area, Flying Boat wreckage site and Male sheds and jetty in Broome (all in Shoreline Cell 74).

There is one Conservation Order listed site (Chinatown Conservation Area in Shoreline Cell 74) but no Heritage Agreement sites in the Kimberley 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 protection from floating and dissolved oil. The rankings for protection priority for these sites are presented in Table 3-24.

Based on these rankings, Shoreline Cells 57, 66 and 74 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 as they include the West Kimberley, a National Heritage Place.

Table 3-24: 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

- State Heritage Register
- Conservation Orders
- Heritage Agreements

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 DotEE and was last updated on 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 67 Commonwealth protected shipwrecks along the Kimberley coastline; about 26 are also protected under State legislation. Two are only protected under State legislation. These wrecks and sites are found continuously along the Kimberley zone, with a cluster found around Broome.

There are 26 shoreline cells in the Kimberley zone which contain Commonwealth and State protected shipwrecks and marine archaeology sites. These are found in Shoreline Cells 5, 17, 19, 20, 24, 27, 38, 39, 56, 58, 64, 65, 68 to 70, 73, 74, 78, 79, 83, 85, 281, 285, 302, 308 and 309.

There are no State Marine Archaeological sites in the Kimberley zone.

Discussion

All shipwrecks 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 in Table 3-25. Given the below rankings and distribution of maritime archaeology in the Kimberley zone, all shoreline cells where shipwrecks are found are ranked Medium for protection from floating and dissolved oil. However, except for Shoreline Cells 78, 83, 85, 302 and 309, all cells are ranked High as they also contain the West Kimberley, a National Heritage Place.

Table 3-25: 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

- DotEE Australian National Shipwrecks Database
- WA Museum State Protected Shipwrecks
- WA Museum Maritime archaeological sites

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 3-26 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 3-26: 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, including aquaculture of pearling oysters, is managed with licencing permits through the DPIRD. Aquaculture licence areas and geospatial locations were obtained from the WA DPIRD. It should be noted that, except for pearling leases the type of aquaculture being undertaken at individual aquaculture sites could not be provided for confidentiality reasons.

Aquaculture development in the North Coast Bioregion which includes the Kimberley zone is dominated by the production of pearls from the species *Pinctada maxima*. Other developing marine aquaculture initiatives in this region include growing trochus and barramundi (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017).

Distribution

Pearl farm sites in the North Coast Bioregion are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands. Pearling leases and holding sites are in Shoreline Cells 17, 19 to 26, 28, 29, 32, 33, 37, 38, 49, 51, 52, 63, 64, 68, 70 to 74, 77 to 80, 292 and 300.

Other aquaculture licenced areas are in Shoreline Cells 19, 52, 57 to 58, 64 and 66 to 68. Marine production of barramundi is focussed in Cone Bay. Furthermore, funding has been obtained to establish an aquaculture zone in this area (Shoreline Cell 52) in which DPIRD will secure strategic environmental approvals, thereby streamlining the approvals processes for commercial projects and providing an 'investment ready' platform for prospective investors. This is expected to lead to developing further aquaculture operations in the region. An Indigenous project at One Arm Point (Shoreline Cell 64) operates a marine hatchery that focusses on various ornamental and edible marine species.

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 after 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, so recovery time is just as varied.

The pearling industry was valued at $78 million in 2015 (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017). The total value of the aquaculture industry in Western Australia, not including pearls and algae, was $13 million in 2014/15.

Shoreline cells containing pearling leases have been ranked Low for protection from floating oil and Medium for protection from dissolved oil due to the economic value of pearling aquaculture and recovery of the species (less than ten years). Shoreline cells where other aquaculture licenced areas occur have also been ranked Low for protection from floating oil and Medium for protection from dissolved oil as, while the economic value is lower, the recovery of certain species may be more than 11 years (Table 3-27).

Table 3-27: Aquaculture protection priority ranking

Type (in each Region)	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Aquaculture Licenced Areas			
Pearling leases and other aquaculture licenced areas	2	3	**Importance:** Pearls & Pearl Oysters $78M annual value in 2015 (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017), <10 year recovery Other aquaculture licenced areas contributed <$20M in 2015 (<0.01% State GDP), >11 years recovery
Data List ▪ DPIRD aquaculture licence areas ▪ DPIRD Pearling leases			

3.4.2 State Managed Commercial Fisheries

Description

The WA State managed commercial and recreational fishing sectors contributed $1.5 billion to WA's Gross State Product in 2014/15. The gross value of Western Australia's fishery and aquaculture production was $490 million in 2015/16 (Mobsby, D and Koduah, A 2017).

There are 16 different State-managed commercial fisheries that operate within the Kimberley zone:

- Pearl Oyster Fishery;
- Northern Demersal Scalefish Managed Fishery;
- West Coast Deep Sea Crustacean Managed Fishery;
- Mackerel Managed Fishery;
- Marine Aquarium Managed Fishery;
- Land Hermit Crab Instrument of Exemption;
- Kimberley Prawn Managed Fishery;
- Abalone Managed Fishery;
- Northern Shark Fishery;
- Specimen Shell Managed Fishery;
- South West Coast Salmon Fishery;
- Kimberley Gillnet and Barramundi Limited Entry Fishery;
- Broome Prawn Managed Fishery;
- Mud Crab Fishery Instrument of Exemption;
- Trochus Fishery Instrument of Exemption; and
- Invertebrates Instrument of Exemption.

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

exact value is not publicly available, but the 2015/16 Fisheries Status report provides an indication of its economic value (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017).

Annual value has been indicated below, with recovery of fisheries also considered and ranked in reference to Table 3-20.

Distribution

There are many small fisheries in the Kimberley shoreline cells, which are a lower priority in terms of economic loss for Western Australia. These include all the fisheries cited above, as their economic values are below $10 million. Most are below $1 million. Those that have an economic value above $1 million are discussed in more detail below.

The Western Australian Pearl Oyster Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. It is a quota-based dive fishery, operating in shallow coastal waters along the north coast bioregion, and targets the silver lipped pearl oyster (*Pinctada maxima*). The pearling industry currently comprises 15 wild-stock licences that can collectively take pearl oysters from Exmouth Gulf to the Northern Territory (NT) border. The fishery is divided into four zones (**Error! Reference source not found.**). Harvesting is focussed between Exmouth Gulf and Cape Leveque, with most pearl oysters collected off Eighty Mile Beach (zone 2) and around the Lacepede Islands (zone 3). Only zones 2, 3 and 4 are in the Kimberley zone. There is no catch from zone 4, so this zone has not been included in the ranking. The shoreline cells within zone 2 along Eighty Mile Beach have been included in the ranking (Shoreline Cells 75 to 87) as well as the main fishing patch off the Lacepede Islands (Shoreline Cell 308).

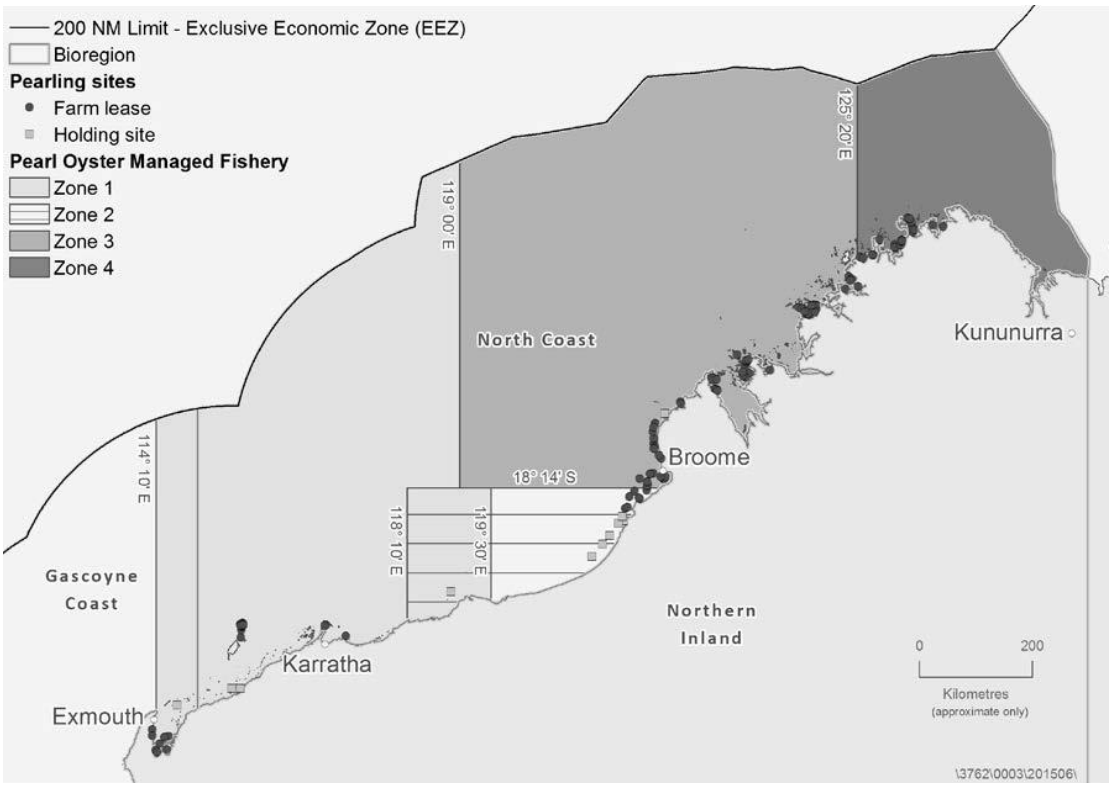

Figure 3-1: Fishing boundaries and zones of the WA Pearl Oyster Fishery, including holding sites and farm lease areas (Hart et al 2016)

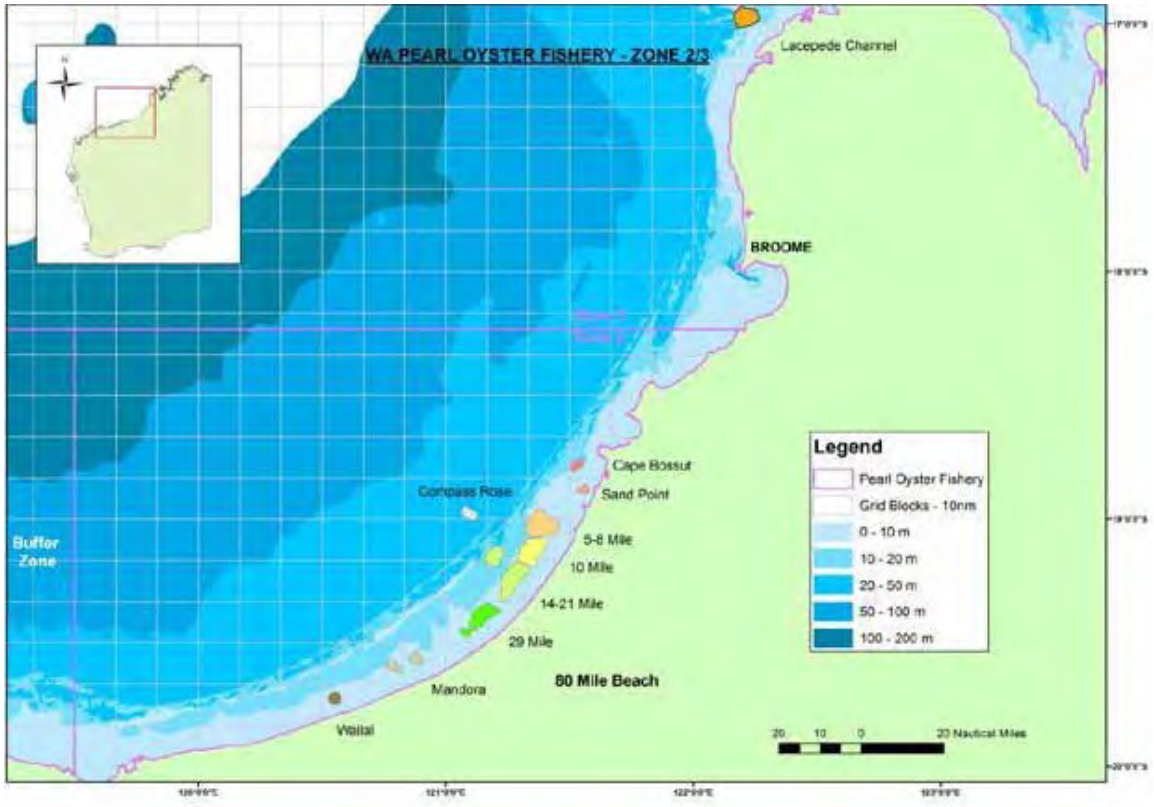

Figure 3-2: Location of main 'fishing patches' in zones 2/3 of the WA Pearl Oyster Fishery (Hart et al 2016)

The Northern Demersal Scalefish Managed Fishery is located east of 120° E longitude and occupies all Kimberley shoreline cells except Shoreline Cells 6 and 309 to 311.

The West Coast Deep Sea Crustacean Managed Fishery can operate along most of the Western Australian coastline. Fishing is allowed from the 150 m isobath to the edge of the Australian Economic Zone. It is therefore prohibited along the coastline and is only present in Shoreline Cells 302, 305 to 307 and 309 to 311.

The Mackerel Managed Fishery is located along most of the Western Australian coastline and is present in all shoreline cells of the Kimberley zone except Shoreline Cell 6.

The Marine Aquarium Fish Managed Fishery can operate in all State waters (between the Northern Territory border and South Australian border). It occupies all shoreline cells of the Kimberley except Shoreline Cells 6, 305 to 307 and 309 to 311. The fishery is typically more active in waters between Esperance and Broome, with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth and Dampier.

The Hermit Crab Fishery specifically targets the Australian land hermit crab (*Coenobita variabilis*) for the domestic and international live pet trade. The fishery operates throughout the year and is the only land-based commercial fishery in Western Australia. The Hermit Crab Fishery is currently permitted to fish Western Australian waters north of Exmouth Gulf (22°30'S). It occupies all shoreline cells of the Kimberley except Shoreline Cells 6, 298, 299, 302 and 305 to 311.

The Kimberley Prawn Managed Fishery can operate from around Koolan Island north to around Kalumburu. It occupies Shoreline Cells 14 to 50 and 281 to 297.

