

Western Australia
Marine Oil Pollution Risk Assessment

Kimberley Zone Report

Prepared for Department of Transport
by Navigatus Consulting

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Outputs in this Series

Web

Interactive webmap application: <http://wamopra.navigatusconsulting.com/login>

Data

GIS attribute tables for DoT internal system.

Reports

- ▶ Navigatus, 2016 – WAMOPRA Preliminary State-Wide Assessment (published)
 - ▷ Appendix A – Exposure Results by Category
 - ▷ Appendix B – Web Based Interface
- ▶ WAMOPRA Pilbara Zone Report (published)
- ▶ WAMOPRA Mid-West Zone Report (published)
- ▶ WAMOPRA Swan Zone Report (published)
- ▶ WAMOPRA South West Zone Report (published)
- ▶ WAMOPRA South Coast Zone Report (published)
- ▶ **WAMOPRA Kimberley Zone Report (*this report*)**

1. Introduction

1.1. Overview

The Western Australian Department of Transport (DoT) is currently running a programme of work looking at matters around marine oil spills. One component of the work is the Western Australia Marine Oil Pollution Risk Assessment (WAMOPRA).

The WAMOPRA is being undertaken in two stages. In Stage One, Navigatus undertook a preliminary state-wide exposure assessment. Stage Two builds on the work developed in Stage One. It consists of specific zone-by-zone assessments and involves incorporating protection priorities and navigational hazard to create a full risk profile.

This document should be considered a companion report to the WAMOPRA webmap application: <http://wamopra.navigatusconsulting.com/>. It summarises the context, methodology and results for the Kimberley Risk Assessment Zone. The other zones are: Pilbara, Swan, Midwest, South West and South Coast.

1.2. Programme Background

The purpose of the overall WAMOPRA programme is to build an assessment of the oil spill risk in Western Australia State waters. This assessment considers regional, national and international data for maritime activity and marine oil spills, current and future levels of activity and protection priorities including environmental sensitivities.

To undertake the WAMOPRA, DoT has commissioned two consultancies. Navigatus Consulting Limited is engaged to collect and analyse information on potential marine oil pollution exposure and build a risk model. Navigatus has special expertise in this field and have undertaken similar work in Victoria and New Zealand (Navigatus 2015).

The second consultant, Advisian, is collecting environmental data to identify protection priorities in the event of a marine oil spill. Protection priority data is fed into the risk model developed by Navigatus to create a picture of oil spill risk including likelihood and consequence.

The results will guide oil spill contingency planning and will enable future resource allocations for oil spill response to take account of the level of identified risk. The main purpose of the risk profile is to inform:

- ▶ Decisions about resource allocation.
- ▶ Identification of areas where management is required to reduce risk.
- ▶ Evaluation of whether there is adequate spill response capability in areas of high risk.

Other requirements include:

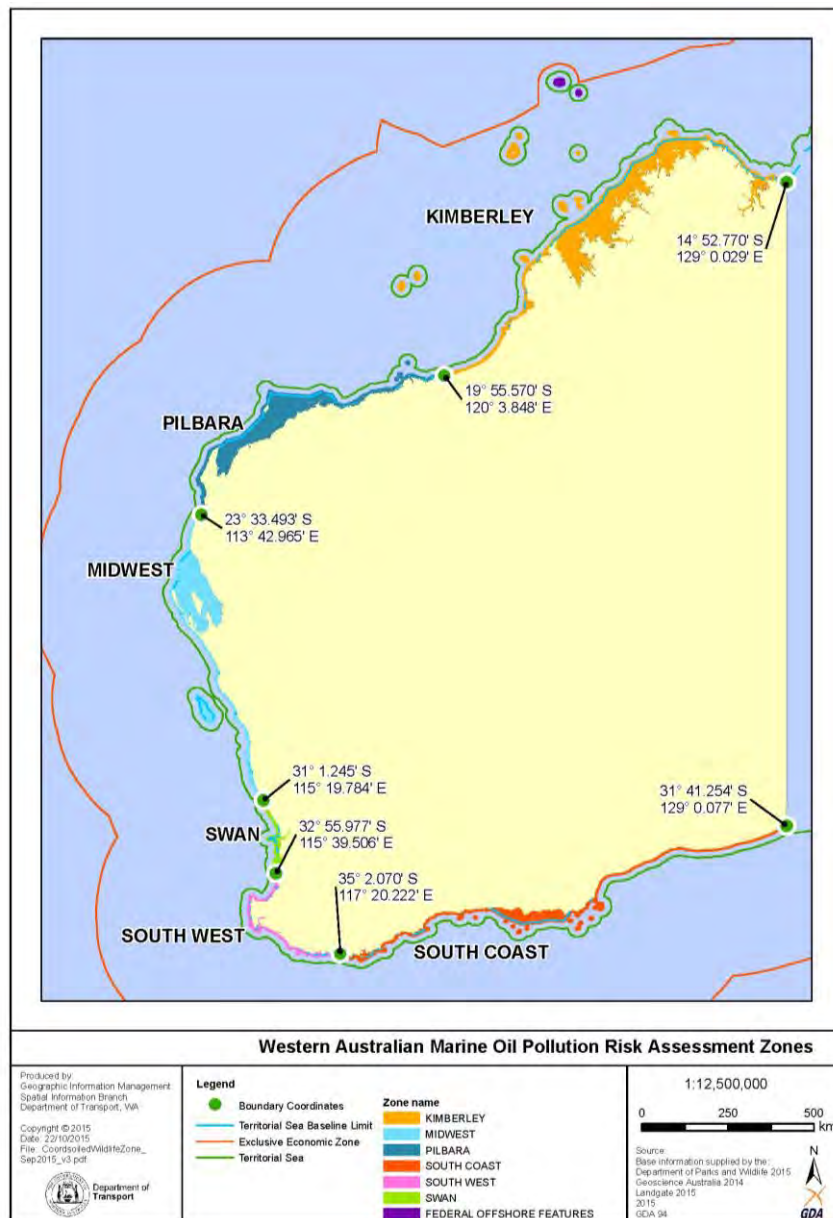
- ▶ Fulfil obligations under WestPlan: Marine Oil Pollution (MOP).
- ▶ Ensure Western Australia is up to date with world standards in oil spill response.
- ▶ Complement the Oil Spill Response Atlas as a decision-making tool.

2. Scope

2.1. Kimberley Zone

This report summarises the context, methodology and results for the Kimberley Risk Assessment Zone. It builds on the work undertaken in the preliminary state-wide assessment. The geographical extents of the Kimberley Zone shoreline are shown in Figure 2.1 along with the other zones.

Figure 2.1 Marine Oil Pollution Risk Assessment Zones



Navigatus undertook a trip to Kimberley and visited the major ports from landside, met with operators, and surveyed a significant length of the coastline by charter flight. Figure 2.2 shows an aerial view of part of the Kimberley coast and the beauty of the area.

Figure 2.2 Aerial view of area between King Sound and Broome Coast (G. Bermingham, Navigatus, 2018)



The primary output of this assessment is the webmap application located at: <http://wamopra.navigatusconsulting.com>. GIS attribute tables are also held by DoT for use in internal systems. This report is a companion report to the website. Outputs in this report are in the form of heat maps, charts and tables.

2.2. Report Outline

The remainder of this report is structured as follows:

- ▶ **Context** – a brief overview of the contextual background informing the WAMOPRA. This includes shipping trends, the current state of the offshore petroleum industry and discussion of short and long-term scenarios.
- ▶ **Data Sources** – a summary of the data sources used in the WAMOPRA. As the Kimberley Zone report builds on the preliminary state-wide assessment some data sources are already discussed in the Stage One report. In these cases a shorter summary is provided and the reader is referred to the Stage One report.
- ▶ **Methodology** – a summary of the methodology used to develop the WAMOPRA. As with the data sources section there are elements of the methodology which are covered in the Stage One report. In these cases a shorter summary is provided and the reader is referred to the Stage One report.
- ▶ **Site visit.** A summary of observations from the Navigatus site visit.
- ▶ **Results** – a presentation of the various results produced by the WAMOPRA:

- ▷ *Exposure* – outputs relating to exposure, i.e. the expected amount of oil in a given shoreline or sea location. Includes breakdown by vessel types and spill sizes. Exposure is combined with protection priorities to produce the Kimberley risk profile.
 - ▷ *Protection Priorities* – the primary output shown is a heat map of the overall protection priority ratings for the Kimberley Zone as provided by Advisian. These ratings are combined with exposure to produce the Kimberley risk profile.
 - ▷ *Risk Profile* – the primary output shown is a heat map which combines exposure and protection priorities to form a full risk profile. The risk profile is the primary risk output in this report and is the synthesis of all inputs into the WAMOPRA.
 - ▷ *Sub-Zone Drill Down* – a short section on each of four sub-zones within the Kimberley Zone (refer Section 5.2 for an explanation of sub-zones). A table is presented for each sub-zone which shows, for each of the shoreline cells in that sub-zone: cell name, overall risk rating, protection priorities ratings, a brief description of the overall protection priority rating and a brief comment on the key drivers of shoreline exposure. The key benefit of these tables is allowing trends in risk drivers to be seen across multiple cells.
- ▶ **Summary** – summary of the key findings.