The Abalone Managed Fishery can operate in all State waters (between the Northern Territory border and South Australian border). It occupies all shoreline cells of the Kimberley except Shoreline Cells 6, 305 to 307 and 309 to 311. However, it operates mostly from the west coast bioregion for Roe's abalone and the south coast bioregion for the greenlip and brownlip abalones.

Remaining fisheries with a value below $1 million include:

- Northern Shark Fishery – has not been included in the ranking as there has been no fishing effort (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017);
- Specimen Shell Managed Fishery – operates in large sections of the Kimberley coast (Shoreline Cells 1 to 5, 7 to 87, 281 to 302 and 308);
- South West Coast Salmon Fishery – while this fishery operates in large sections of the Kimberley coast (Shoreline Cells 1 to 5, 7 to 87, 281 to 302 and 305 to 311), most of the catch is from the southern waters of WA (Fletcher WJ, Mumme MD and Webster FJ (eds), 2017);
- Kimberley Gillnet and Barramundi Limited Entry Fishery – operates in large sections of the Kimberley coast (Shoreline Cells 1 to 5, 7 to 81 and 301);
- Broome Prawn Managed Fishery – operates in Shoreline Cells 50 to 87, 297 to 302 and 308;
- Mud Crab Fishery Instrument of Exemption – operates in large sections of the Kimberley coast (Shoreline Cells 1 to 5, 7 to 57, 60 to 69, 281 to 297, 300 and 301);
- Trochus Fishery Instrument of Exemption – operates in Shoreline Cells 50 to 54, 63 to 68, 300 and 301; and
- Invertebrates Instrument of Exemption – operates in large sections of the Kimberley coast (Shoreline Cells 1 to 5, 7 to 87, 281 to 302 and 308).

Discussion

The pearl oyster fishery is linked to the aquaculture of pearls which generated $78 million in 2015 and is discussed in Section 3.4.1. Only shoreline cells along Eighty Mile Beach (Shoreline Cells 75 to 87) and the main fishing patch off the Lacepede Islands (Shoreline Cell 308) have been included in the fisheries ranking.

The Northern Demersal Scalefish Managed Fishery principally targets the higher-value species such as the goldband snapper and red emperor, resulting in an economic value of $5-10 million. However, most of the catch is taken from offshore areas, as only line fishing is permitted within inshore areas where the majority of the shoreline cells are located.

The West Coast Deep Sea Crustacean Managed Fishery as a whole contributed $3.8 million to the economy in 2015/16. However, this fishery operates primarily in the Gascoyne bioregion. The contribution from the Kimberley zone is therefore considered to be negligible.

The large pelagic resource, of which the Mackerel Managed Fishery is only one component, contributed $3-5 million to the West Australian economy in 2015/16.

The Marine Aquarium Fish Managed Fishery, which the Hermit Crab Fishery is a part of, contributed $1-5 million to the economy in 2015/16.

The Kimberley Prawn Managed Fishery contributed $1-5 million to the economy in 2015/16.

The Abalone Managed Fishery contributed $1.2 million from Roe's abalone (mostly from the west coast bioregion) and $6.2 million from greenlip and brownlip abalones (mostly from the south coast bioregion). The contribution from the Kimberley zone is therefore considered negligible.

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. However, considering the very low economic values of the majority of fisheries operating in the Kimberley except for the Pearl Oysters Fishery, and that these operate in large areas of the Western Australian coastline, all fisheries have been ranked Very Low for protection from both floating and dissolved oil. The shoreline cells relevant to the Pearl Oysters Fishery have also been ranked Very Low for protection from both floating and dissolved oil, as the recovery of the species is below ten years and the main fishing areas occupy more than ten shoreline cells.

Annual value has been indicated below, with recovery of fisheries also considered and ranked in reference to Table 3-26.

Table 3-28: 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 AND ten shoreline cells or less	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 AND ten shoreline cells or less Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND ten shoreline cells or less	3	4	
$501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND ten shoreline cells or less	2	3	

Value Measure	Ranking		Description
	Floating	Dissolved	
$101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or <$20M (<0.01% State GDP) and recovery of species is >11 years AND ten shoreline cells or less	1	2	
$21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or <$20M (<0.01% State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or <$20M (<0.01% State GDP) and recovery of species is <10 years	1	1	

Data List

- DPIRD Individual Fisheries shapefiles
- DPRID Annual Fisheries Report (2015-16)

3.4.3 Commonwealth Managed Fisheries

Description

Commonwealth fisheries contributed approximately $439 million in gross value of product to Australia in 2015/16 (Mobsby D and Koduah A, 2017). The fisheries are typically limited to 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 2017 has been used, as provided by AFMA. This data allows a smaller area of economic importance for the fishery to be identified, rather than the entire permit area. The commercial information for each Commonwealth 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 exact value is not publicly available.

There are four Commonwealth managed fisheries which overlap the Kimberley zone. These are:

- North West Slope Trawl Fishery;
- Western Tuna and Billfish Fishery;

- Northern Prawn Fishery; and
- Southern Bluefin Tuna Fishery.

Distribution

The North West Slope Trawl Fishery 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. In the Kimberley zone, the areas of concentrated effort are only present in some of the offshore islands in Shoreline Cells 305 to 307 and 309 to 311.

The Western Tuna and Billfish Fishery operates in Australia's Exclusive Economic Zone and the high seas of the Indian Ocean. In recent years, effort has concentrated off south-west Western Australia and South Australia. In the Kimberley zone, the areas of concentrated effort are only present in some of the offshore islands in Shoreline Cells 305 and 306. However, since 2000 these were only fished in 2012 and 2013.

The Northern Prawn Fishery operates from Cape Londonderry in Western Australia to Cape York in Queensland to the outer limit of the Australian Fishing Zone. However, the areas of concentrated effort are mainly located in the Gulf of Carpentaria except for red-legged banana prawn (*F. indicus*), which is mainly caught in Joseph Bonaparte Gulf off the coast of Western Australia. This area of concentrated effort occupies Shoreline Cells 1 to 5 and 7 to 14.

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. No areas of concentrated fishing effort overlap with any shoreline cells in the Kimberley zone (Patterson et al, 2017).

Discussion

Only a limited number of vessels operate in the North West Slope Trawl Fishery (two in 2015/16), therefore the commercial value of this fishery is unknown (Patterson et al, 2017). However, considering the large areas of concentrated effort outside Kimberley shoreline cells, the economic contribution of these are likely to be negligible.

Only a limited number of vessels operate in the Western Tuna and Billfish Fishery (three in 2015/16), therefore the commercial value of this fishery is unknown (Patterson et al, 2017). However, considering the large areas of concentrated effort outside Kimberley shoreline cells, the economic contribution of these are likely to be negligible.

The Northern Prawn Fishery contributed $124 million to the Australian economy in 2016. However, banana prawns only contributed $40.3 million dollars (Patterson et al, 2017). A total of 2,842 tonnes of banana prawns were caught, of which only around 50 tonnes were red-legged banana prawn, the species mostly caught in the Kimberley. Therefore, the economic contribution of the red-legged banana prawn caught of the Kimberley coast is likely to be very small.

The area of concentrated effort for each fishery is a large area, of which only a small portion are located within Kimberley shoreline cells. Therefore, using the rankings from Table 3-29, the shoreline cells have been ranked Very Low for protection from both floating and dissolved oil due to the presence of Commonwealth managed fisheries.

Table 3-29: 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 the 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 North West Slope Trawl Fishery
- Fishing effort for Western Tuna and Billfish Fishery
- Fishing effort for Northern Prawn Fishery
- Fishing effort for Southern Bluefin Tuna Fishery
- Commonwealth Managed Fisheries concentrated areas of fishing effort and fishery status report

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 located mid ocean or distant from navigational hazards 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.

There are five ports in the Kimberley zone; one that falls in the Kimberley Ports Authority jurisdiction (Broome Port) and four managed by others including Derby, Wyndham, and Yampi Sound, which includes Cockatoo Island and Koolan Island port facilities. The Kimberley Ports Authority will in due course assume the current DoT responsibilities of all ports in the Kimberley.

Distribution

Broome Port is found in Shoreline Cells 72 to 74, Derby Port is found in Shoreline Cells 54 to 61, Yampi Sound Port – Cockatoo Island and Koolan Island facilities are found in Shoreline Cells 49 to 51, and Wyndham Port is found in Shoreline Cells 3 to 7.

Discussion

Ports are used to import and export goods. The impact of an oil spill on ports relates to the safety requirement to reduce or cease operating to allow spill recovery activities to occur. This results in a direct net loss to the operators in a port. Economic impact to a port has been based on the annual tonnage of throughput, as the economic values are not publicly available for all ports in Western Australia. The annual reports are based on tonnes of export and import. The commercial significance based on tonnage throughput is presented in Table 3-30.

Broome Port is the only deep water port in the West Kimberley, and is the maritime gateway for petroleum products, construction materials, break bulk cargoes, livestock exports, cruise liners and expeditionary cruise vessels. The port supports the regional pearling, fishing and tourism industries. Broome Port is the largest port in the Kimberley and exported/imported 525,000 tonnes of cargo in 2015/16. This is relatively small compared to other ports in Western Australia, and has therefore been ranked a Very Low priority.

Wyndham Port is the only port between Broome and Darwin which offers deep water access, and is currently managed and operated, at time of writing, by Cambridge Gulf Ltd (CGL) under a Port Operating Agreement with the Minister for Transport. The live export trade continues to be an important trade for the port, with more than 29,163 head of cattle being exported during the year, which totalled more than 8,500 tonnes. The port also handles small tourist vessels and boutique cruise ships which operate in the north west, along with occasional shipments of explosives. Wyndham Port exported/imported 194,000 tonnes of cargo in 2015/16. This port is ranked Very Low for protection from both floating and dissolved oil.

The other ports included in the assessment including Derby and the facilities at Yampi Sound are currently non-operational. However, these ports are smaller than Broome or Wyndham and have therefore been ranked Very Low for protection from both floating and dissolved oil.

Table 3-30: 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 3-26.
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 3-26.
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 3-26.
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 3-26.
<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 3-26.

Data List

- DoT shipping and pilotage ports dataset
- DoT Port Authorities dataset
- DoT Ports Handbook – Western Australia 2016

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 damage the operating facility and, depending on the facility, the damage may be significant. 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 DPIRD 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 is one known seawater intake in the Kimberley zone located at the Cygnet Bay Pearl Farm and Kimberley Marine Research Station in Shoreline Cell 64.

A proposed seawater intake for an LNG facility is also located at James Price Point. However, after discussions with the Steering Committee, this intake was not included in the ranking process.

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.

The saltwater intakes for the Cygnet Bay Pearl Farm and Kimberley Marine Research Station have been ranked Low for protection from both floating and dissolved oil.

Table 3-31: 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 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 and research facility seawater intakes	2	2	**Importance:** Onshore aquaculture and research facilities would lose their stock and/or research. 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

- DoT seawater intake locations and types
- DPIRD aquaculture and research facility intake and outfall locations

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 Kimberley zone such as:

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

A Tourism Satellite Account (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.

Data for income from tourism is available per Local Government Area (LGA) tourism region. In the Kimberley zone, the following LGAs have been assessed:

- Broome;
- Derby-West Kimberley; and
- Wyndham-East Kimberley.

As tourism in the Kimberley is heavily reliant on nature based activities, an oil spill at a popular destination may impact tourism and the income generated. A number of popular tourist destinations are accessed by cruise vessels departing mainly from Broome and Wyndham. The cruise vessel industry can be an important contributor to the economy. In 2015/16, it was estimated that the cruise ship industry generated close to $7 million for Broome's economy and about 30 direct jobs. The popular cruise vessel destinations are also accessed by other means and are therefore important tourist destinations.

As part of a broader WAMSI research project examining human use off the Western Kimberley coast, a team from Murdoch University estimated visitation by expedition cruise vessels using cruise itineraries advertised online. The study found that there were 18 vessels (excluding vessels engaged in fishing tours) advertising Kimberley cruise itineraries in 2013, indicating relatively little change since a 2008 study (Sherrer at al, 2008). The cruises take place mainly from April to September between Broome and Wyndham. Just over half of these vessels carried less than 20 passengers, but the two largest accommodated more than 100 passengers (Beckley, 2015). The WAMSI Kimberley node human use project was used to identify the most popular cruise vessel destination areas along the Kimberley coastline.

Distribution

The Broome LGA occupies Shoreline Cells 60 to 87, 301, 308, 310 and 311. The key population centre of Broome is in Shoreline Cells 73 and 74.

The Derby-West Kimberley LGA occupies Shoreline Cells 41, 42, 44 to 61 and 294 to 301, The key population centre of Derby is in Shoreline Cell 58.

The Wyndham-East Kimberley LGA occupies Shoreline Cells 1 to 44 and 281 to 295. The key population centre of Wyndham is in Shoreline Cells 4 and 5.

A small number of shoreline cells assigned to offshore islands are not captured within the LGA boundaries cited above, so are not included in the tourism statistics. However, these do not contain key population centres and it is considered that these would contribute only a negligible portion to the tourism income.

The WAMSI Kimberley node human use project identified 114 sites listed in the itineraries of cruise vessels in the Kimberley in 2013, up from 96 sites in 2008. Thirty per cent of the sites, however, were visited less than 20 times during the season and only by smaller vessels. The most popular places to visit by cruise vessel, excluding the port of Broome, were Montgomery Reef (Shoreline Cells 294 and 295), Horizontal Falls (Shoreline Cell 49), Raft Point (Shoreline Cells 41, 42 and 44), Prince Regent River (Shoreline Cell 36), Talbot Bay (Shoreline Cell 49) and King George Falls (Shoreline Cell 13) (Beckley, 2015).

Discussion

The contribution from tourism ranges from around $69 million per annum in Derby-West Kimberley to around $293 million per annum in Broome. The total revenue from tourism in Western Australia is $10,954 million in 2015, of which 4.3% comes from the Kimberley zone.

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, as well as the most popular cruise vessel destinations which were identified through the WAMSI Kimberley node human use project. The rankings for protection priority are presented in Table 3-32.

Based on these rankings all shoreline cells in the Kimberley zone corresponding to the above features have been ranked Very Low for protection from both floating and dissolved oil, as the zone provides a fairly minor portion of the state's tourism.

Table 3-32: Tourism protection priority category

Tourism Area	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Tourism Region key population centre and most popular cruise vessel destination areas >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 and most popular cruise vessel destination areas 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 and most popular cruise vessel destination areas <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 Kimberley zone along with their population size are listed in Table 3-33.