3. Context

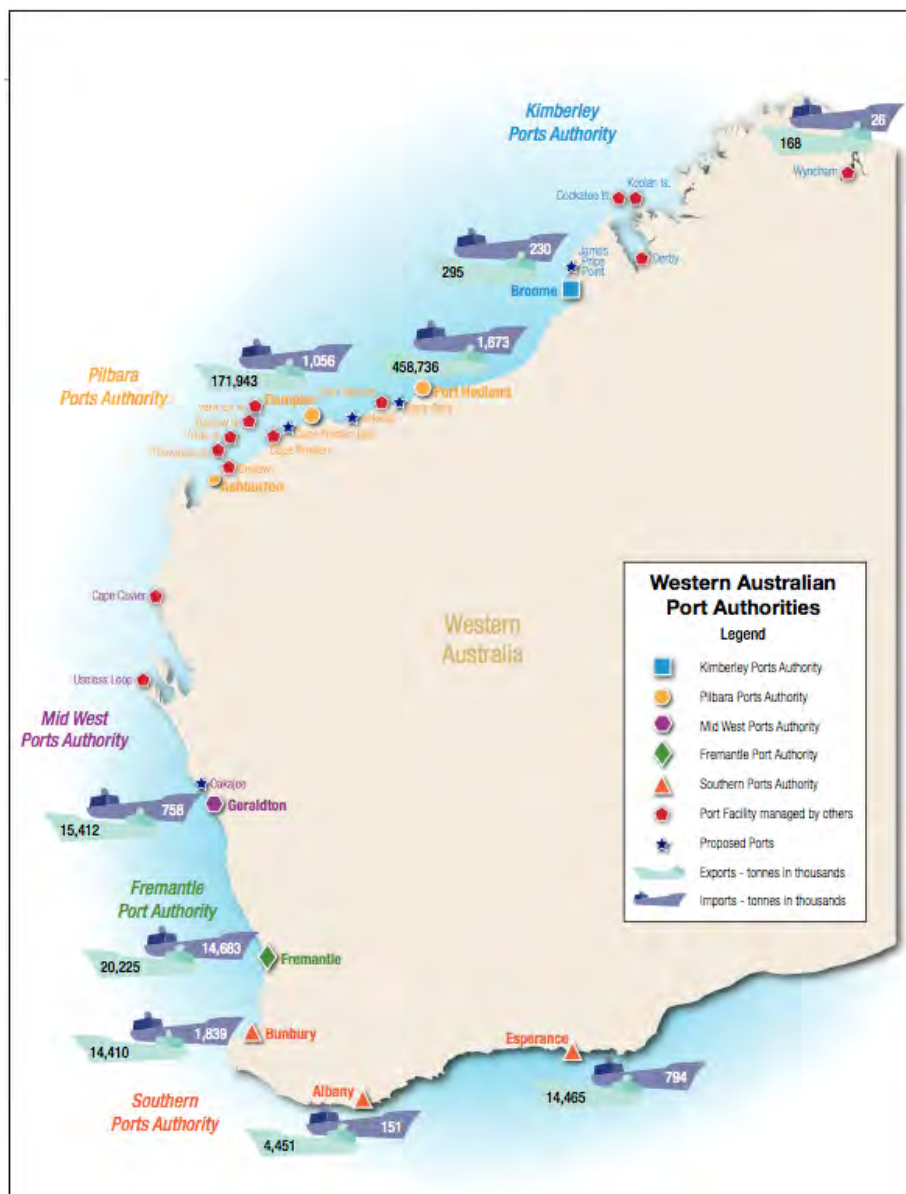
3.1. Level of activity

The largest port in the Kimberley region is the Port of Broome. The Port of Wyndham is now less busy than it has been and is currently managed privately on behalf of the Department of Transport. The Port of Derby, like Wyndham, is also managed on behalf of the Department of Transport under a port operation agreement.

While there are several ports, the level of activity and trade volumes are much less than most commercial ports in Western Australia. The number of tanker vessel tracks close to the coastline is low, predominantly representing transits to and from the Port of Broome. There are reasonably high levels of passing traffic in the north west of the Kimberley region from vessels transiting to and from Port Hedland (in the Pilbara region).

Offshore there are exploration permits in the Browse Basin and Bonaparte Basin.

Figure 3.1 Overview of WA trade volumes 2015– 2016 (Department of Transport 2016)

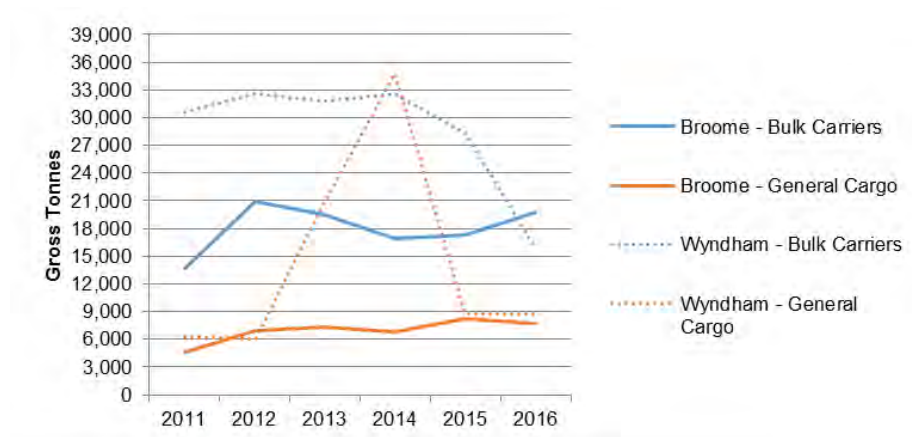


3.2. Vessel Trends

Vessel Size

There is a general trend in shipping towards larger vessels as operators strive to realise gains from economies-of-scale. This is less evident in vessel traffic statistics for the Kimberley zone. Figure 3.2 shows the change in the average size of bulk carriers and general cargo vessels visiting the Port of Broome and Port of Wyndham as trending slightly upwards. At the Port of Wyndham, average vessel size was greatest in 2014.

Figure 3.2 Average Vessel Size, 2010 – 2017

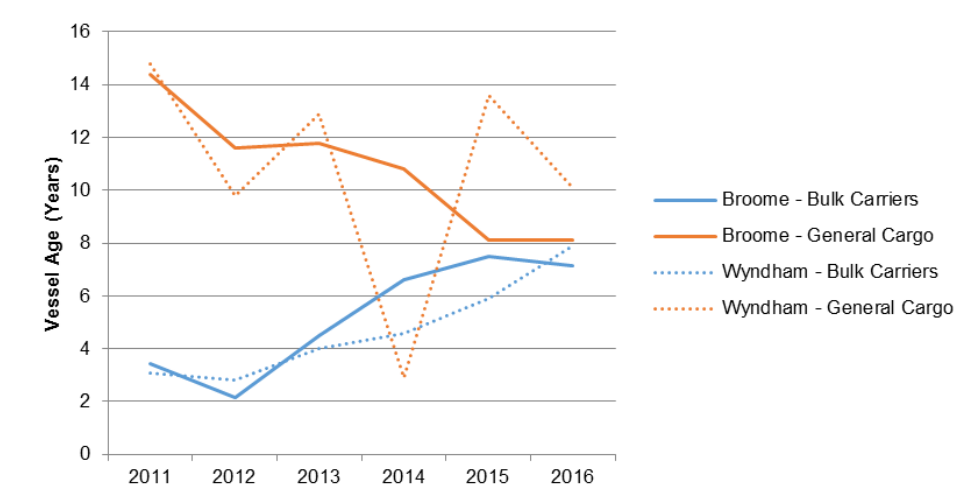


Data source: AMSA

Vessel Age

Vessel age is another factor to consider and has been identified by the Australian Maritime Safety Authority (AMSA) as one of the key predictive factors in overall vessel safety. Figure 3.3 shows the average vessel age for bulk carrier and general cargo vessels visiting the Port of Broome and Port of Wyndham. The age of general cargo vessels has almost halved over the period whereas, bulk carrier vessel age has trended up. The latter observation may reflect lower investment in new bulk carriers due to lower commodity prices.

Figure 3.3 Average Vessel Age, All Vessels, 2010 - 2017 (AMSA)

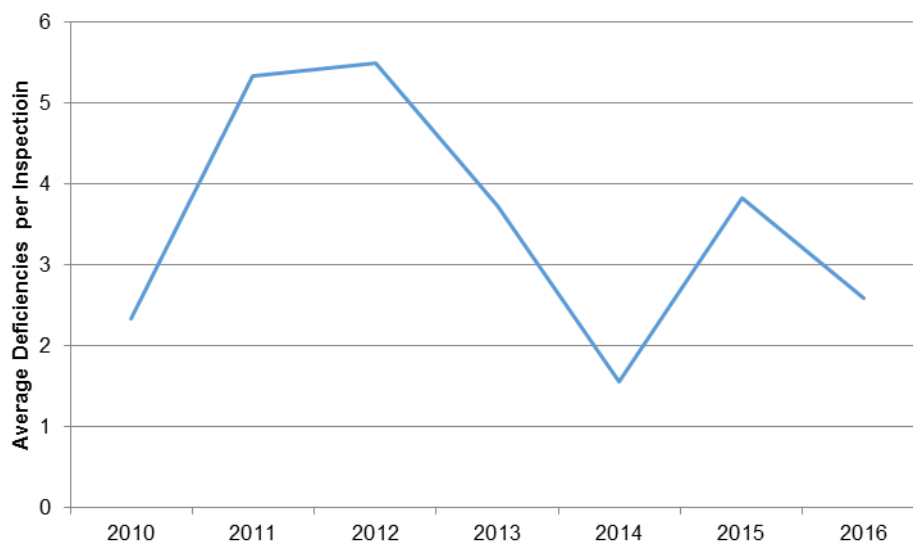


Data source: AMSA

Vessel Deficiencies

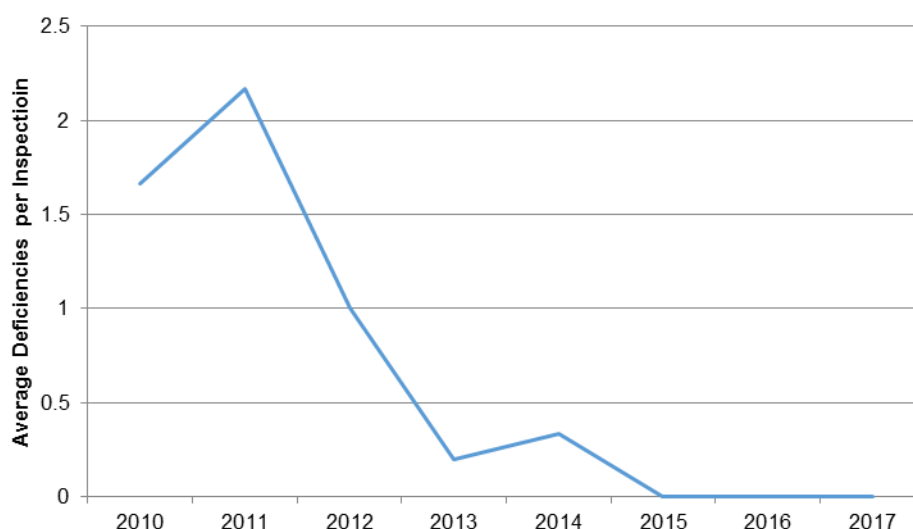
AMSA collects data on the numbers of vessel deficiencies found by the Port State Controls and Flag State Control inspections. Figure 3.4 shows the average number of deficiencies found per inspection at the Port of Broome. There was an average of 7 – 8 inspections per year, ranging from 2 (in 2012) to 15 (in 2013). Data showed only one inspection occurring in Port of Wyndham, which was in 2014 (with no deficiencies found). In 2011 to 2012 the average number of deficiencies was around five per inspection. The overall trend is improving, reducing to less than four per inspection since 2012.

Figure 3.4 Average Deficiencies per Inspection at Port of Broome



There are around 30 major deficiency categories in the AMSA data. These categories cover a wide range of administrative, procedural, structural and operational factors. Figure 3.5 shows the average number of deficiencies per inspection categorised as 'Safety of Navigation' at Port of Broome. This has trended down since 2011, with no such deficiencies recorded over the three years of record.

Figure 3.5 Average 'Safety of Navigation' Deficiencies per Inspection at Port of Broome



3.3. Vessel Routes

Figure 3.6 and Figure 3.7 show vessel tracks for medium and large tankers off the Western Australia coast near the Kimberley zone (calendar years 2013-2015 inclusive). A proportion of the medium tankers visit the Port of Broome and fewer visit the Port of Wyndham. No large tankers visited either port.

Figure 3.6 Medium Tanker vessel tracks (2013-2015 AIS data)

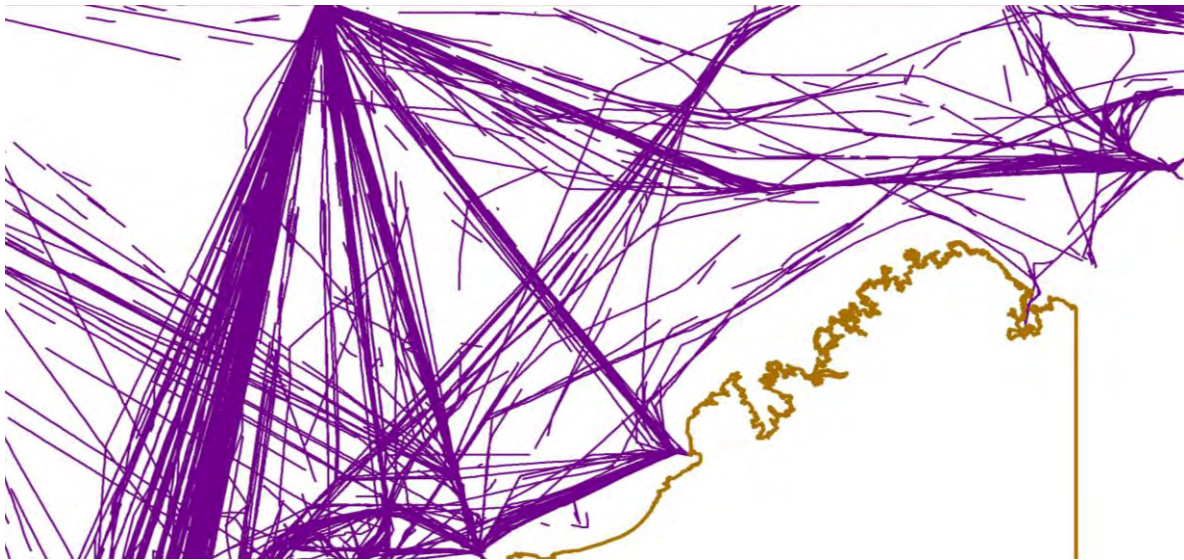


Figure 3.7 Large Tanker vessel tracks (2013-2015 AIS data)

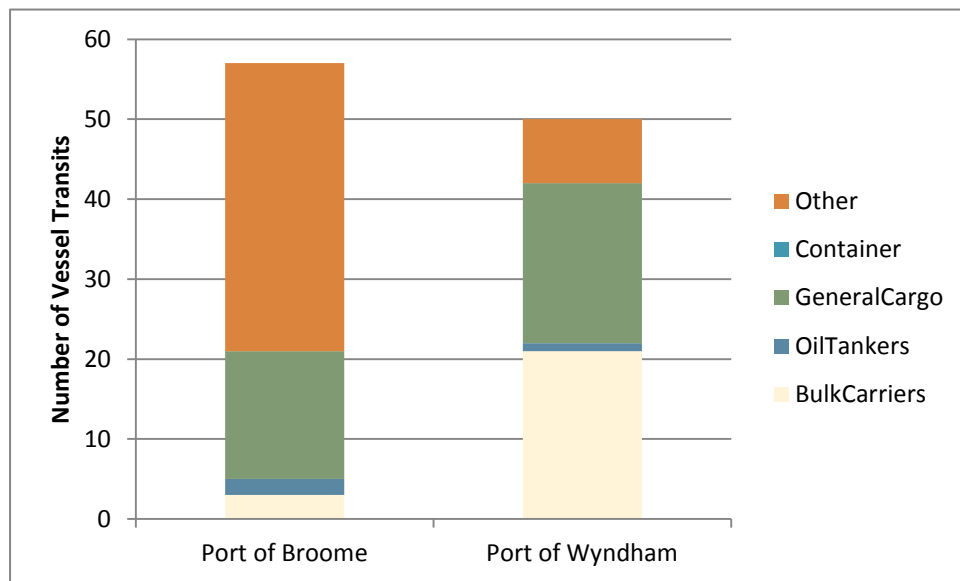


Other trends such as changes from heavy bunker fuels to distillate fuels in response to IMO regulations are discussed in the state-wide report. It is not expected these will have an immediate effect on the risk profile for the Kimberley zone.

3.4. Major Ports

The three largest ports in the Kimberley zone are Broome, Wyndham, and Derby. Figure 3.8 shows vessel transits at these ports. Broome and Wyndham have similar levels of traffic. Derby does not show vessel transits in the data. The AIS data used in the analysis shows vessels over 500 gross tonnes (GT) and a significant proportion of vessels in the 100-500GT range. Smaller vessels and those not fitted with AIS transmitters are not included in this analysis.

Figure 3.8 Annual Vessel Transits¹

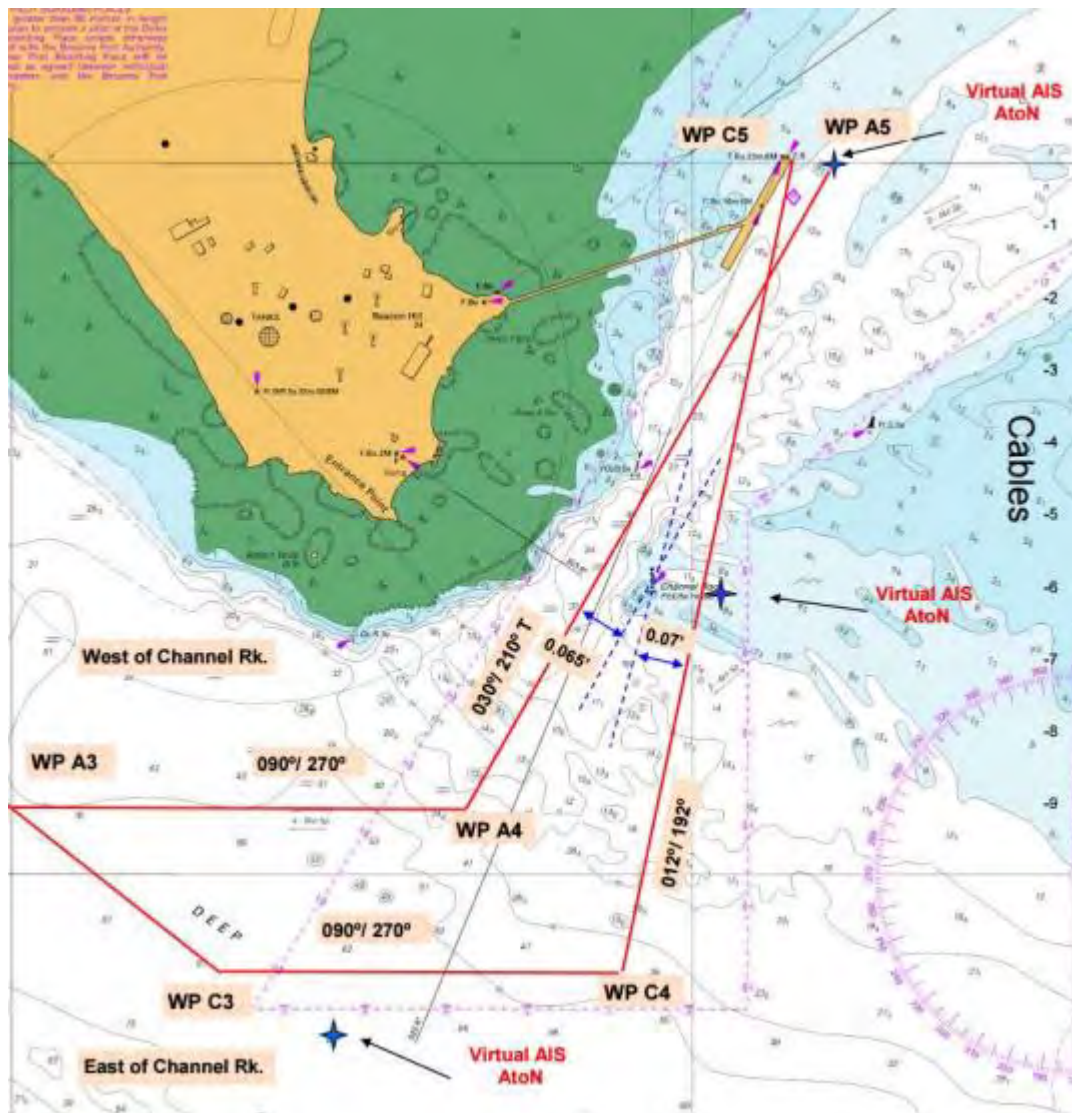


¹ Source: AMSA. Data is averaged for years 2013-2015. Vessels classed as "commercial" are not shown.

3.4.1. Port of Broome

The largest port in the Kimberley zone is the Port of Broome.

Figure 3.9 Port of Broome passage plan (reference only)



As an indication of activity levels at the port, Figure 3.8 shows the numbers of transits² by different vessel types. At the Port of Broome most vessels fall into the 'other' category³, with general cargo vessels making up most of the remainder.

The Port of Broome is the only deepwater port in West Kimberley. It has a large tidal range, large areas of shallow water, and as a result, strong currents (Fremantle Sailing Club 2014).

Imports and exports through the Port of Broome are fairly balanced (Figure 3.11 and Figure 3.12). Imports are dominated by fuel and oils, as well as drilling equipment and bulk product. Exports are comprised mainly of drilling equipment and bulk product, fresh water, and fuel

² A transit is defined as a single movement. A ship visiting a port will usually comprise two transits.

³ Chemical tankers, passenger vessels, MODUs/FPSOs transit, gas carriers.

bunkers. While these exports were decreased in 2017 – 2018, exports of livestock (cattle, sheep and goats) have remained fairly consistent over the data period.

There is an increasing number of visits by cruise ships to this port - 16 cruise vessels arrived at Port of Broome in 2017/2018 and there are 31 booked for the 2019 year (Kimberley Ports Authority 2019). The number of cruise vessel visits is expected to continue to increase. Freight traffic through the port is dominated by exports.