Table 3-33: Towns in the Kimberley zone and their approximate populations

Town	Population
Broome	14,000
Beagle Bay	285
Derby	3,500
Koolan Island	Unknown but very low
Kalumburu	412
Wyndham	900

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 DotEE CAPAD Marine dataset, an updated DBCA CAPAD dataset and the Marine Parks Draft Zoning Plan 2017. These datasets include areas in the marine park category, with designations including:

- Sanctuary zones;
- Recreational zones;
- Special purpose zones; and
- General use zones.

Distribution

Shoreline cells include the ones encompassing:

- Argo-Rowley Terrace Marine Reserve (Shoreline Cells 309 to 311);
- Eighty Mile Beach Marine Reserve and Park (Shoreline Cells 80 to 87);
- Joseph Bonaparte Gulf Marine Reserve (Shoreline Cells 8 and 9);
- Kimberley Marine Reserve (Shoreline Cells 65 to 69, 281 to 283, 285, 293, 298, 299 and 308);
- Mermaid Reef Marine Reserve (Shoreline Cell 309);
- Roebuck Marine Reserve (Shoreline Cells 73 to 76);
- Nyangumarta Warrarn Indigenous Protected Area (Shoreline Cell 84 to 87);
- Lalang-garram/Camden Sound Marine Park (Shoreline Cells 35 to 41, 44 and 292 to 297);
- Rowley Shoals Marine Park (Shoreline Cells 310 and 311);
- Scott Reef Nature Reserve (Shoreline Cells 306 and 307); and
- An unnamed Marine Reserve (WA51046) (Shoreline Cells 74 to 76).

Discussion

The marine park and management areas are used for 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 3-34.

Based on these rankings, shoreline cells associated with the marine parks/reserves in the Kimberley have been ranked Low for protection from floating and dissolved oil.

Table 3-34: 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

- DotEE CAPAD multi-user zones in marine management areas or marine parks
- DBCA CAPAD update
- Marine Parks draft zoning plan 2017

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, which included data for one beach in the Kimberley, Cable Beach.

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 Geonoma dataset and Geomorphology Smartline dataset were used to identify sandy beaches 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

A number of beaches are located close to towns. Shoreline cells around Broome (Shoreline Cells 72 to 75) have sandy beaches, including Quongdong, Cable, Riddell and Roebuck beaches. Shoreline Cell 3 contains an unnamed beach in the vicinity of Wyndham which appears in the Geonoma and Geomorphology Smartline datasets.

Additional beaches, those not in the vicinity of a town, include Honeymoon Beach (Shoreline Cell 17), Naturalists Beach (Shoreline Cell 33), Umburi Beach (Shoreline Cell 42), Ngungayarra Beach (Shoreline Cell 44), Front Beach (Shoreline Cell 50), Back Beach (Shoreline Cell 50), Yumurryumuh Beach (Shoreline Cell 51), Eastern Beach (Shoreline Cell 65), Lombadina Beach (Shoreline Cell 65), Smirnoff Beach (Shoreline Cell 70), Eco Beach (Shoreline Cell 76), Eighty Mile Beach (Shoreline Cells 80 to 87) and a number of unnamed isolated beaches (Shoreline Cells 1, 2, 8, 16, 18 to 32, 34, 35, 37 to 41, 46, 48, 49, 52, 53, 61 to 64, 66 to 69, 71 and 77 to 79). Of these unnamed beaches, none spanned more than one shoreline cell.

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 the number of visitors for patrolled beaches was obtained from Surf Life Saving WA. Cable Beach, adjacent to the Kimberley's largest town Broome, received over 170,000 attendees during patrol hours in 2017.

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 3-33).

Cable Beach, where visitor numbers are reported at >100,000, has been ranked Very Low for dissolved oil and Low for protection from floating oil. Other beaches in the shoreline cells around Broome and Wyndham have also been ranked Very Low for protection from dissolved oil and Low for protection from floating oil based on their vicinity to a town.

All other beaches described above have been ranked Very Low for protection from dissolved and floating oil based on Table 3-35.

Table 3-35: Beaches protection priority ranking

Value Measure	Ranking		Main Factors Considered in Ranking
	Floating	Dissolved	
Beaches			
Beaches with >1 million visitors a year Or, in the Top Ten Beaches by Tourism WA	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. Where beaches are close to a town and the beach occupies more than two shoreline cells, only the two shoreline cells closest to the town are ranked.
Beaches with >100,000 visitors a year Or, beaches in the vicinity of a town	2	1	
Beaches with <100,000 visitors a year Or, all other beaches	1	1	

Data List

- Top ten beaches, Western Australia 2017
- Surf Life Saving WA patrolled beaches
- Geomorphology smartline
- Geonoma dataset

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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 ▪ 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 ▪ Algae/filter feeders (subtidal)	▪ 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 (subtidal) ▪ Algae/filter feeders (intertidal) ▪ 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 (subtidal) ▪ Seagrass (intertidal)	▪ 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* ▪ Coral (intertidal)	▪ 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		▪ WA protected shipwrecks and maritime archaeology	▪ Commonwealth heritage places: Indigenous, historic and Natural heritage places ▪ Commonwealth Maritime Cultural Heritage ▪ State protected heritage places	National heritage places: Indigenous, historic and Natural heritage places	▪ All World Heritage areas
Economic	▪ State Managed Commercial Fisheries: $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or <$20M (<0.01% State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 Or<$20M (<0.01% State GDP) and recovery of species is <10 years ▪ Ports throughput <1 million tonnes annually ▪ Tourism Region key population centre and most popular cruise vessel destination areas (<5% of State income from tourism)	▪ Pearling leases and other aquaculture licenced areas ▪ State Managed Commercial Fisheries: $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 ▪ Ports throughput 1.1-10 million tonnes annually ▪ Salt works seawater intakes, aquaculture and research facility seawater intakes and seawater intakes for LNG facilities ▪ Tourism Region key population centre and most popular cruise vessel destination areas (5-10% of State income from tourism)	▪ State Managed Commercial Fisheries: $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 ▪ Ports throughput 11-100 million tonnes annually ▪ Cooling water intakes for power stations ▪ Tourism Region key population centre and most popular cruise vessel destination areas (>10% of State income from tourism)	▪ State Managed Commercial Fisheries: >$1B (>0.5% of State GDP) Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ 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 ▪ Ports throughput 101-400 million tonnes annually	▪ Ports throughput >401 million tonnes annually Reverse osmosis potable water plant seawater intakes
Social, Amenity and Recreation	▪ Beaches with <100,000 visitors a year Or all other beaches	▪ Marine Parks, Marine Management Areas and Marine Nature Reserve ▪ Beaches with >100,000 visitors a year Or beaches in the vicinity of a town	▪ Beaches with >1 million visitors a year Or, in the Top Ten Beaches by Tourism WA		

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	▪ 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 EN species (fish) Very Certain ▪ 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	▪ 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) ▪ 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/filter feeders	▪ 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		▪ WA protected shipwrecks and maritime archaeology ▪ Commonwealth heritage places: Indigenous and historic heritage places	▪ National heritage places: Indigenous and historic heritage places ▪ Commonwealth heritage places: Natural heritage places ▪ Commonwealth Maritime Cultural Heritage ▪ State protected heritage places	▪ National heritage places: natural heritage places	▪ World Heritage areas
Economic	▪ Commonwealth Managed Fisheries: <$20M (<0.01% State GDP) and recovery of species is <10 years ▪ Ports throughput <1 million tonnes annually ▪ Tourism Region key population centre and most popular cruise vessel destination areas (<5% of State income from tourism)	▪ State Managed Commercial Fisheries: $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or <$20M (<0.01% State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 ▪ Ports throughput 1.1-10 million tonnes annually ▪ Salt works seawater intakes, aquaculture and research facility seawater intakes and seawater intakes for LNG facilities ▪ Tourism Region key population centre and most popular cruise vessel destination areas (5-10% of State income from tourism)	▪ Pearling leases and other aquaculture licenced areas ▪ State Managed Commercial Fisheries: $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells $101M-$500M (0.05-0.25% of State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or $21M-$100M (0.01-0.05% State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 ▪ Ports throughput 11-100 million tonnes annually ▪ Cooling water intakes for power stations ▪ Tourism Region key population centre and most popular cruise vessel destination areas (>10% of State income from tourism)	▪ State Managed Commercial Fisheries: $501M-$1B (0.25-0.5% of State GDP) and recovery of species is <10 years AND ten shoreline cells or less Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years AND more than ten shoreline cells Or $101M-$500M (0.05-0.25% of State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ Commonwealth Managed Fisheries: $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 ▪ Ports throughput 101-400 million tonnes annually ▪ Reverse osmosis potable water plant seawater intakes	▪ State Managed Commercial Fisheries: >$1B (>0.5% of State GDP) Or $501M-$1B (0.25-0.5% of State GDP) and recovery of species is >11 years AND ten shoreline cells or less ▪ 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 ▪ Ports throughput >401 million tonnes annually
Social, Amenity and Recreation	▪ All town sites ▪ Beaches with >100,000 visitors a year Or beaches in the vicinity of a town ▪ Beaches with <100,000 visitors a year Or all other beaches	▪ Marine Parks, Marine Management Areas and Marine Nature Reserve ▪ Beaches with >1 million visitors a year Or in the Top Ten Beaches by Tourism WA			

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.

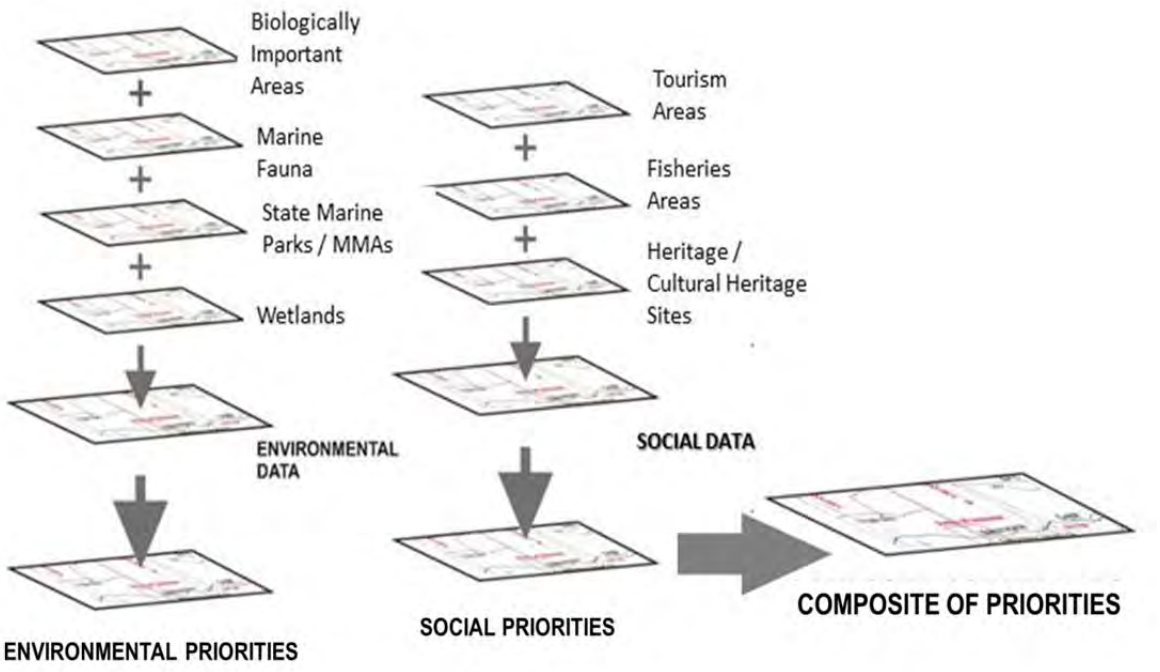

Figure 5-1: Example illustration of composite of ranked geospatial data

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).

This method was selected for this project because:

- It is a known and standard method previously used with success;
- It produces a single output for each overall highest priority ranking of 'floating oil', 'dissolved oil' and 'overall';
- It produces data identifying the shoreline cells with highest protection priority, and details what aspect caused the highest ranking; and
- No scripting is required in the geoprocessing 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; and
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 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 of 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 of 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 the 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 the 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 its ranking either for floating or dissolved hydrocarbons.

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

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Table 5-1: Attribute table format (Extract, Shoreline Cell number 79)

Shoreline Cell ID	Category ID	Category Name	Floating Ranking	Dissolved Ranking	Overall Ranking	Brief Description Floating Oil	Brief Description Dissolved Oil	Data Sources Floating Oil	Data Sources Dissolved Oil
79	1	Protected Fauna	5	4	5	Birds: *Calidris tenuirostris* (great knot) [CR] Specimen (WAM Vouchered)	Birds: *Calidris tenuirostris* (great knot) [CR] Specimen (WAM Vouchered)	DBCA fauna dataset 20171106	DBCA fauna dataset 20171106
79	2	Protection Areas	4	4	4	Closed waters: prohibition on commercial fishing (Roebuck Bay)	Closed waters: prohibition on commercial fishing (Roebuck Bay)	Prohibition on Commercial Fishing (Roebuck Bay) Order 2013	Prohibition on Commercial Fishing (Roebuck Bay) Order 2013
79	3	Cultural Heritage	4	4	4	National Heritage: The West Kimberley	National Heritage: The West Kimberley	DotE National Heritage List 20160211	DotE National Heritage List 20160211
79	4	Economic	2	3	3	Pearling leases: La Grange Bay – Cape Bossut Pearl Holding Site	Pearling leases: La Grange Bay – Cape Bossut Pearl Holding Site	DPIRD Pearling Leases 20171019	DPIRD Pearling Leases 20171019
79	5	Social, Amenity & Recreation	1	1	1	Beaches: isolated	Beaches: isolated	Geomorphology smartline 20171212 (ABSAMP); Geonoma dataset 20171214	Geomorphology smartline 20171212 (ABSAMP); Geonoma dataset 20171214

Shoreline Cell ID	Category ID	Category Name	Floating Ranking	Dissolved Ranking	Overall Ranking	Brief Description Floating Oil	Brief Description Dissolved Oil	Data Sources Floating Oil	Data Sources Dissolved Oil
79	6	Overall	5	4	5	Birds: *Calidris tenuirostris* (great knot) [CR] Specimen (WAM Vouchered)	Birds*: Calidris tenuirostris* (great knot) [CR] Specimen (WAM Vouchered); Closed waters: prohibition on commercial fishing (Roebuck Bay); National Heritage: The West Kimberley	DBCA fauna dataset 20171106	DBCA fauna dataset 20171106; Prohibition on Commercial Fishing (Roebuck Bay) Order 2013; DotE National Heritage List 20160211

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.