Figure 3.10 Exports and imports through the Port of Broome⁴

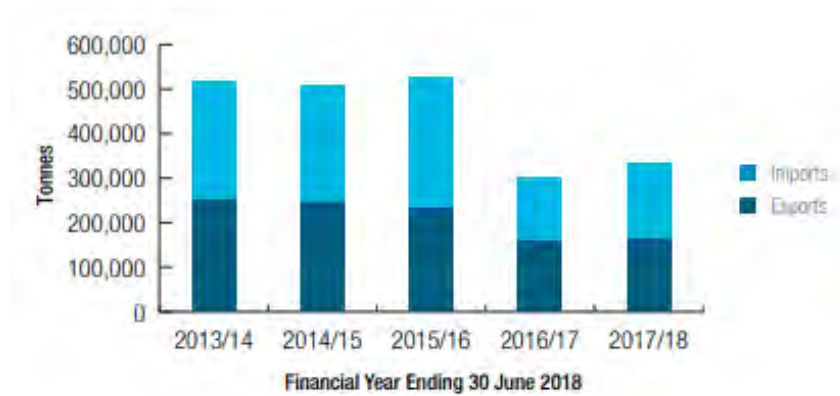


Figure 3.11 Annual imports to the Port of Broome⁵

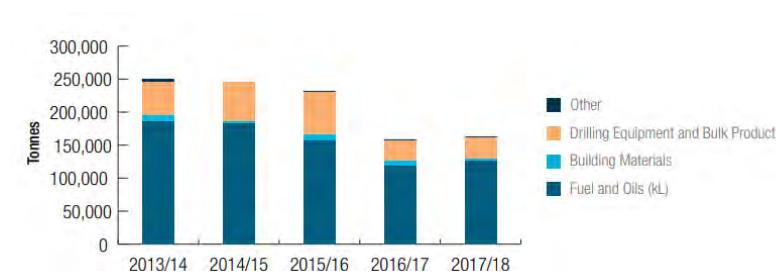
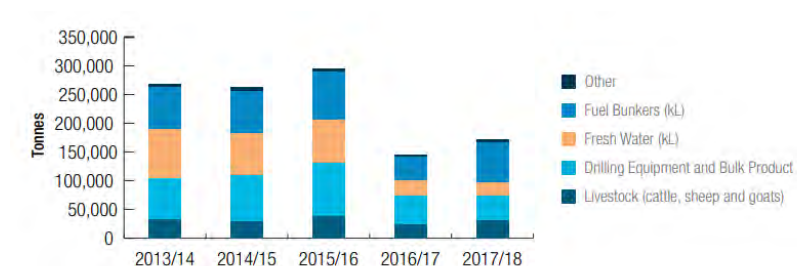


Figure 3.12 Annual exports from the Port of Broome⁶



The Port of Broome is situated in Roebuck Bay, is approached through Roebuck Deep and entered between Channel Rock and the reef extending south-east of Entrance Point. There are depths of less than 10m lying close north and south of the approach.

⁴ Figure from Annual Report 2018 (Kimberley Ports Authority 2018)

⁵ Figure from Annual Report 2018 (Kimberley Ports Authority 2018)

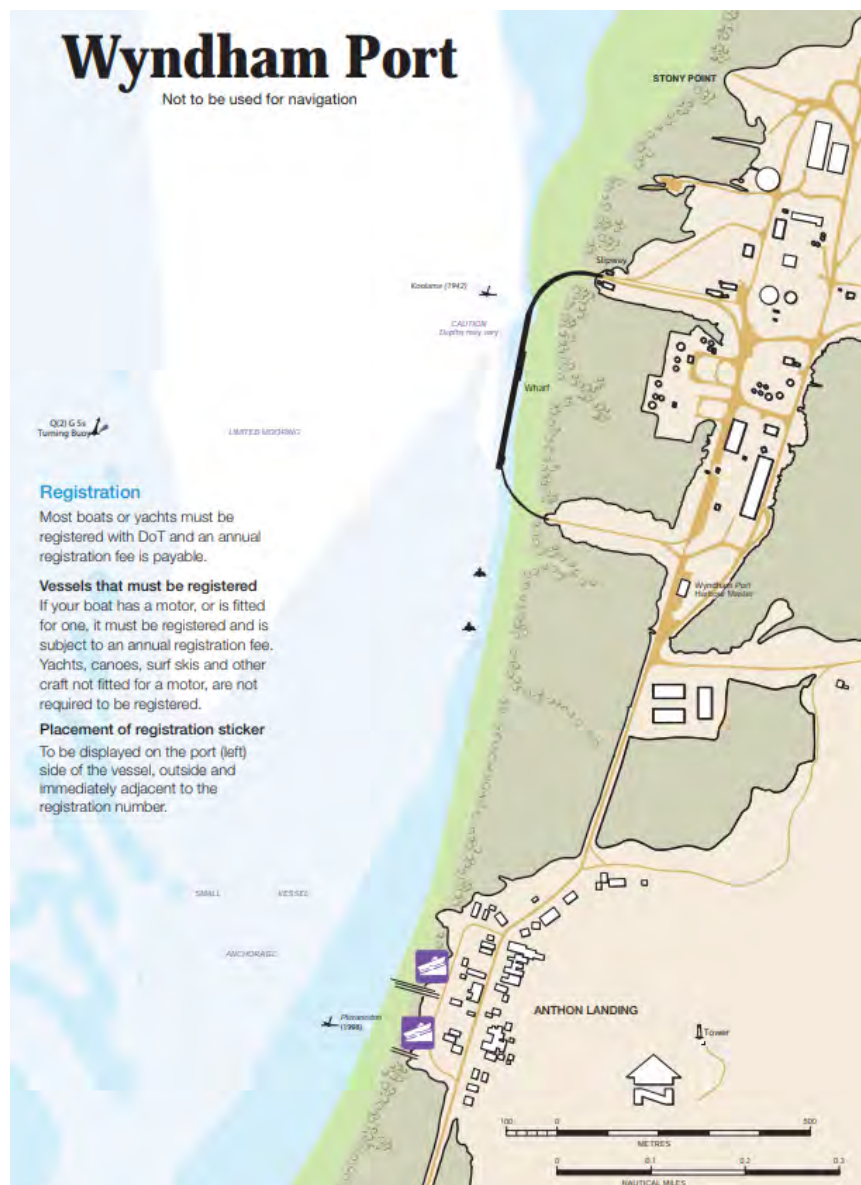
⁶ Figure from Annual Report 2018 (Kimberley Ports Authority 2018)

Tidal currents make the passage through the channel challenging and groundings have occurred. Pilotage is compulsory for all commercial vessels over 150 gross tonnage (GT) not under the command of an exempt master.

3.4.2. Port of Wyndham

The Port of Wyndham consists of one wharf. The port is currently managed privately on behalf of the Department of Transport. The approach to Wyndham is greatly affected by tidal range and flow. Strong winds, including strong katabatic winds blowing off Bastion Range can be experienced. Pilotage is compulsory for vessels over 500 GT.

Figure 3.13 Wyndham port (Department of Transport 2017b)



The Port of Wyndham is mostly visited by general cargo and bulk carrier vessels, and AIS data shows a similar number of vessel transits as at Broome. Current freight volumes are low. The level of activity has changed greatly in the past and could again in the future. Cruise vessels occasionally visit.

Figure 3.14 and Figure 3.15 show the approach to Wyndham and the port itself.

Figure 3.14 View of Gulf of Cambridge (G. Bermingham, Navigatus, 2018)



Figure 3.15 View of Port of Wyndham (left) and public wharf (right) (G. Bermingham, Navigatus, 2018)



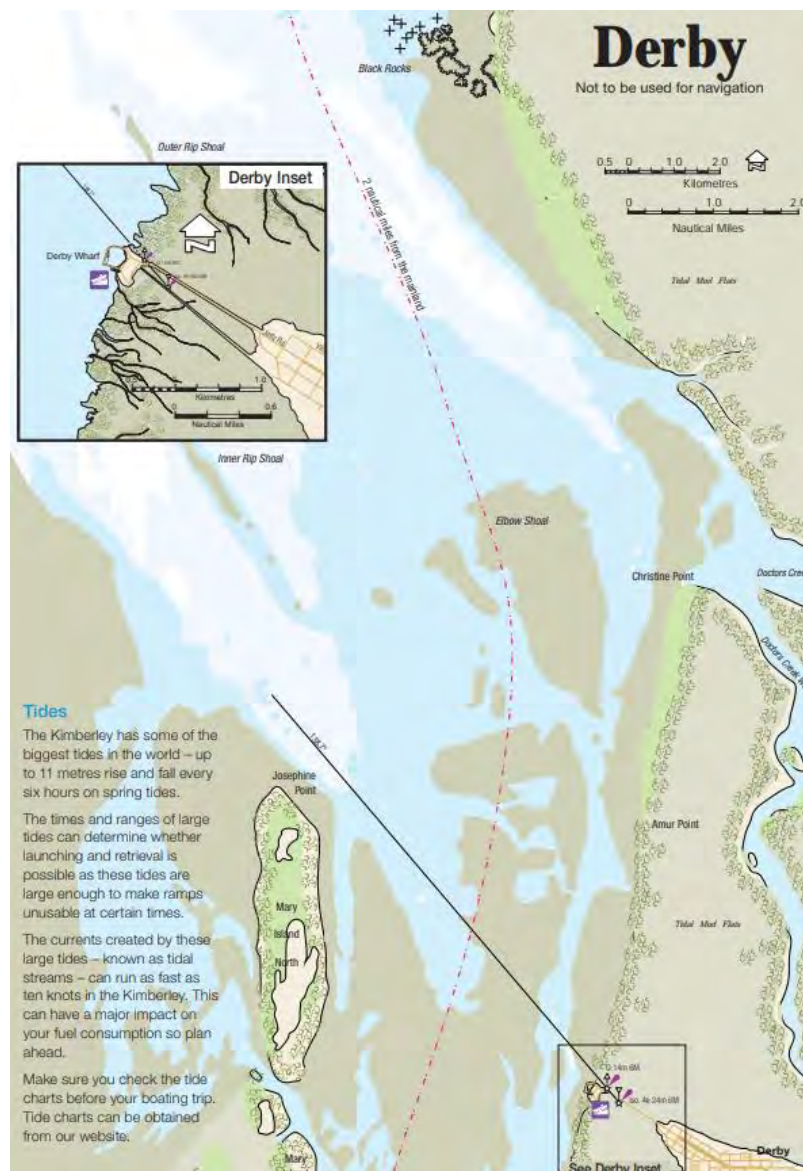
3.4.3. Port of Derby

The Port of Derby, like Wyndham, is managed on behalf of the Department of Transport under a port operation agreement (by the Shire of Derby).

There is a proposal to establish an oil and gas supply base at Koolan Island – if this goes ahead then the Port of Derby may be improved and updated as part of the logistics chain. This would result in an increase in vessel transits and changes in the types of vessels visiting the port.

The port area dries and so most operations involve barges.

Figure 3.16 Port of Derby (Department of Transport 2017a)



3.5. Petroleum Industry

Western Australian petroleum producers were contacted with a request to provide data for the WAMOPRA in 2015. Operators were asked to complete a questionnaire designed to gather information on offshore petroleum assets and activities. The primary focus was to capture the location, status and product type of offshore assets that each organisation operates.

Operators were also asked to provide contextual comments relating activity levels at wells and the number of exploration and development wells drilled per year.

As mentioned above, the Stage Two assessment involved moving from public data sources of petroleum activities from prior years to acquisition of information directly from operators about current and future operations. Key differences from the data used in Stage One are:

- ▶ Product types are lighter than those originally input into the model. There is a greater proportion of facilities producing gas and condensate (Group I), as well as Group II oils. These oils are defined as dissolving and do not travel as far as Group III and Group IV oils. The change in oil types from the data used in the state-wide assessment may be due to the natural progression of fields over time as product is extracted. The Wheatstone LNG project also means there are more gas facilities coming on board. These have been included in the current analysis.
- ▶ Some producing facilities have been decommissioned or suspended. This is due to a combination of lower oil prices and facilities being towards the end of their producing lifespan.
- ▶ There was a notable reduction in exploration activity compared to the public data sets used in Stage One which were based on earlier years. This is a result of lower oil prices. Exploration activity tends to rebound around 18 months after oil prices recover.

Data was obtained from operators on the basis that individual operators would not be identified in the outputs of this study due to commercial sensitivities.

4. Data Sources

4.1. Overview

The analysis used a range of data inputs, including:

- ▶ Vessel activity:
 - Vessel types, routes and number of transits.
 - Vessel cargo types and volumes.
- ▶ Ports and marine terminals:
 - Port locations, bunkering and transfers.
- ▶ Petroleum industry activity - locations, purpose, phase, oil types and related activity for; wells, platforms, pipelines, FPSOs.
- ▶ Spill events:
 - Event occurrence frequencies for vessels and offshore infrastructure.
 - Resulting spill size probability density functions.
- ▶ Environmental conditions - wind and current data.
- ▶ Oil classifications.

These data sources are discussed in the preliminary state-wide report and a brief outline of vessel activity, petroleum industry data and navigational hazard data is provided below as these data sources have seen updates since the state-wide report.

4.2. Vessel Activity

Vessel activity inputs in the model are primarily based on Automatic Identification System (AIS) data which is collected and held by AMSA. Navigatus commissioned AMSA to interrogate the AIS information system and provide three years of processed data in a suitable format for further pre-processing and incorporation into the model. The steps taken by AMSA were:

- ▶ Filter data set for relevant geographic scope and three-year time period from 2013 to 2015.
- ▶ Use ship inspections ('ShipSys') database to populate vessel type and size information missing from AIS data.
- ▶ Use GIS tool to convert individual AIS 'point' reports to 'line' voyages based on report time.

The resulting data was then provided to Navigatus and a density analysis was undertaken on the vessel tracks. This determined the number of vessel transits per year through each 10km hexagon sea cell for each vessel type/size category. The process included grouping vessels into the following categories for the WAMOPRA outputs:

- ▶ Bulk Carriers
- ▶ Chemical Tankers
- ▶ General Cargo
- ▶ Container
- ▶ Gas Carrier

- ▶ MODUs and FPSOs⁷ (in transit)
- ▶ Commercial
- ▶ Oil Tankers
- ▶ Passenger

The use of AIS data to populate vessel activity information is described in the state-wide report (Navigatus 2016). The model simulates the potential for vessels to be off track as well as coastal operations of smaller vessels whose behaviour is less predictable.

Vessels smaller than 100GT are not considered in the analysis for the following reasons:

- ▶ Smaller vessel activity is typically more erratic and unpredictable.
- ▶ Below this size vessels tend to store fuel in separate tanks rather than against the hull so are less likely to spill in the event of a collision.
- ▶ To reduce the 'noise' from small vessels which do not have the potential to add significantly to the risk profile (although spill responders will typically respond to spills from smaller vessels with greater frequency than larger vessels).

4.3. Navigational Hazard

The analysis incorporated a navigational hazard factor, determined from the following inputs:

- ▶ Examination of navigation charts and the Australian Pilot (*Admiralty Sailing Directions Australian Pilot Volume 1*).
- ▶ A site visit to Kimberley, including visiting the major ports from landside, meeting with operators and harbourmasters, studying navigational charts and surveying a significant length of the coastline by charter flight.

The development of the navigational hazard ratings and incorporation into the model are outlined in the Methodology section.

4.4. Petroleum Industry

There are offshore exploration permits in the Browse Basin and Bonaparte Basin.

⁷ MODUs – mobile offshore drilling units, FPSOs – floating production integrity services.

5. Methodology

5.1. Overview

The following sections outline key elements of the WAMOPRA methodology, or elements that have been introduced or modified in Stage Two. These include:

- ▶ Spatial Framework – the spatial basis for the WAMOPRA modelling and outputs.
- ▶ Navigational Hazard
- ▶ Exposure and Risk – an explanation of two key output measures, how they are defined and displayed.
- ▶ Limitations – a brief note on the limitations of the WAMOPRA given its primary use as a strategic-level tool.

While the broad model approach and outputs are similar, the methodology used in this report is not identical in all respects to that used in the reports previously prepared for the Pilbara, Swan and Midwest Zones. This is due to ongoing developments in the model methodology, as described in Section 5.3 below, and due to context changes since issue of the previous regional reports. The rationale includes;

- ▶ accounting for a reduction in oil exploration activity as a result of the lower oil price, which has fallen significantly over the duration of this project,
- ▶ introducing improvements to the modelling engine as a result of ongoing research and development.

While the refinements in the method have changed some of the individual cell ratings, the overall patterns of risk and areas of focus remain the same.

5.2. Spatial Framework

The model is based on two layers of cells; shoreline cells and sea cells.

Shoreline cells are used for visualising shoreline risk and exposure. The shoreline cell layer consists of cells which are 20km long (along the coast) by 10km wide (seaward extent) and which are compliant with shoreline features and shape.

The shoreline cells display exposure, protection priorities and risk for shoreline areas that could credibly be affected by contact with, or proximity to, either floating or dissolving oil. Therefore, the 10km width is a nominal distance, rather than representing the true seaward extent of oil impact, and primarily set for visualisation purposes.

There are 116 shoreline cells in the Kimberley region. For the purposes of this report, shoreline cells are also grouped into two 'sub-zones'.

The two sub-zones are: WA12 and WA13. The shoreline cells and sub-zones within the Kimberley zone are shown in Figure 5.1.

Sea cells are arranged on a 10km hexagonal grid which covers all marine areas. The grid extends approximately 200-300km seaward off all shorelines, excluding Christmas Island. The grid enables modelling of potential oil release, oil dispersion and the likelihood of reaching shore.

The grid is used for managing vessel activity information, positions of offshore elements and environmental factors of the modelling. This system includes flags for cells representing

ports and harbours to account for vessel related activity, oil-handling-processes and constrained waterways. The hexagonal grid is also the basis of Navigatus modelling of oil dispersion, with the geometry enabling the computational efficiency needed for such a large geographic area.

The state-wide report contains additional information on the shoreline and hexagon cells.

Figure 5.1 Kimberley Shoreline Cells and Sub-Zones

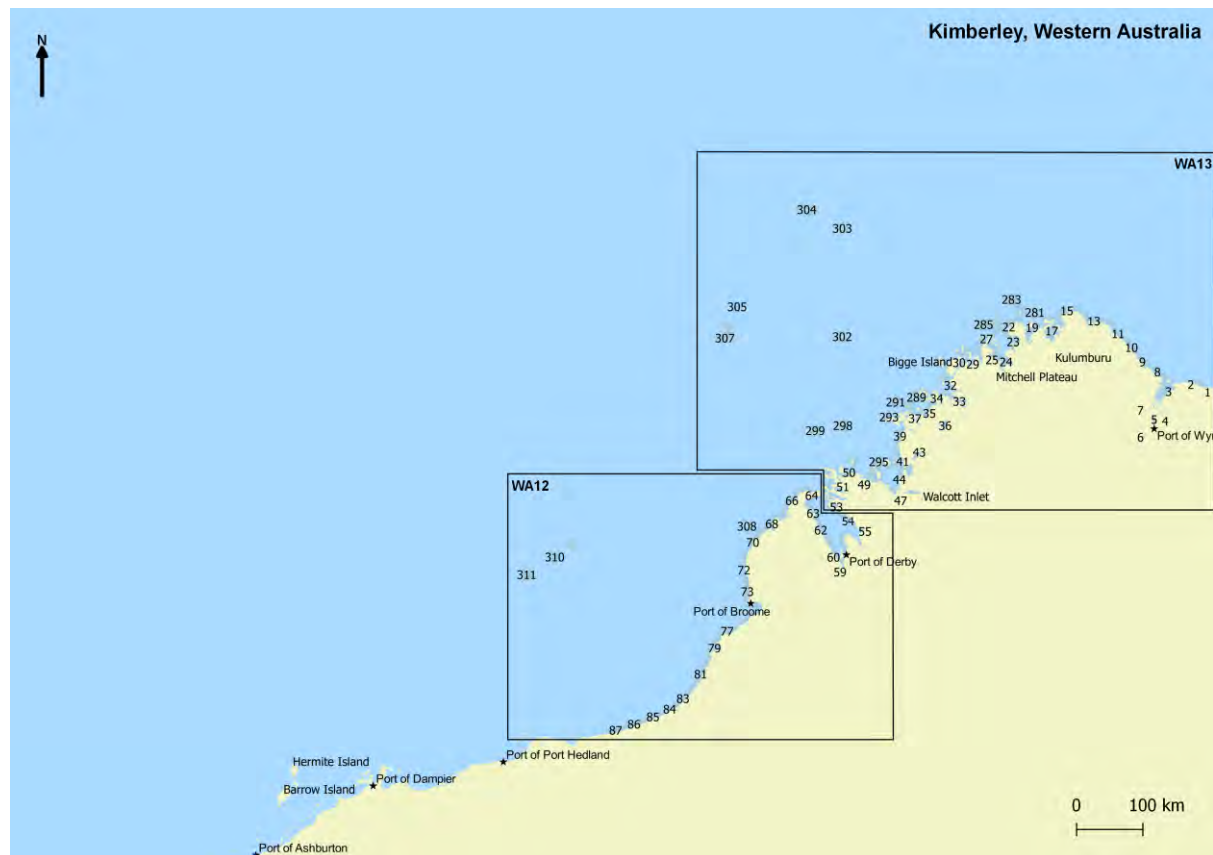


Table 5.1 Cell identity numbers to names listing: WA12 Subzone

Cell ID	Cell Name	Cell ID			
54	Meda River mouth spit SW - Helpman Island (A)	71	Coulomb Point - Red Bluff (B)	308	Red Bluff - Chimney Rocks (B)
55	Meda River mouth spit SW - Helpman Island (B)	72	Cape Boileau - Coulomb Point (A)	309	Mermaid Reef
56	Point Torment - Meda River mouth spit SW (A)	73	Cape Boileau - Coulomb Point (B)	310	Clerke Reef
57	Point Torment - Meda River mouth spit SW (B)	74	Entrance Point - Cape Boileau	311	Imperieuse Reef
58	Jangerie - Point Torment (A)	75	Cape Gourdon - Cape Villaret (A)		
59	Jangerie - Point Torment (B)	76	Cape Gourdon - Cape Villaret (B)		
60	Malaburra Spring - Jangerie (A)	77	Saddle Hill - Cape Gourdon (A)		
61	Malaburra Spring - Jangerie (B)	78	Saddle Hill - Cape Gourdon (B)		
62	Malaburra Spring - Jangerie (C)	79	Tryon Point - False Cape Bossut (A)		
63	Swan Island - Cornambie Point	80	Tryon Point - False Cape Bossut (B)		
64	Packer Island - Swan Island (A)	81	Cape Jaubert - Tryon Point		
65	Packer Island - Swan Island (B)	82	Samphire bore coast - Cape Jaubert (A)		
66	Packer Island - Swan Island (C)	83	Samphire bore coast - Cape Jaubert (B)		
67	Packer Island - Swan Island (D)	84	Samphire bore coast - Cape Jaubert (C)		
68	Chimney Rocks - Packer Island	85	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (A)		
69	Red Bluff - Chimney Rocks (A)	86	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (B)		
70	Coulomb Point - Red Bluff (A)	87	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (C)		