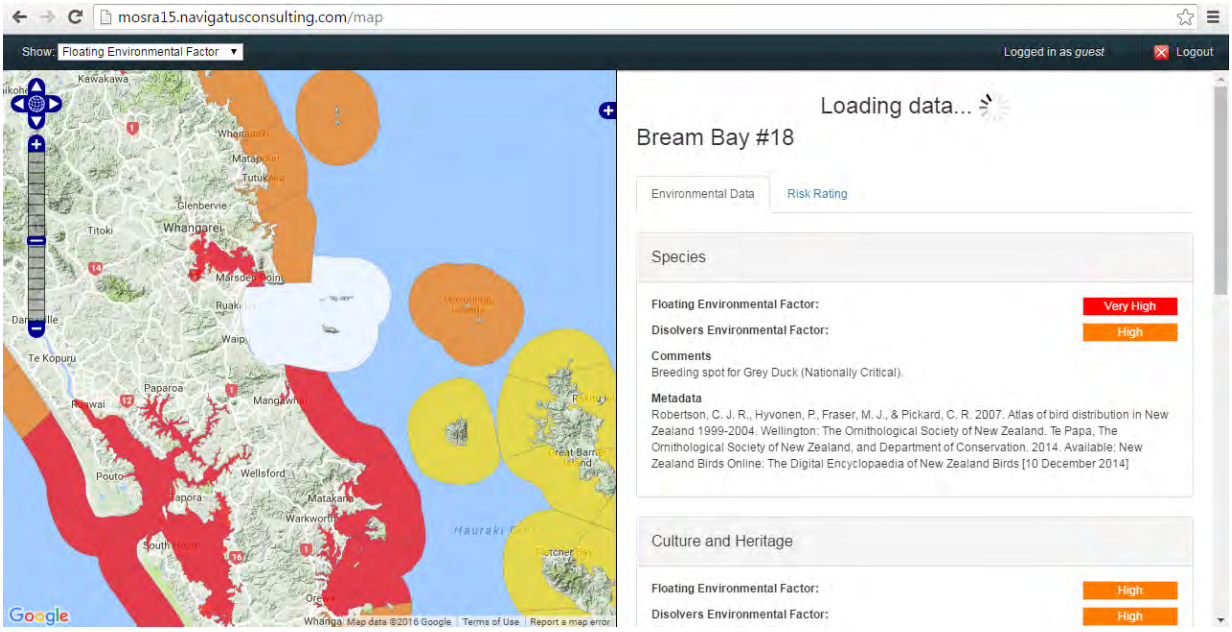

Figure 6-1: Marine Oil Spill Risk Assessment WebMap sample by Navigatus for New Zealand (accessed 31 July 2016)

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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 Kimberley 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:

- Eleven shoreline cells in the Kimberley zone have been ranked Very High for protection from the impacts of floating oil on protected fauna. These are driven by critically endangered shorebirds. Forty-eight shoreline cells have been ranked High for protection from floating oil due to critically endangered shorebirds and the endangered sei whale, fin whale and Olive Ridley turtle. The remaining 56 shoreline cells have been ranked Medium for protection from floating oil. Ranking for protection from dissolved oil was generally lower than for floating except for one shoreline cell (Shoreline Cell 55) which was ranked High for protection from dissolved oil compared to Medium for protection from floating (Appendix A: Figure A1 and Figure A2).
- Twelve shoreline cells have been ranked Very High for protection of Protection Areas from floating oil, a further 94 have been ranked High, and nine have been ranked Medium or Low priority. For protection from dissolved oil, 12 have been ranked Very High, 94 have been ranked High and nine have been ranked Medium priority. These Very High and High rankings for Protection Areas cover 106 of the 115 shoreline cells in the Kimberley zone. The Very High rankings for protection from both floating and dissolved oil are due to three Ramsar wetlands: Ord River Floodplain, Roebuck Bay and Eighty Mile Beach (Appendix A: Figure A3 and Figure A4). The shoreline cells ranked High include Nature Reserves and Important Wetlands, coral reefs, mangroves and salt and freshwater marshes.
- Ninety-three shoreline cells have been ranked High for Cultural Heritage in the Kimberley zone, as they are associated with the West Kimberley, a National Heritage area. All other shoreline cells have been ranked Medium (seven shore line cells) or do not have a ranking (Appendix A: Figure A5 and Figure A6).
- The effect of the ranking of economic impacts in the Kimberley zone sees 35 shoreline cells ranked Medium for protection from dissolved oil. These are due to aquaculture and pearling leases (Appendix A: Figure A7 and Figure A8). All other shoreline cells have been ranked Low or Very Low for protection from both floating and dissolved oil.
- The Social, Amenity and Recreation rankings in the Kimberley zone are never higher than a Low (Appendix A: Figure A9 and Figure A10).
- The cumulative ranking for all categories for both floating oil and dissolved oil effects, results in most of the Kimberley zone being ranked High (95 out of 115 shoreline cells).

The remainder have been ranked Very High (18) or Medium (two) 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 DotEE SNES and BIA polygons, while the DBCA dataset comprised discrete points. A number of additional datasets from research institutions and oil and gas companies were also used, including WAMSI Kimberley node project data and INPEX data.

The majority of the Kimberley 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 and Endangered species, including birds, marine mammals 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 Critically Endangered curlew sandpiper, great knot, northern Siberian bar tailed godwit and eastern curlew and Endangered sei whale, fin whale and Olive Ridley turtle.

Protection Areas

There were 16 datasets used to identify **Protection Areas** in the Kimberley zone. The most comprehensive of these is the DotEE compiled CAPAD datasets for marine and terrestrial areas and the updated dataset by the WA DBCA. Other key datasets were for internationally and nationally important wetlands (Ramsar wetlands and Nationally Important Wetlands datasets) and DBCA's legislated land and waters database. The DBCA historic mangroves dataset, MFB project dataset, Geomorphology smartline dataset and Geonoma dataset were very useful for identifying coastal and intertidal habitats. The CAMRIS seagrass dataset and ReefKIM dataset were important for identifying seagrass and coral reef distribution, though the former had some limitations (refer to Section 3.2.7). 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 Protection Areas which have been ranked Very High are associated with important habitat protection zones around three Ramsar wetlands, and the areas which have been ranked High are those with Nature Reserves and Important Wetlands, coral reefs, mangroves and salt and freshwater marshes.

Cultural Heritage

The key state-wide datasets used in this category were the DotEE provided World Heritage Areas dataset, National Heritage Areas dataset, Commonwealth Heritage Places, the Australian National Shipwrecks Database and the State protected shipwrecks and maritime archaeological sites dataset. 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 Kimberley zone. 100 shoreline cells have been ranked based on Heritage. Of these, 93 have been ranked High as they are associated with the West Kimberley, a National Heritage area (Appendix A: Figure A5 and Figure A6).

Another seven shoreline cells have been ranked Medium, generally due to the presence of Commonwealth shipwrecks or heritage areas.

Economic

The key datasets used to identify the key **Economic** priorities for protection were the DPIRD aquaculture licenced areas and pearling leases datasets, the State and Commonwealth Managed commercial fisheries datasets, Ports and Shipping datasets and tourism statistics. These datasets are comprehensive and state-wide. The WAMSI Kimberley node human use project was also used to identify the most popular cruise vessel destination areas along the Kimberley coastline.

The priority for protection from dissolved oil based on Economic aspects has resulted in a ranking of High in 35 shoreline cells. This is mostly due to the presence of a large number of pearling leases in the Kimberley zone which contributed $78 million to the State economy in 2015.

All other shoreline cells have been ranked Low or Very Low for protection from both floating and dissolved oil, as their overall contribution to the State economy was low.

Social, Amenity and Recreation

The key datasets used to identify **Social, Amenity and Recreation** values in the Kimberley zone included the multi-use zones of the marine parks and reserves in the DotEE CAPAD Marine dataset, an updated DBCA CAPAD dataset and the Marine Parks Draft Zoning Plan 2017. The other key data was popularity information for WA beaches, sourced from Surf Life Saving WA and the Geonoma dataset and Geomorphology Smartline dataset for sandy beaches, which was used as a proxy for potentially popular beaches. This is because, except for Broome, there was no data from Surf Life Saving WA in the Kimberley zone.

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

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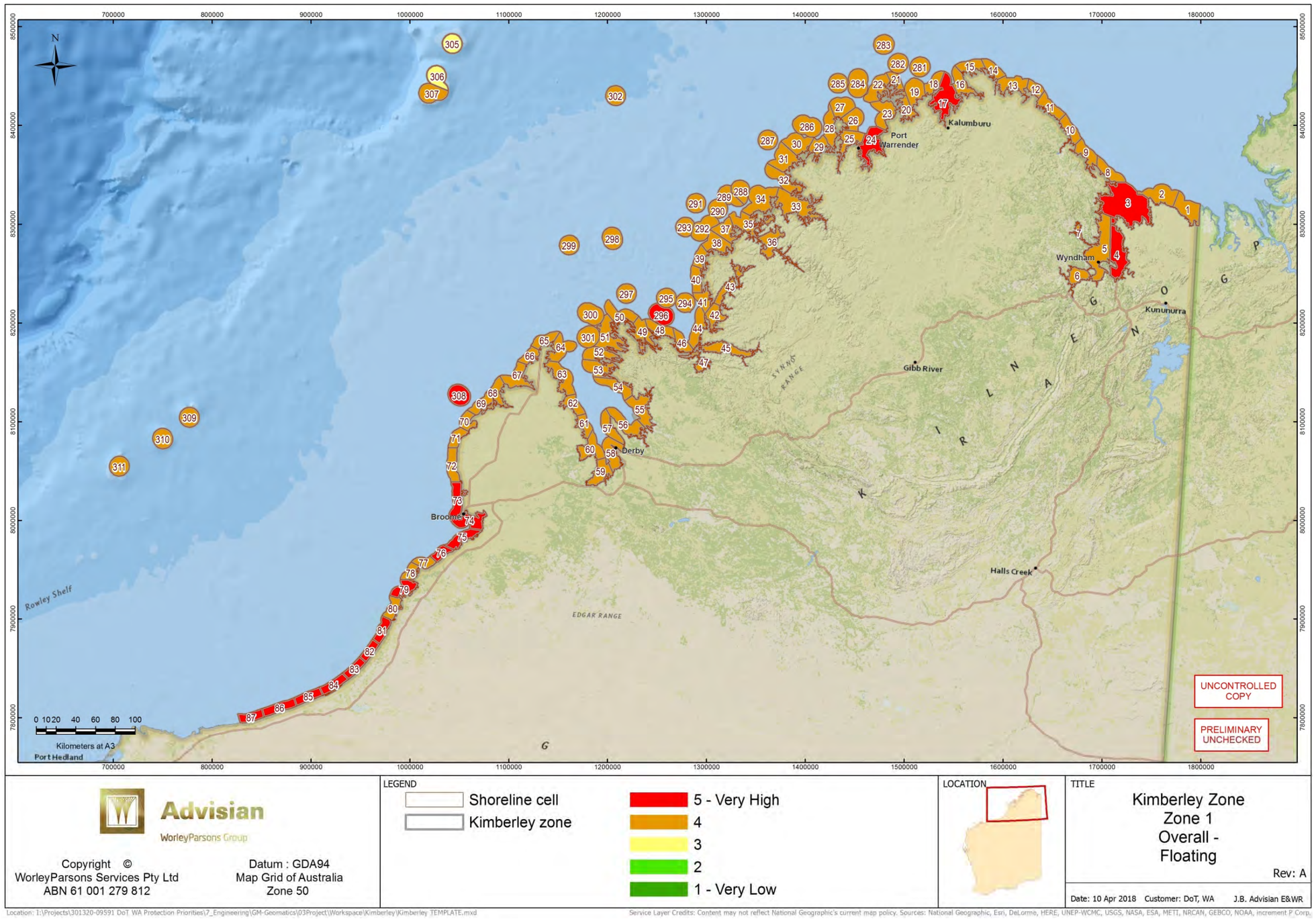

Figure 7-1: Cumulative (including all category rankings) shoreline cell protection priority ranking for floating hydrocarbons effects

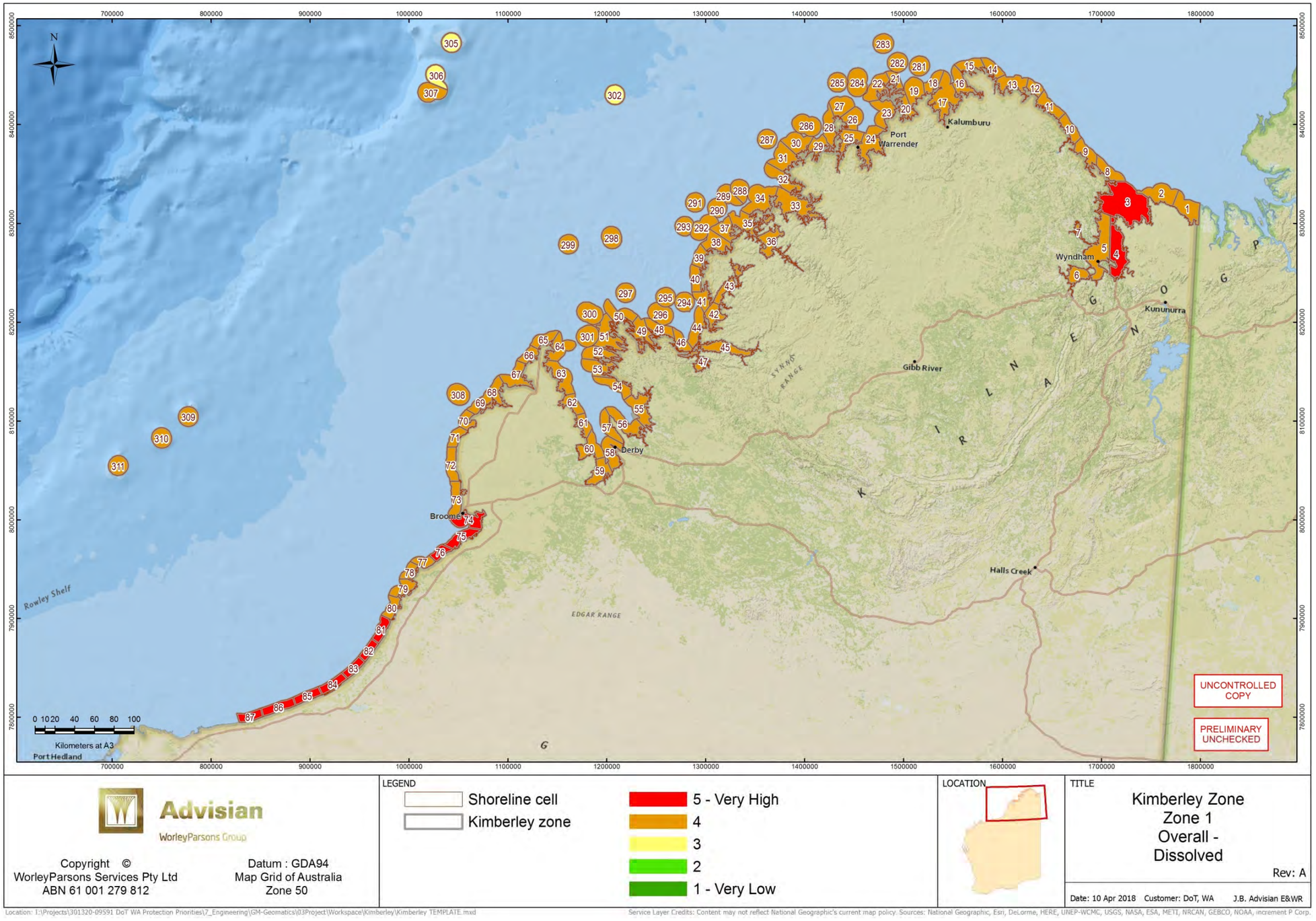

Figure 7-2: Cumulative (including all category rankings) shoreline cell protection priority ranking for dissolved hydrocarbons effect