Table 5.2 Cell identity numbers to names listing: WA13 Subzone

Cell ID	Cell Name	Cell ID	Cell Name	Cell ID	Cell Name
1	East Cape Domett - WA-NT Border (A)	28	Swift Bay - Davidsons Point (A)	281	Low Island Point - Anjo (C)
2	East Cape Domett - WA-NT Border (B)	29	Swift Bay - Davidsons Point (B)	282	Davidsons Point - Cape Bougainville (A)
3	East Cape Domett - WA-NT Border (C)	30	Augereau Island - Combe Hill Point (A)	283	Davidsons Point - Cape Bougainville (B)
4	Bare Hill - East Cape Domett (A)	31	Augereau Island - Combe Hill Point (B)	284	Davidsons Point - Cape Bougainville (C)
5	Bare Hill - East Cape Domett (B)	32	Augereau Island - Combe Hill Point (C)	285	Davidsons Point - Cape Bougainville (D)
6	Bare Hill - East Cape Domett (C)	33	Cape Torrens - Anderdon Islands Point	286	Augereau Island - Combe Hill Point (D)
7	Bare Hill - East Cape Domett (D)	34	Cape Wellington - Cape Torrens (A)	287	Augereau Island - Davidsons Point
8	Bare Hill - East Cape Domett (E)	35	Cape Wellington - Cape Torrens (B)	288	Cape Wellington - Cape Torrens (C)
9	Aunty Islet - Thurburn Bluff	36	High Bluff - Cape Wellington (A)	289	Cape Wellington - Cape Torrens (D)
10	Cape Bernier - Elsie Island N	37	High Bluff - Cape Wellington (B)	290	Battery Point - High Bluff (B)
11	Cape Rulhieres - Cape Bernier	38	Battery Point - High Bluff (A)	291	Battery Point - Cape Wellington
12	Un-named Head - Cape Rulhieres (A)	39	Un-named Promontory - Battery Point	292	Battery Point - High Bluff (C)
13	Un-named Head - Cape Rulhieres (B)	40	Raft Point - Un-named Promontory (A)	293	Marnebulorgne Community N Point - Battery Point (A)
14	Un-named Head - Cape Rulhieres (C)	41	Raft Point - Un-named Promontory (B)	294	Raft Point - Un-named Promontory (E)
15	Cape Talbot - Cape Londonderry (A)	42	Raft Point - Un-named Promontory (C)	295	Raft Point - Un-named Promontory (F)
16	Cape Talbot - Cape Londonderry (B)	43	Raft Point - Un-named Promontory (D)	296	Raft Point - Un-named Promontory (G)
17	Low Island Point - Anjo (A)	44	Marnebulorgne Community N point - Shale Island (A)	297	Marnebulorgne Community N Point - Battery Point (B)
18	Low Island Point - Anjo (B)	45	Shale Island - Raft Point	298	Marnebulorgne Community N Point - Augereau Island (A)
19	Cape Bougainville - Low Island Point (A)	46	Marnebulorgne Community N point - Shale Island (B)	299	Point Osborne - Marnebulorgne Community N Point
20	Cape Bougainville - Low Island Point (B)	47	Marnebulorgne Community N point - Shale Island (C)	300	Point Osborne - Nares Point (A)
21	Cape Bougainville - Low Island Point (C)	48	Marnebulorgne Community N point - Shale Island (D)	301	Point Osborne - Nares Point (B)
22	Cape Bougainville - Low Island Point (D)	49	Nares Point - Un-named Peninsular (A)	302	Marnebulorgne Community N Point - Augereau Island (B)
23	Crystal Head - Cape Bougainville	50	Nares Point - Un-named Peninsular (B)	303	Augereau Island - Cape Londonderry
24	Davidsons Point - Crystal Head (A)	51	Point Osborne - Sir Richard Island (A)	304	Marnebulorgne Community N Point - Augereau Island (B)
25	Davidsons Point - Crystal Head (B)	52	Point Osborne - Sir Richard Island (B)	305	Augereau Island - Cape Londonderry
26	Davidsons Point - Crystal Head (C)	53	Point Osborne - Sir Richard Island (C)	306	Ashmore Reef
27	Davidsons Point - Crystal Head (D)			307	Seringapatam Reef

5.3. Navigational Hazard

Overview

The overall navigational hazard factor is comprised of the following factors:

- ▶ **Physical Features** – in particular submerged and non-drying features. Considerations include likelihood of groundings, collisions, and ease of navigation using radar.
- ▶ **Complexity** – reflects multifaceted operations / mix of vessel types and activities as well as environmental conditions such as wind, currents, swell and lee shore.
- ▶ **Activity Density** – this includes number of vessel movements and other marine activities.

These factors are combined into an overall navigational hazard rating.

The overall navigational hazard for each cell around the Western Australia coastline was rated as minor, moderate, significant, major or critical for each of the above factors according to the scoring system in Table 5.3.

Table 5.3 Rating System and Values

Issue Rating	Description	Value Assigned
Critical	Expected to lead to a future incident.	25
Major	Expected to be a key factor in contributing to an incident.	16
Significant	Individually controllable, but in combination with other factors could contribute to an incident.	9
Moderate	A factor that can be managed in normal operations.	4
Minor	Well within normal operation to manage or respond to (minor matter).	1

The following describes how each of the factors was determined:

Physical: Physical hazards were identified in workshops with expert mariners. All non-surface physical features have the potential to be hazardous should a vessel be in the close vicinity. To account for this all shoreline areas received a higher default rating than open sea areas (Low instead of Very Low) and subsequent efforts were focussed around areas with higher traffic density, such as ports.

Complexity: Complexity ratings were identified in workshops with expert mariners. The complexity rating includes the complexity of approach operations as well as environmental conditions wind, currents, swell and lee shore.

Activity Density: The model uses annual vessel transits through a cell as a key input for calculating exposure and risk. This is an arithmetic calculation and increases with the number of transits.

However, as shipping density increases other factors come into play such as the interaction between ships. These interactions can mean higher risk of collision, lower margins of error and the potential need for evasive manoeuvring. Overall, this results in a further increase in risk. This additional risk is captured in the model through the activity density rating.

Strictly the number of vessel transits is incorporated only once in the model, however, the activity density measure represents the risk through the interaction between ships. Activity density was determined based on vessel tracks generated from AIS data.

Synthesis of Hazard Factors

The three separate factors are combined to form an overall Navigational Hazard Rating. This is determined by summing the individual rating values as shown in Table 5.3.

Table 5.3 Overall Navigational Hazard Ratings

Sum of Individual Factors	Overall Rating	Overall Value	Display Colour
>30	Very High	25	
21-30	High	16	
11-20	Moderate	9	
6-10	Low	4	
<=5	Very Low	1	

Vessel Incident Probabilities

For consistency with the analysis undertaken at the national level, the vessel accident probabilities and estimates of likely spill amounts were adopted from Appendix IV and Appendix V of a study undertaken by DNV for AMSA in 2011. The probabilities are developed for a number of different incident categories (e.g. collision, grounding, etc) and for a range of different vessel types.

These probabilities were then converted to a per cell basis. For example, in the open sea, incident probabilities are presented on a per vessel operating hour basis. On average it is expected to take approximately 30mins for a vessel to traverse a cell, so the hourly probability was divided by two.

As incidents are more likely to occur in some areas than others, the base incident probability is modified according to the relative degree of navigational hazard in the area. A modifier is used at a sea-cell level to redistribute the probabilities to areas with higher navigational hazard ratings (ie higher risk). The value of the modifier is set to ensure that the total probability for each combination of incident type and vessel type across Western Australia sums to the same overall probability as the raw probabilities (before distribution). The objective and effect of the modifier is to distribute the global probabilities of incidents to those locations where the contextual information indicates that those types of incidents are more likely.

To develop the modifier, each sea cell was classified as either Port, Restricted Water, or Open Sea, being the three location types presented in the AMSA study. In each sea cell, the number of vessels (e.g. oil tankers) is multiplied by the probability of an incident (e.g.

collision) for that cell location type (e.g. restricted water). When summed across all cells for all of Western Australia, this represents the WA incident probability for that type of vessel and incident. The expected amount of oil spilt in the event of an incident for vessels is estimated using the cumulative probability relationships presented in the above AMSA report.

Care is taken to ensure that the distribution of risks is internally consistent. For instance groundings are only assigned to shore cells even though the base probability is derived from DNV estimates of the global average of groundings per hour steamed. The model allocates the grounding probabilities so that groundings are more likely in areas where higher numbers of vessels travel closer to shore. Conversely, the assigned probability of grounding when on a course more than 50 km from the shore is nil.

Infrastructure

The infrastructure probabilities were adopted from the International Association of Oil & Gas Production's Risk Assessment Data Directory: Blowout frequencies (OGP 2010a) and Riser and Pipeline release frequencies (OGP 2010b).

The infrastructure cumulative spill probability relationships were developed from several sources, including International Association of Oil & Gas Production, AMSA, and Stantec (Stantec 2014).

5.4. Exposure and Risk

Key output measures are exposure and risk. The first step in calculating risk is determining exposure. Exposure can be considered as the total 'expected' amount of spilled oil that would be spilled in or arrive at a given cell in an 'average' one year period.

Fundamentally exposure is based on:

- ▶ Likelihood of a vessel being present (number of transits per year) OR presence of offshore petroleum infrastructure.
- ▶ Likelihood of a spill event (e.g. grounding, collision, well blowout) conditional on the above.
- ▶ Likelihood of different spill size possibilities (ranging from 1 tonne through to 500,000 tonnes) conditional on the above.
- ▶ Movement of oil (taking into account wind, currents and degradation) conditional on the above.

Exposure is presented according to the continuous scale in Figure 5.2.

Figure 5.2 Exposure Scale



In turn, risk is determined by combining exposure with protection priorities in the following manner:

Figure 5.3 Calculation of Risk



Risk outputs are provided for each shoreline cell on a five step scale ranging from very low to very high. The risk scales are shown in Figure 5.4.

Figure 5.4 Risk Scales



The information presented assesses the risk and exposure for all sources of oil that may end up on the shore in that cell. Some of the oil may originate from spills in other nearby cells, or from more distant seaward sources.

Shoreline risk and exposure outputs are for areas within state waters only.

5.5. Limitations

The WAMOPRA study has the following key limitations:

- ▶ The study was carried out at a level of detail appropriate for a strategic level study. The range of spill sizes considered was 1 tonne up to 500,000 tonnes and the physical discrimination for impacts was based upon a 20km coastline distance and 10km hexagonal open water cells.
- ▶ The calculated risk profile is built upon available local and global information. Analysis cannot predict specific future events, only likely outcomes over time based on the balance of probabilities. This study is based upon the data available – either via public sources, or as supplied by stakeholders - and the quality of the findings is determined in part by the quality of that data.