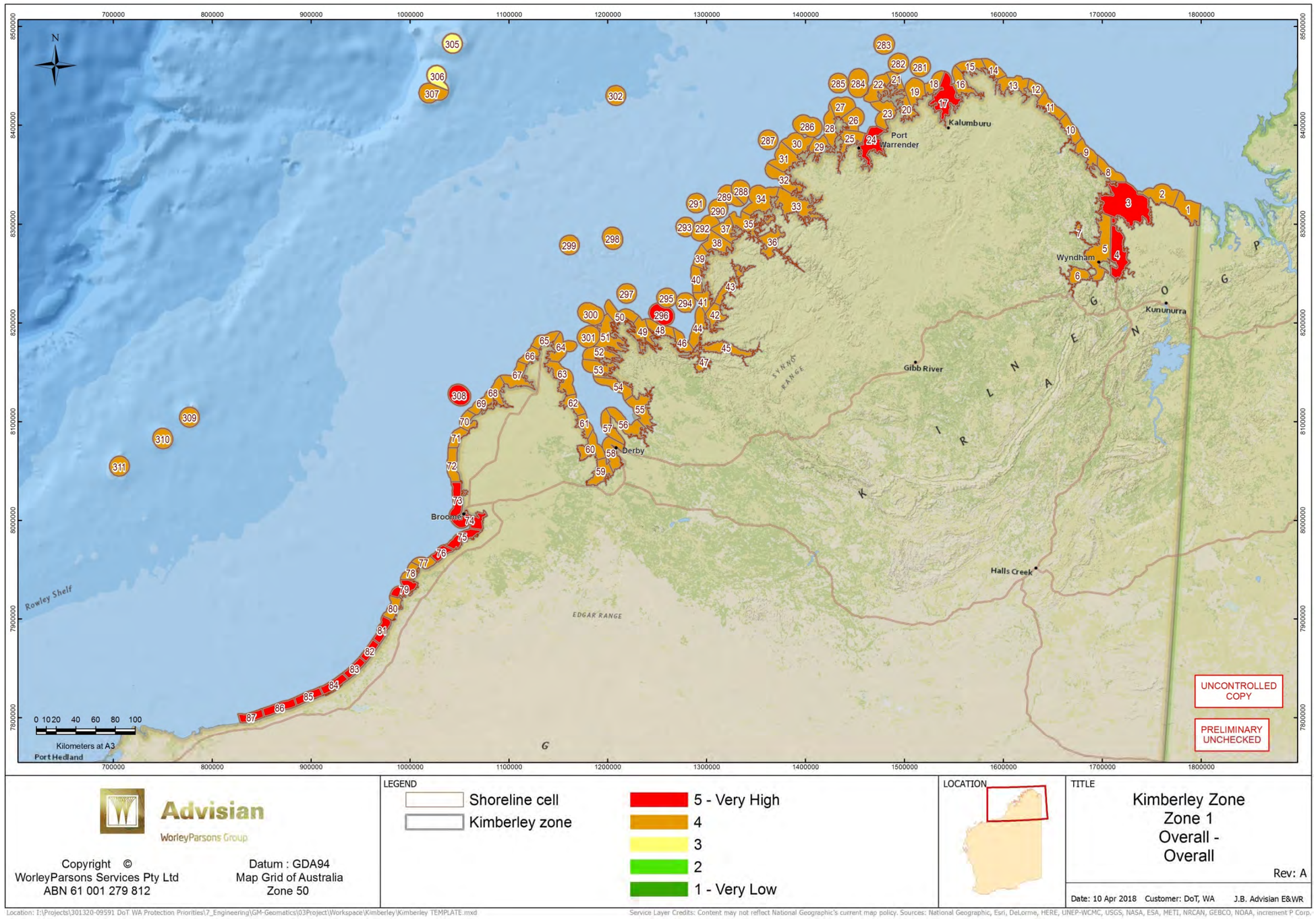

Figure 7-3: Cumulative (including all category rankings) shoreline cell protection priority ranking, for both floating and dissolved effects

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8 Discussion

The key discussion points from the Kimberley zone are:

1. Dataset comparison;
2. Dataset compilation;
3. Genetically isolated populations;
4. Identification of subtidal and intertidal zones;
5. Uniqueness of the Kimberley;
6. Lack of data; and
7. Kimberley islands.

8.1 Dataset Comparison

More than 45 datasets have been incorporated for use in the Kimberley zone. These have been sourced from various government departments, tertiary institutes and private organisations, and adapted for use for the project. Through the project's intimate exploration of the data on a large regional scale, there has been a question raised about comparing different datasets between zones. For example, the Pilbara zone completed in August 2016 has had many regional scale studies undertaken in the area, such as the Pilbara Oiled Wildlife Response Plan, while other zones may not.

The Kimberley zone has therefore relied on data sourced from studies done by DBCA in the marine and coastal protected areas, fisheries related investigations by the DPIRD, as well as the DoT ESI dataset for regional comparison. Though there have been some gaps with the ESI dataset (some areas 'unclassified'), in general the predominant coastal characteristics have been identified. Additional datasets have also been used to identify particular habitats, and these have been assigned a relevant ESI (MFB project dataset, Geonoma, Geomorphology smartline; Table 3-15).

The coastal marine habitats are best defined in the marine parks and coastal marine protection areas provided by DBCA and the DPIRD, where they have been extensively studied. The Kimberley zone has a marine network that generally well represents and protects the zone's key habitats. These are based on many of the areas identified in the Wilson *et al.* (1994) report, which recommended a 'representative' marine system for WA. The additional areas identified in the report which have not become formally protected as part of this marine reserve system have also been incorporated into this assessment, to ensure all areas for protection have been included.

There have been plans to undertake broad-scale mapping of the WA coastline in order to map marine habitats, coastal habitats and bathymetry. While the raw LiDAR data has been captured, this has yet to be processed. A review of the general classifications in the multiple habitat datasets identified through this project could be useful in creating a broad set of general classification criteria. This can be used to create a dataset that is compatible with the existing information, for future refinement of this project's outcomes.

8.2 Dataset Compilation

During the initial data list and compilation stages, various research and government institutions were completing extensive studies as part of the WAMSI Kimberley node project. Advisian was able to gather some of this data through data-sharing agreements, however, some data was unable to be gathered due to time constraints. It is also expected that additional research may be undertaken in the Kimberley. If this information becomes available in the future, it may be beneficial to review the current rankings, particularly for the protected areas and protected fauna. In particular, the WAMSI Kimberley dugong research project dataset could not be obtained in time to finalise this report, as we did not receive approval from all Aboriginal custodians. It is recommended that this dataset be reviewed and, if required, included in any updates of the report and/or used in any response planning situation when it is made available.

8.3 Genetically Isolated Populations

During the Steering Committee workshop, the genetic isolation of certain fauna populations was discussed and whether these should be taken into account in the ranking process. An isolated population, should it be impacted by an oil spill, may result in its complete loss or longer recovery times, while a more open population would be able to recover more easily. Discussions with researchers suggested that genetic isolation should be taken into account in the ranking process if possible (i.e. provide a high ranking for genetically isolated population).

Various WAMSI Kimberley node projects have started to assess population isolation in the Kimberley.

The WAMSI project '1.1.3 Ecological connectivity of Kimberley marine communities' identified that:

- Habitat forming organisms (coral, seagrass) typically exhibited the most localised population structure, with evidence for limitations to dispersal evident on scales of tens of kilometres or less; and
- Broadly, the divisions in seagrasses, corals and fish were between the Dampier Peninsula and Buccaneer Archipelago sites, but the positions and breadths of the boundaries differed for individual taxa.

The WAMSI project '1.2.4 Abundance, population genetic structure and passive acoustic monitoring of Australian snubfin and humpback dolphins across the Kimberley' identified:

- Evidence of limited genetic connectivity between snubfin dolphins at Roebuck Bay and Cygnet Bay/Cone Bay, with evidence of a potential third genetic population further north/east.

Site-specific assessments of the abundance of three inshore dolphin species in the Kimberley showed site fidelity for several populations, particularly in snubfin dolphins (Brown et al 2016).

These studies illustrated the need to undertake further research to obtain site-specific baseline data on local populations to determine potential threats and management requirements. Due to the current paucity of information, particular about protected fauna, the rankings in this report do not currently take into account the potential isolation of populations.

As more research into population genetic structures becomes available, this assessment as well as those of other zones could be revisited to account for genetically isolated populations in the ranking process.

8.4 Identification of Subtidal and Intertidal Zones

The protection priority rankings for Terrestrial Protection Areas, Marine Protection Areas, and Coral, Seagrass and Algae were influenced by the respective features' spatial relationship with the subtidal or intertidal zone. The following datasets were used to delineate the shoreline cells by subtidal, intertidal and coastal zone:

- Geomorphology Smartline Mean High Water Mark (MHWM);
- OSRA ESI index Mean Low Water Mark (MLWM) and MHWM; and
- DBCA Historical Mangroves.

Validation of the Geomorphology Smartline MHWM determined the dataset did not contain the MHWM for Shoreline Cells 309, 310 and 311, so the OSRA ESI index MHWM was used for those three shoreline cells. Further validation identified mangroves landward of the MHWM. As all mangroves lie within the intertidal zone, areas landward of the MHWM containing mangroves listed in the DBCA Historical Mangroves dataset were reclassified as intertidal. The resulting MHWM layer separated the coastal area from the intertidal zone within each shoreline cell. This layer was used to inform the Terrestrial Protection Areas protection priority rankings.

Validation of the OSRA ESI index MLWM identified numerous gaps in coverage along the Kimberley coastline and throughout the offshore island areas. Due to these data gaps, manual inspection was used to assign protection priority rankings for each Marine Protection Area feature within each shoreline cell. The manual inspection was informed by the OSRA ESI index MLWM, Geomorphology Smartline MHWM and aerial imagery, resulting in each Marine Protection Area feature within each Shoreline Cell being classified as subtidal or intertidal/coastal, informing the protection priority rankings.

All datasets used to identify areas of coral, seagrass and algae within each shoreline cell, except the ACEAS Seagrass Map dataset, contained attribute information about whether each feature spanned the subtidal or intertidal zone. Due to the coarse resolution of the ACEAS Seagrass Map, the areas of seagrass detailed could lie within either the subtidal or intertidal zone, therefore the conservative option (intertidal) was used to inform the protection priority ranking.

8.5 Uniqueness of the Kimberley

A number of aspects of the Kimberley zone make it unique compared to other zones. Most of the Kimberley's marine environment is internationally recognised as being in very good ecological condition and is included in the less than four per cent of the world's marine environment rated as having had very low impact from humans (Government of Western Australia, 2011).

The complexity and diversity of the Kimberley marine environment means there are eight major marine bioregions, more than in any other part of Western Australia. Six marine bioregions are coastal (Eighty Mile Beach, Canning, King Sound, Kimberley, Bonaparte and Cambridge Bonaparte) and two are offshore (North West Shelf and Oceanic Shoals) (Government of Western Australia, 2011).

The Kimberley contains two of only a dozen areas in the world with huge intertidal flats rich in shorebirds. Roebuck Bay and Eighty Mile Beach Ramsar wetlands are summer refuges to hundreds of thousands of internationally protected migratory waders that fly from as far afield as Siberia. Both are at the receiving end of the world's most species-rich shorebird flyways. Roebuck Bay also lays claim to having the largest known population of snubfin dolphins, found only in Australia (Government of Western Australia, 2011).

Some of the largest mangrove patches in Australia, considered among the most pristine mangrove forests in the world, fringe the Kimberley coast, with a total area of 140,000 hectares. Stands comprise up to 18 tree species, and their fauna is rich and distinctive (Government of Western Australia, 2011).

The Kimberley has most of the oldest archaeological sites and the greatest diversity of rock art in Australia. Aboriginal people have a connection with Kimberley waters that dates back tens of thousands of years. There are hundreds of archaeologically significant marine sites (such as shell middens and fish traps), and the ocean remains significant in oral traditions and spiritual activities (Government of Western Australia, 2011).

This uniqueness has been recognised through the creation of the Kimberley West National Heritage area as well as large areas of Ramsar wetlands, and is reflected in the overall ranking, with 113 of the 115 shoreline cells being ranked High or Very High for protection from oil.

8.6 Lack of Data

The Kimberley zone is one of the least studied of the zones, so the potential issue of lack of data was discussed during the Steering Committee workshop. Lack of data may reduce the risk ranking of certain shoreline cells, which could reduce the number of resources allocated to protection priorities and potentially impact high conservation priorities. This is particularly true of Protected Fauna and Protection Areas, where information relies on the results of habitat and fauna surveys.