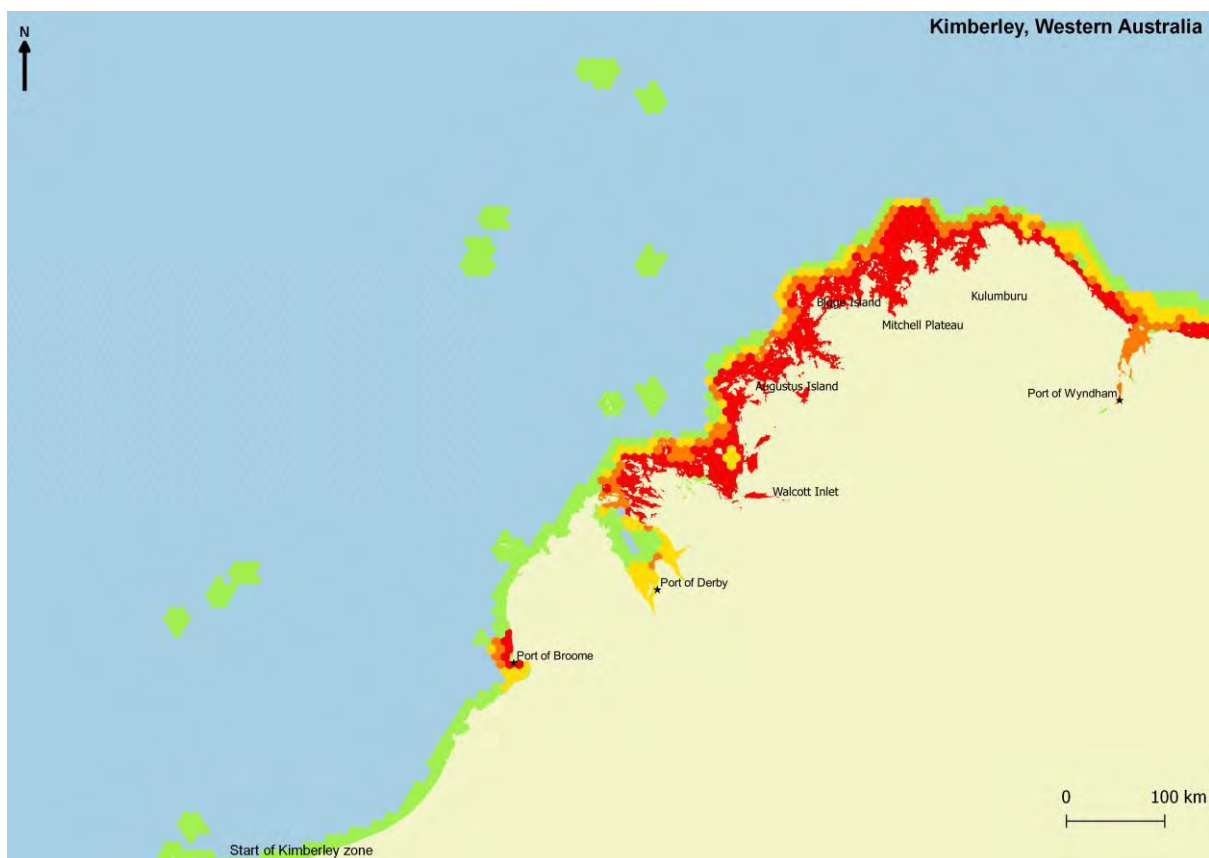
6. Results

6.1. Navigational Hazard Results

Navigational Hazard Factors

The results for the individual physical, complexity and activity density factors are shown respectively in Figure 6.1, Figure 6.4 and Figure 6.5. The overall navigational hazard heat map is shown and discussed in the following section. Note that in each of the heat maps navigational hazard information assigned to each of the risk model's hexagon cells outside of the Kimberley zone is not shown.

Figure 6.1 Physical Hazard Ratings



There are a large proportion of cells with a very high physical hazard rating. The higher rating is due to the coastline, moving sandbanks, and the considerable number of submerged drying and non-drying features.

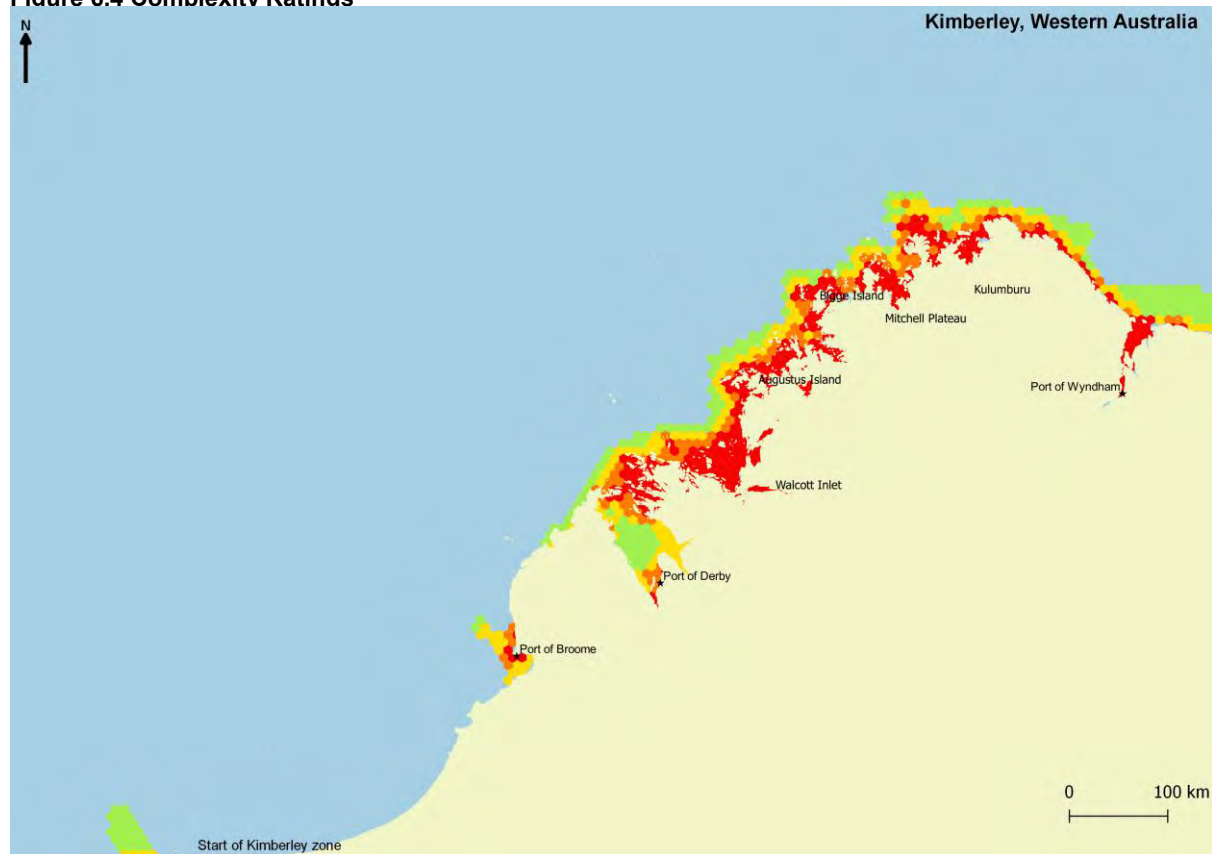
Figure 6.2 and Figure 6.3 are illustrative of some of the physical hazards in the Kimberley region.

Figure 6.2 Holothuria Banks (G. Bermingham, Navigatus, 2018)



Figure 6.3 Kimberley coastline (G. Bermingham, Navigatus, 2018)

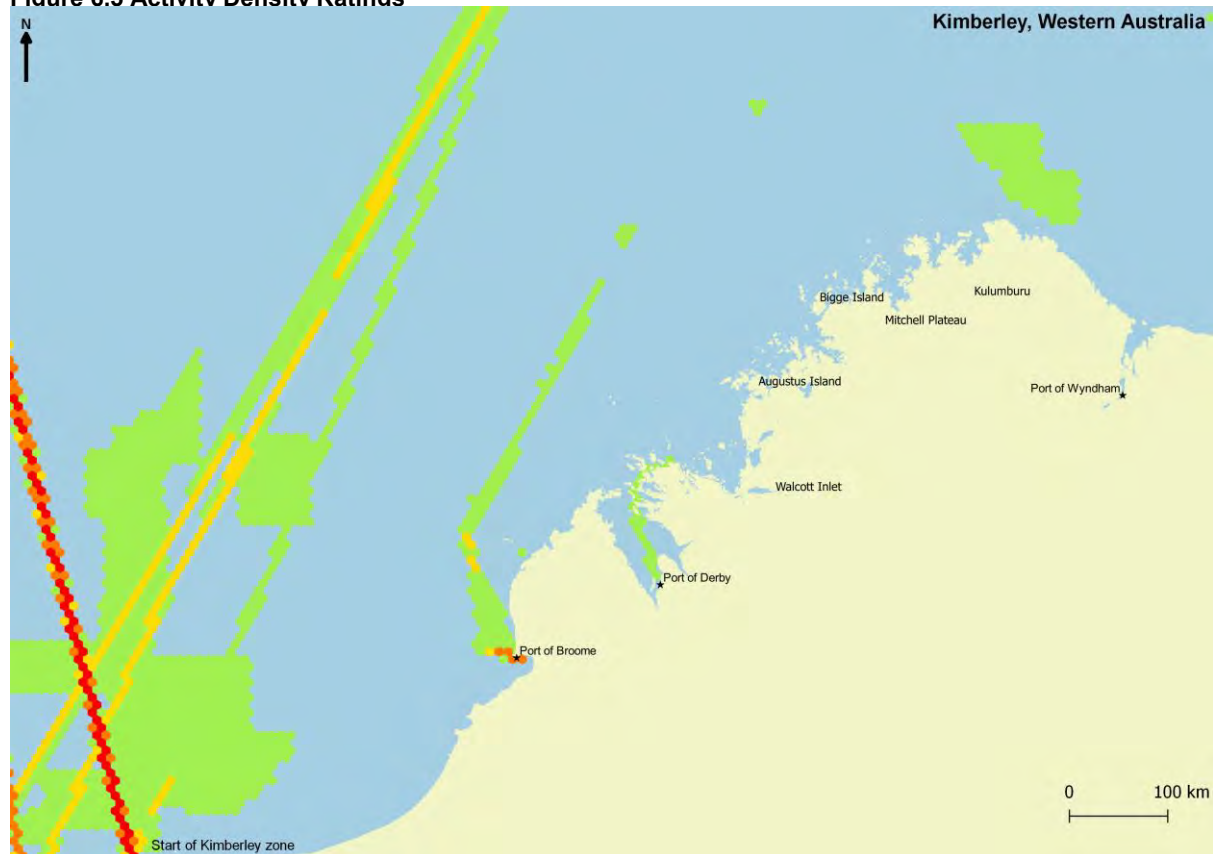


Figure 6.4 Complexitv Ratinas

The coastline between Port of Wyndham and past Walcott Inlet is rated as having high complexity for several reasons. The area is poorly surveyed – some areas haven't been surveyed in over 50 years ago and many parts have not been surveyed at all. The Royal Australian Navy is currently beginning to survey this area. The area is not under pilotage and it is becoming popular with expedition cruise ships, which do approach close to the coast and up through rivers.