Seagrass is one particular example of a dataset where there was a lack of data. The CAMRIS Seagrass dataset from the CSIRO, which contains information about the distribution of seagrass around the Australian coastline, was initially used as per previous zones. However, after analysing the distribution of seagrass in the Kimberley, it was evident that large areas where seagrass was deemed not to occur were more likely to mean surveys had not yet been undertaken, and that seagrass distribution in those areas had not yet been confirmed. This was confirmed by the Australian Centre for Ecological Analysis and Synthesis seagrass dataset, which shows known areas of seagrass, confirms where seagrass is known not to occur, and areas where the presence of seagrass still needs to be confirmed. This results in a seagrass map where the presence of seagrass has not been confirmed for the majority of the coastal zone north of Derby.

After analysing all datasets and comparing rankings with other zones, it has been deemed unlikely that the lack of data would have resulted in misidentified shoreline cell rankings. A large number of cells which have been ranked Very High or High for protection are a result of known protection priorities such as Ramsar Wetlands, National Heritage sites, etc. The known and likely distribution of threatened species has also provided good confidence in the ranking process. However, as more research is undertaken in the Kimberley, the risk ranking will be able to be further refined to provide more information on potential protection priorities underlying a relevant cell ranking, thereby allowing resources to be adequately allocated in the event of an oil spill.

8.7 Kimberley Islands

The broad continental shelf off the Kimberley coast supports coral reefs, banks, shoals and more than 2,500 near-shore islands. The Kimberley islands support plants and animals that are found nowhere else and are refuges for native species that have disappeared from or are threatened on the mainland by fire, introduced animals and weed invasion. A major biological survey of Kimberley islands conducted by DEC, with support from the Western Australian and Australian Museums and traditional owners, has confirmed that almost all are free of introduced animals and weeds, and that they are less subjected to fire than the mainland.

The islands off the Kimberley coast are either included in the shoreline cells that include the mainland (near shore islands) or have their own shoreline cells when these are further away from the mainland (offshore islands; shoreline cells 281 to 311). Offshore islands generally have a similar or lower ranking than the mainland which can be explained by the following:

- Due to their isolated nature, the offshore islands would receive less visitors and therefore the rankings for Heritage, Economic, and Social, Amenity and Recreation categories are generally lower than the mainland shoreline cells;
- A lack of data may have contributed to the lower ranking of offshore islands in the Protected Fauna category. As discussed in Section 8.6, as more research is undertaken in the Kimberley including on offshore islands, the risk ranking will be able to be further refined, as more information on potential protection priorities underlying a relevant cell ranking will be available.

It should be noted that, apart from two offshore shoreline cells, the overall cumulative ranking of offshore islands is similar to the mainland shoreline cells (High to Very High).

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9 Conclusions

The following are key conclusions of this study:

- The Kimberley zone is highly vulnerable to marine oil pollution, both from floating and dissolved hydrocarbons.
- A number of aspects of the Kimberley zone make it unique compared to other zones. The prevalence of mangrove habitat and sheltered and exposed tidal flats along the majority of the coastline is a driver for key vulnerability areas in the Kimberley zone. The zone includes Ramsar wetlands, the West Kimberley which is on the National Heritage List, and breeding habitats for Critically Endangered and Endangered shorebirds, whales and turtles.
- The Steering Committee provided invaluable input and advice regarding the suitability of datasets and ranking of criteria, while also addressing the desire to be robust and transparent when identifying protection priorities.
- This is a static assessment and further data, information, locations and priority rankings can change in the future. This is particularly true of the Kimberley zone due to its remoteness and until recently paucity of research undertaken in this region.
- 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.
- This report and assessments are intended as a guide only, and are intended to enhance the process and deliver a more effective response time in the event of an oil spill off the Kimberley coast.
- DoT would need to consult with the DAA and local Aboriginal stakeholders independently in the event of an oil spill.

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Appendix A Shoreline Cell Maps

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Protected Fauna

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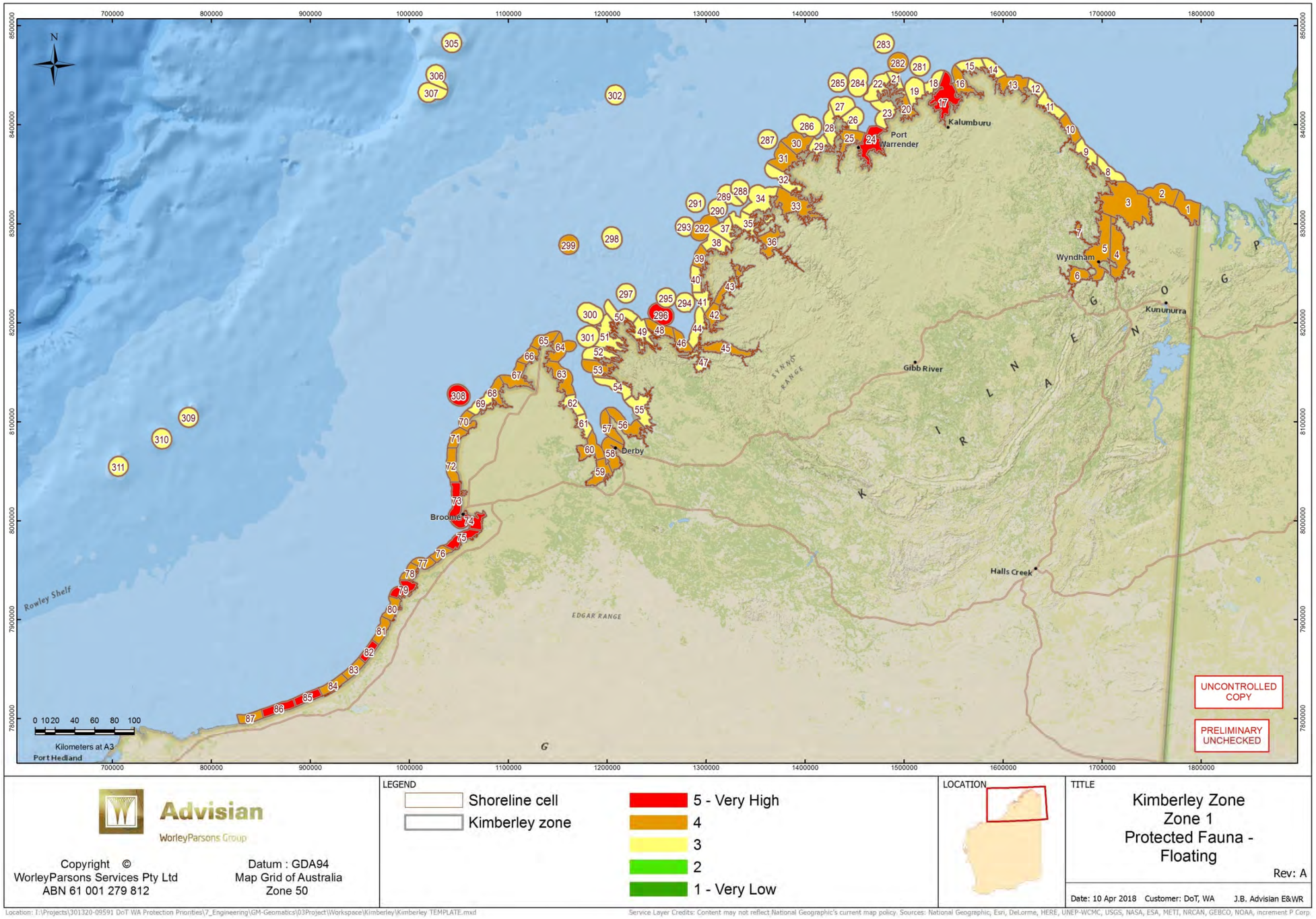

Figure A1: Protected Fauna shoreline cell protection priority ranking for floating hydrocarbons effects

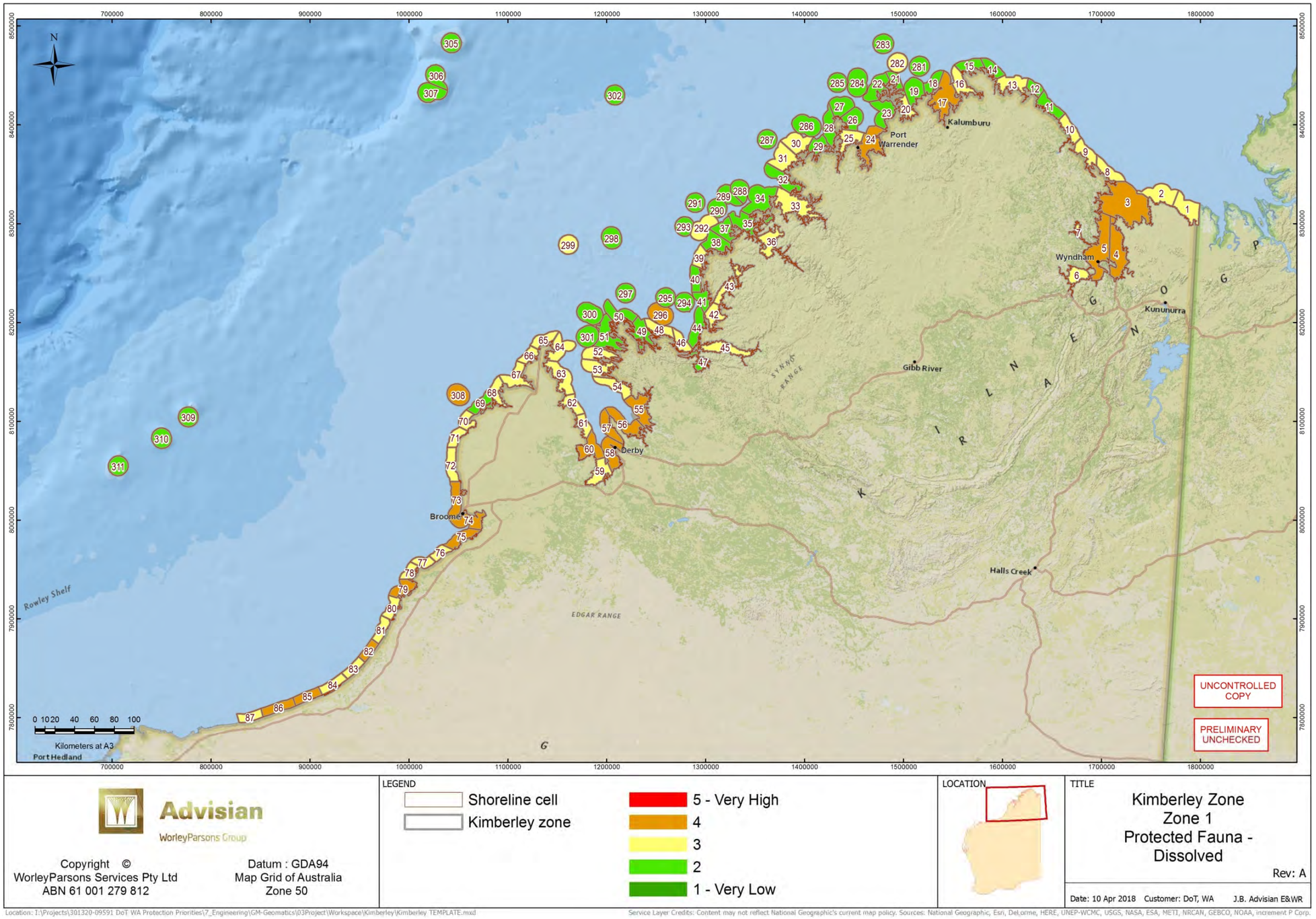

Figure A2: Protected Fauna shoreline cell protection priority ranking for dissolved hydrocarbons effects

Protection Areas

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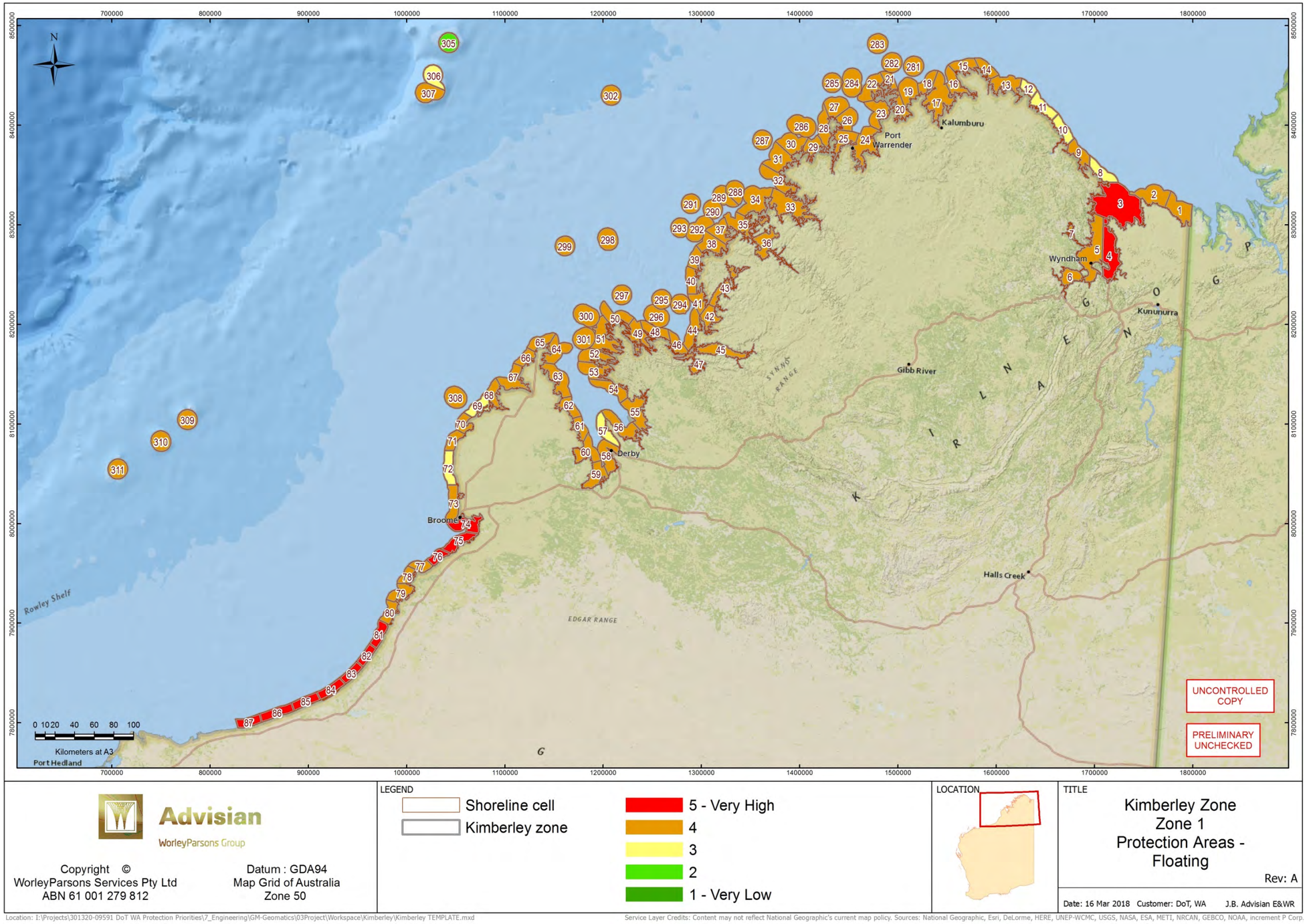

Figure A3: Protection Areas shoreline cell protection priority ranking for floating hydrocarbons effects

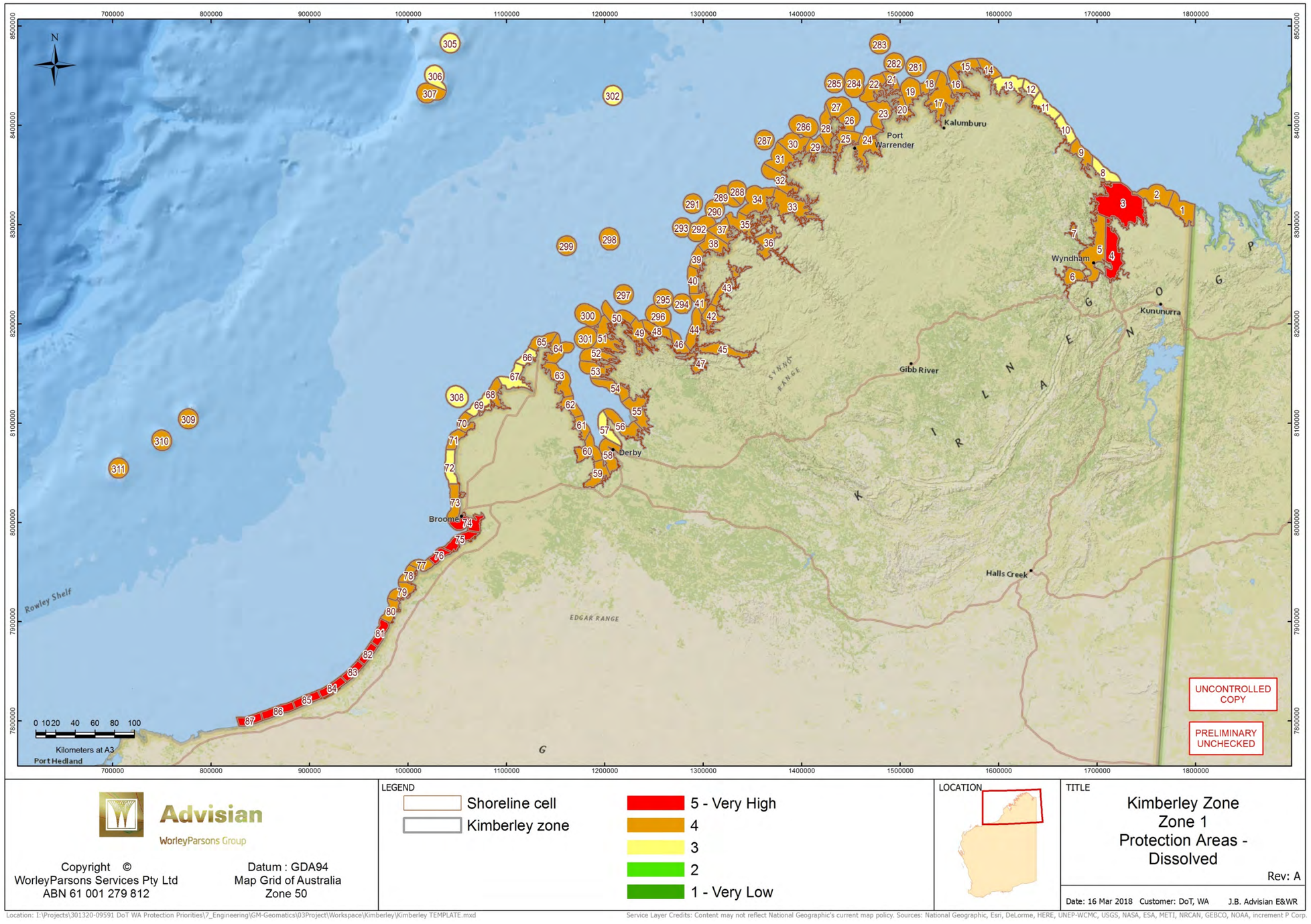

Figure A4: Protection Areas shoreline cell protection priority ranking for dissolved hydrocarbons effect

Cultural Heritage

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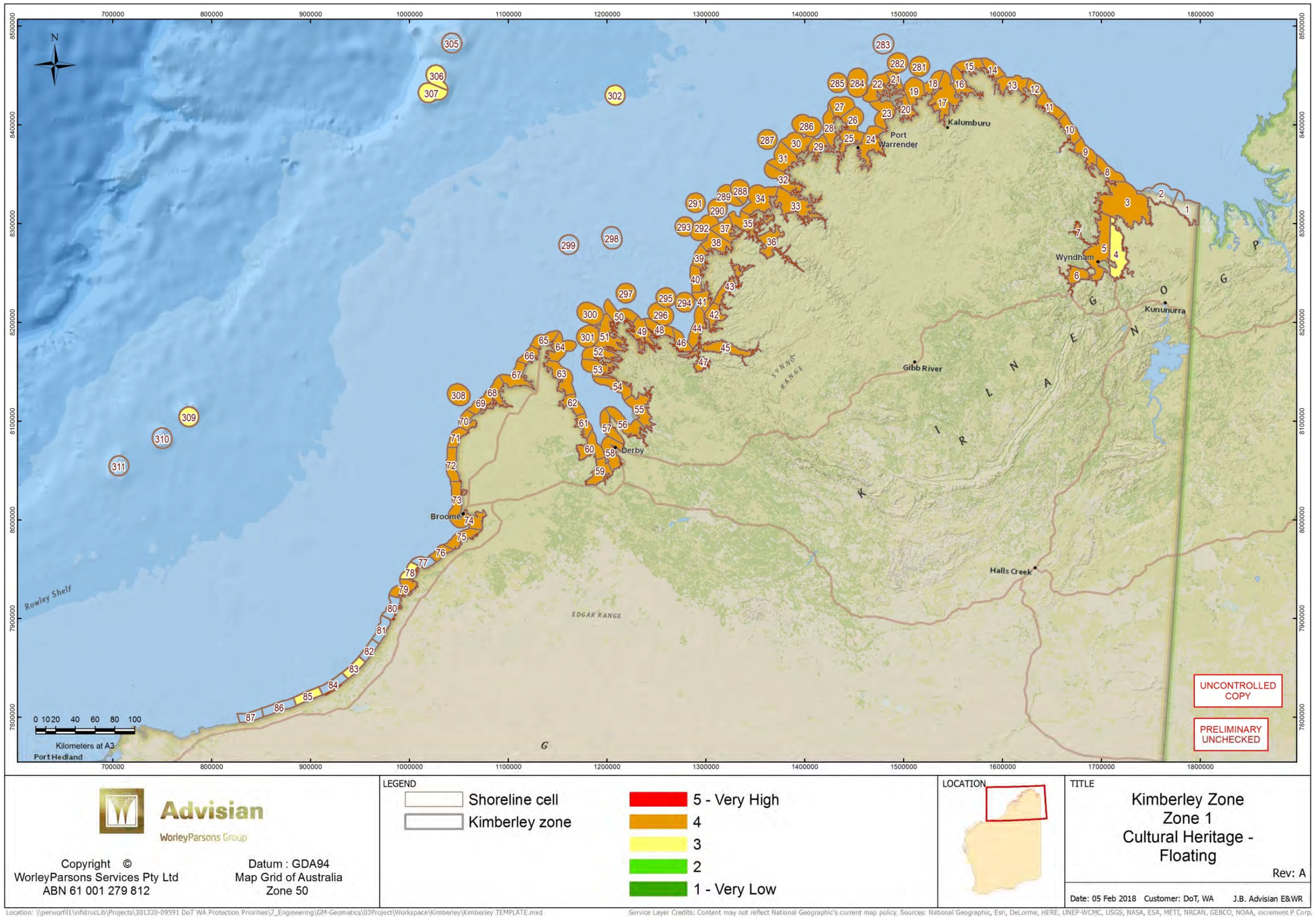

Figure A5: Cultural Heritage shoreline cell protection priority ranking for floating hydrocarbons effects

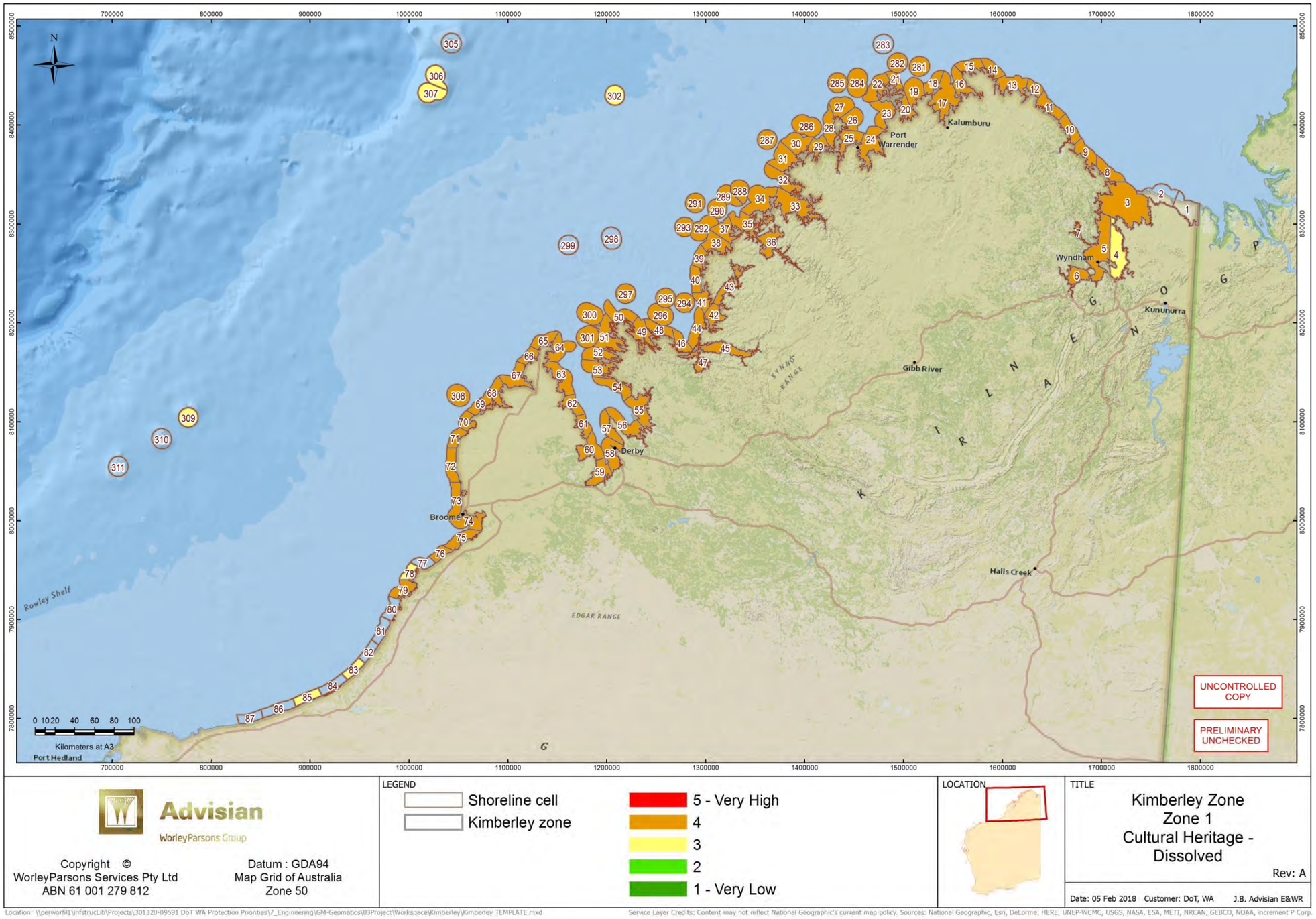

Figure A6: Cultural Heritage shoreline cell protection priority ranking for dissolved hydrocarbons effects

Economic

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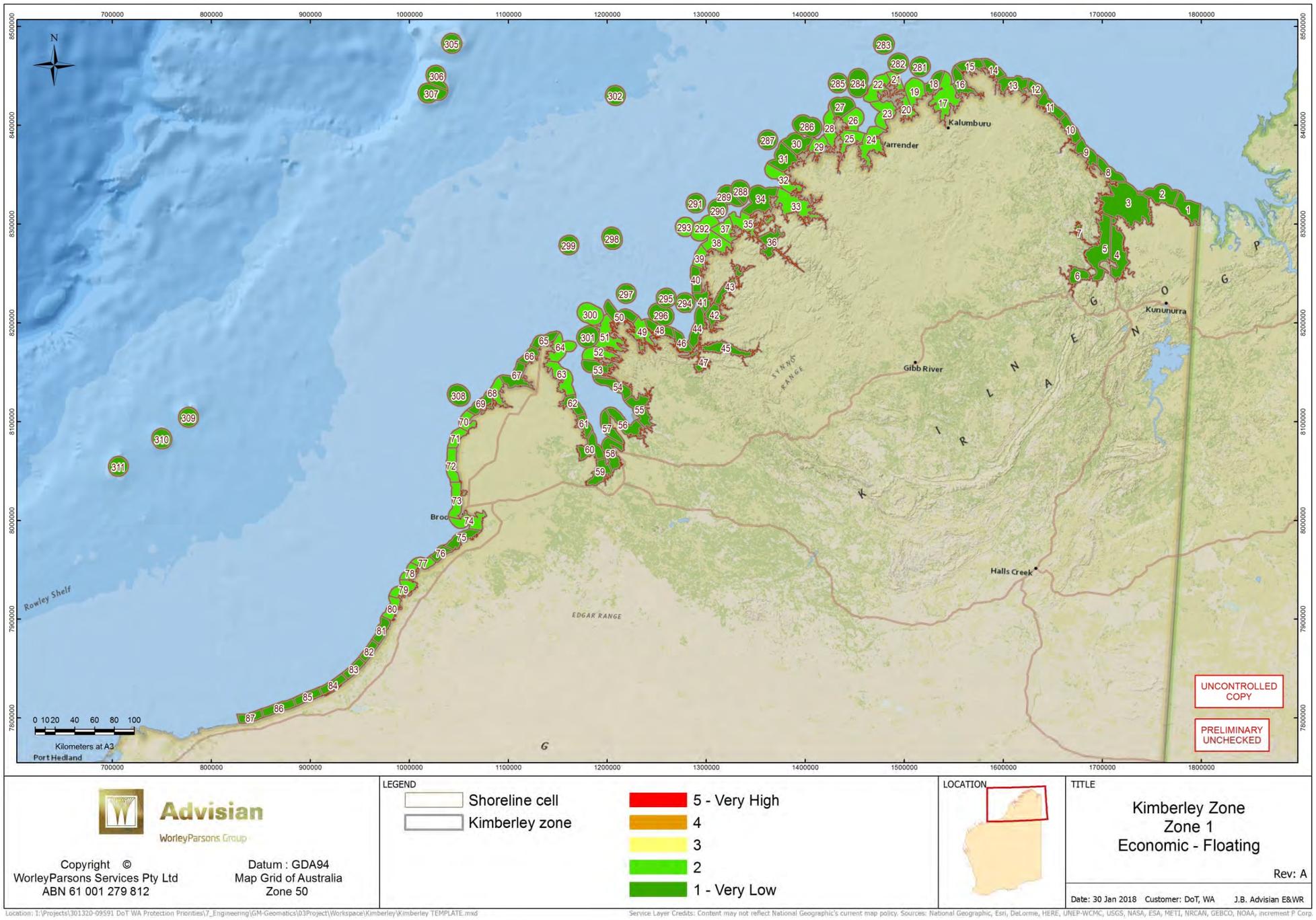

Figure A7: Economic shoreline cell protection priority ranking for floating hydrocarbons effects

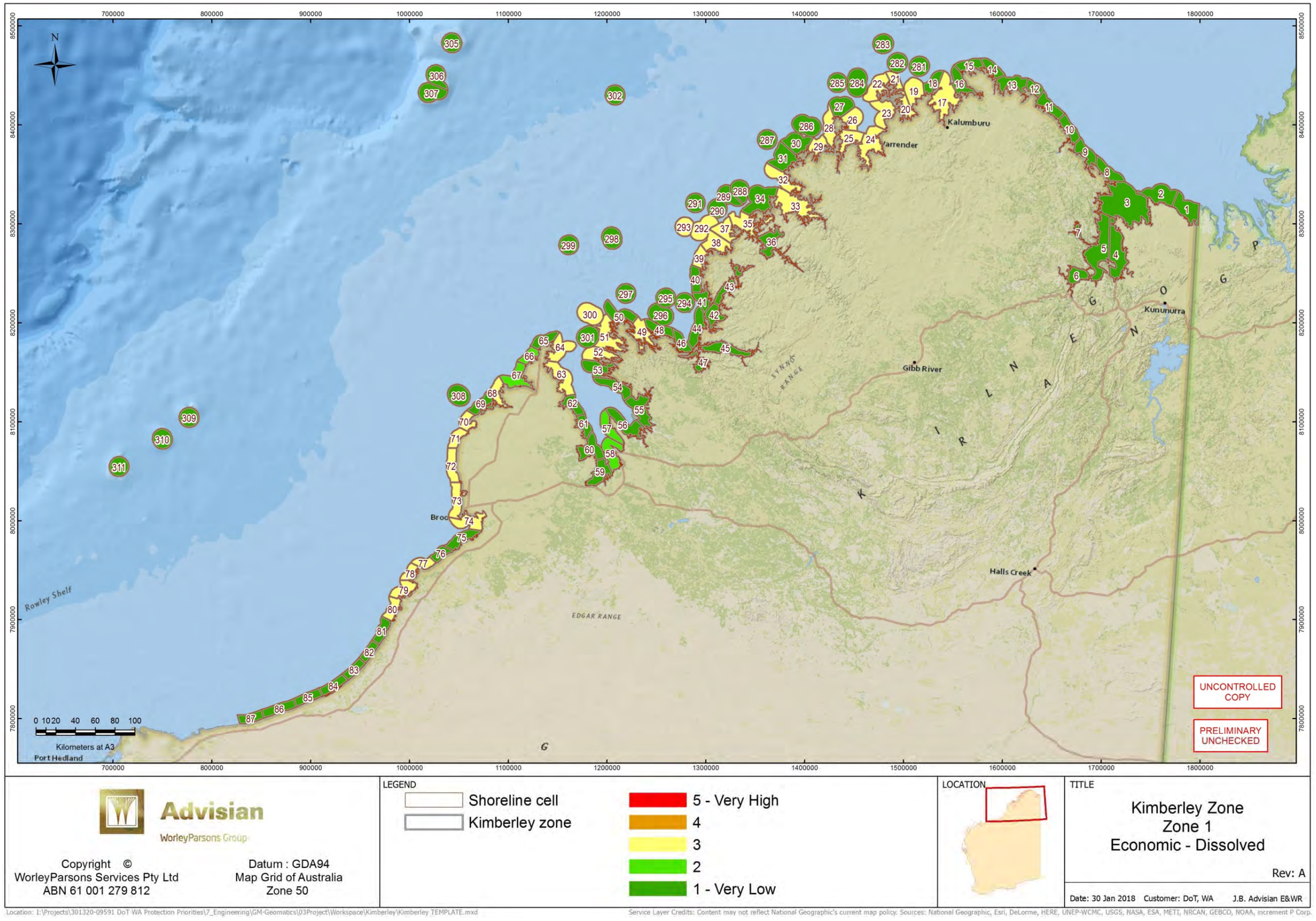

Figure A8: Economic shoreline cell protection priority ranking for dissolved hydrocarbons effect

Social, Amenity and Recreation

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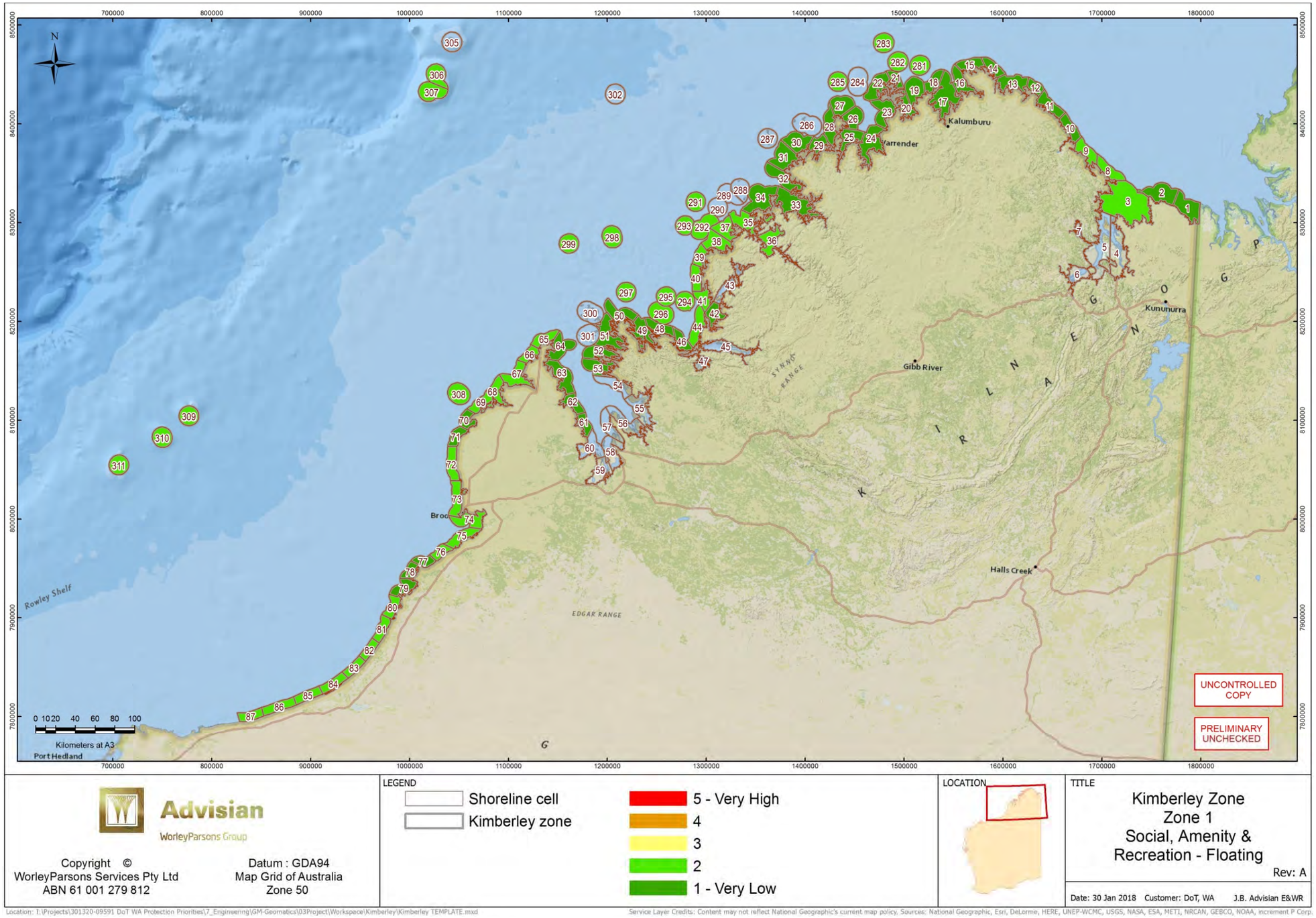

Figure A9: Social, Amenity and Recreation shoreline cell protection priority ranking for floating hydrocarbons effects

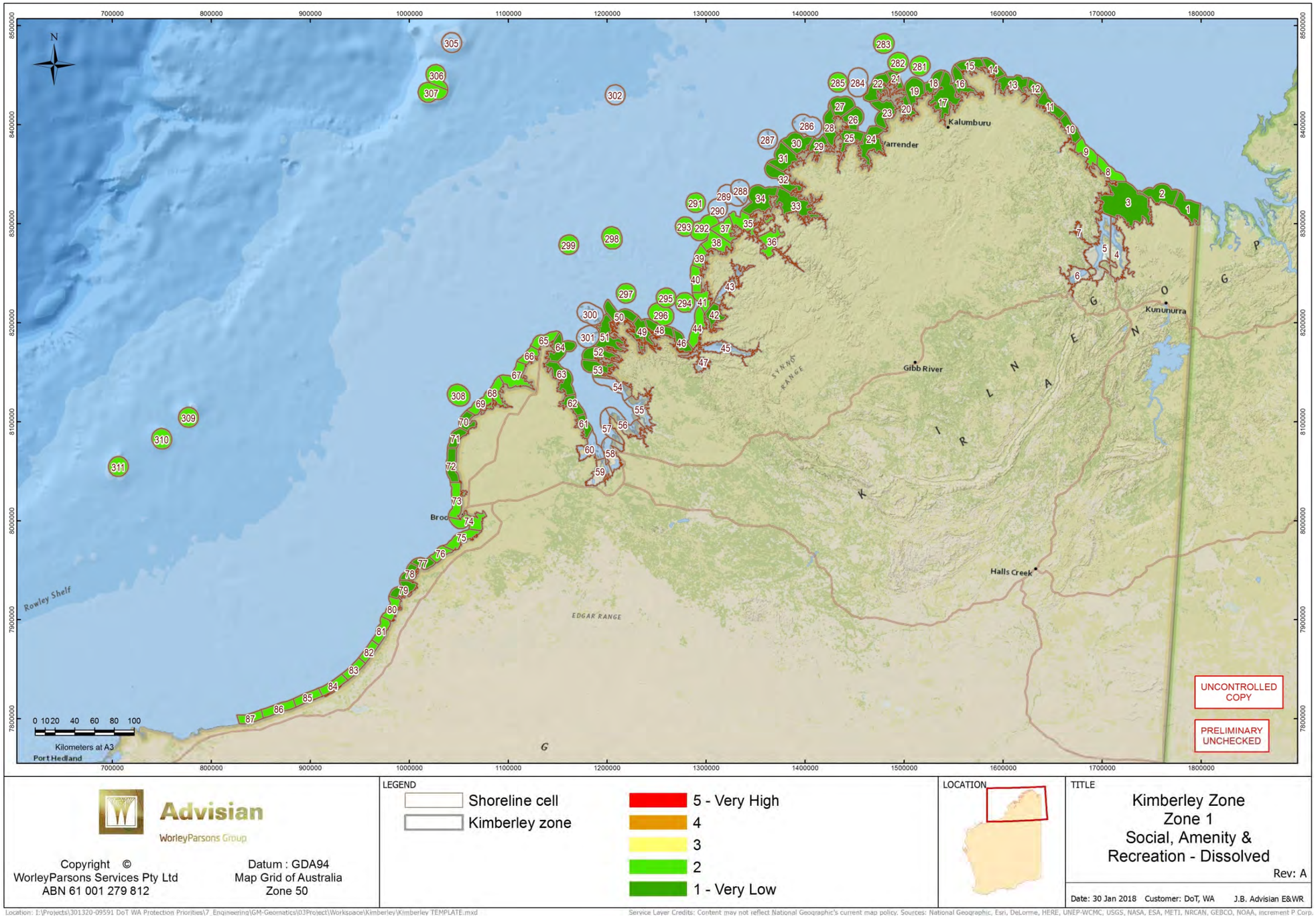

Figure A10: Social, Amenity and Recreation shoreline cell protection priority ranking for dissolved hydrocarbons effects