Currents are strong and complex in many areas and create significant hazards, this contributes to the high ratings including in the Port of Broome. Vessels entering the Port of Broome crab in due to these currents, despite the seemingly simple approach. Incidents have occurred here, including a large rig tender grounding near to shore.

Figure 6.5 Activity Density Ratios

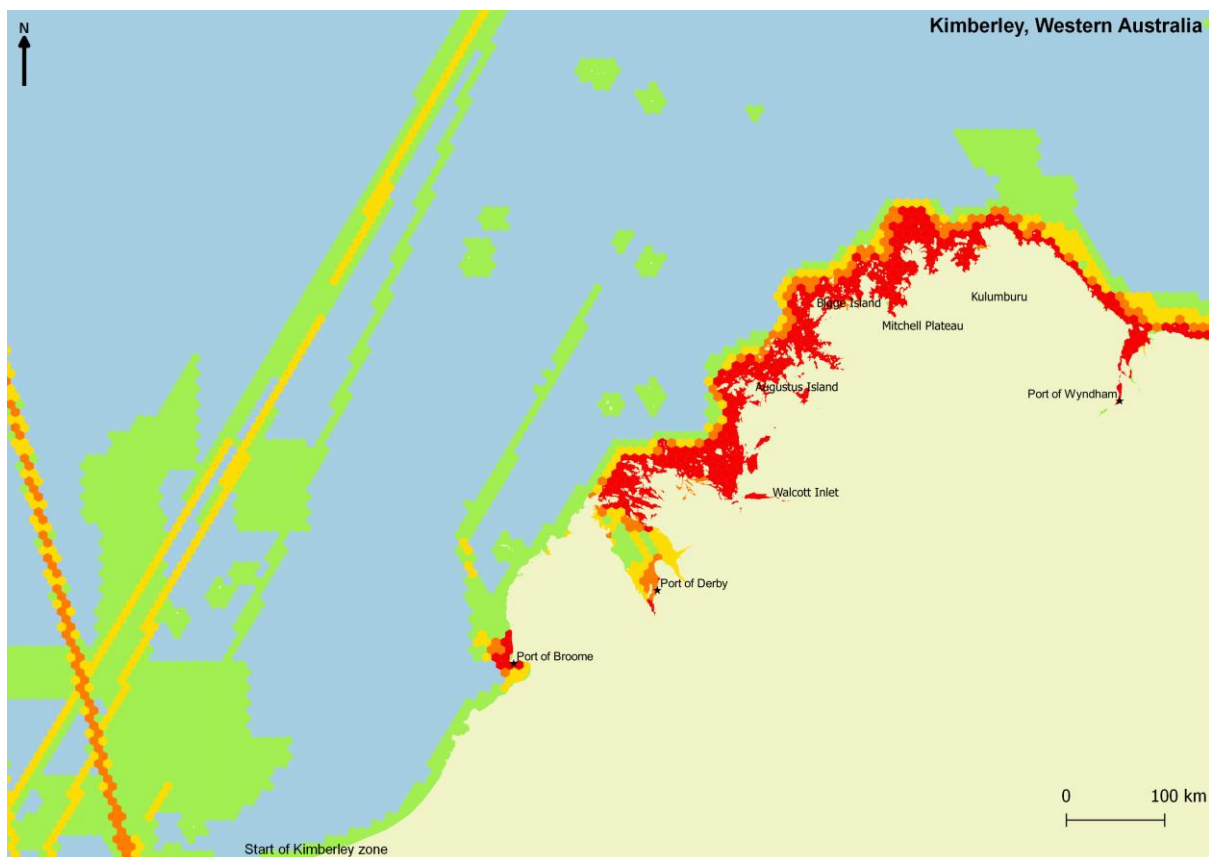


Activity density is highest in the western most part of the Kimberley zone. This is principally due to activity to/from Port Hedland (the port is outside of the Kimberley zone). There is also heightened activity density at the Port of Broome. Oil exploration activity in the Bonaparte Basin shows as slightly increased activity density (to the northwest of Kulumburu).

Overall Navigational Hazard

The combination of the three factors produces an overall rating as described in Section 5.3. This overall navigational hazard rating is shown in Figure 6.6 and a brief description of the driving factors is provided below.

Figure 6.6 Overall Navigational Hazard Ratings



Overall there is a notably higher level of navigational hazard in Kimberley than the other zones. This is driven predominantly by the physical hazard and complexity ratings.

6.2. Oil Exposure

Overview

Exposure represents the likely volume of oil that could arrive at a given area, taking into account both the size of spill and the probability of spill (including the influence of overall hazard rating). While the likelihood of any particular spill is low, exposure allows the contribution of different sources to the risk profile to be compared.

The oil exposure in both the shoreline and hexagon cells is dominated by floating oils, although dissolving oils are likely to increase in the future. Oil exposure can be viewed by floating or dissolving oils at the webmap application:

<http://wamopra.navigatusconsulting.com>

In this section results are presented for exposure to both shoreline cells and hexagon cells.

Shoreline Exposure

Figure 6.7 shows the shoreline exposure profile for the Kimberley zone. In general the exposure is very low.

Figure 6.7 Shoreline Exposure

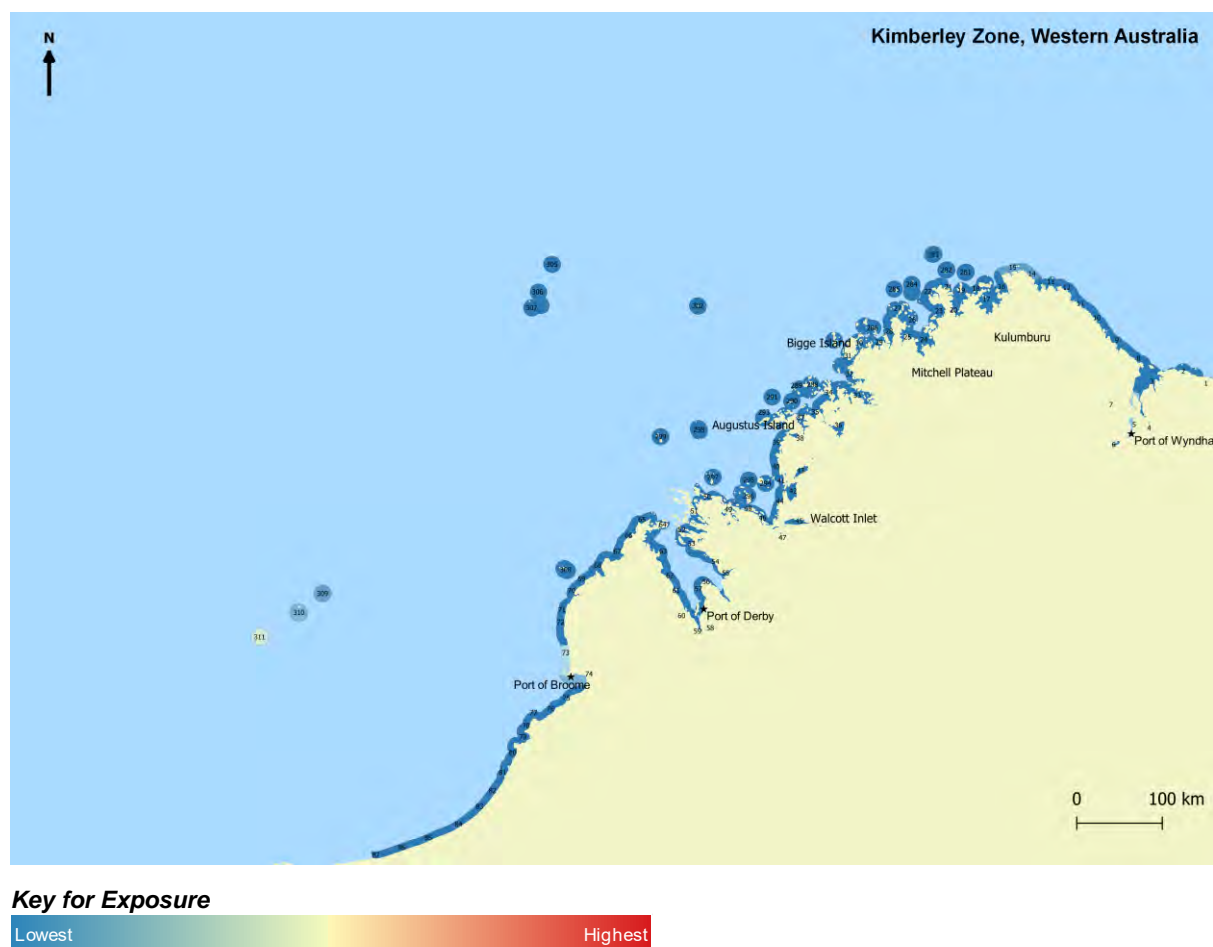


Figure 6.8 shows the proportion of shoreline exposure generated by each spill size band. Around one third of the oil expected to arrive at the Kimberley zone shoreline is due to potential spills in the 50,000+ tonne band, followed by the 5,000 – 50,000 band.

Figure 6.8 Proportion of Shoreline Exposure by Spill Size (tonnes)

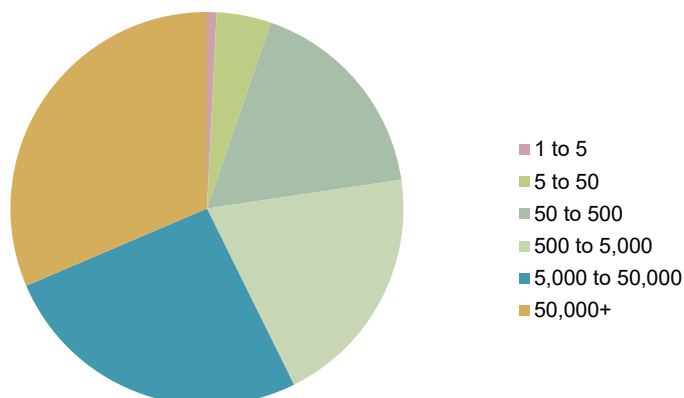


Figure 6.9 is similar to Figure 6.8 in that it shows the proportion of shoreline exposure generated by each spill size band. However, this measure of exposure is further broken down by sub-zone.

Sub-zone WA12 has larger quantities of expected oil arriving. For sub-zone WA13 most of this is from spills in the 50,000+ tonne band, while WA12 has a more even spread between various potential spill sizes.

Figure 6.9 Kimberley Shoreline Exposure by Spill Size (tonnes) and Sub-Zone

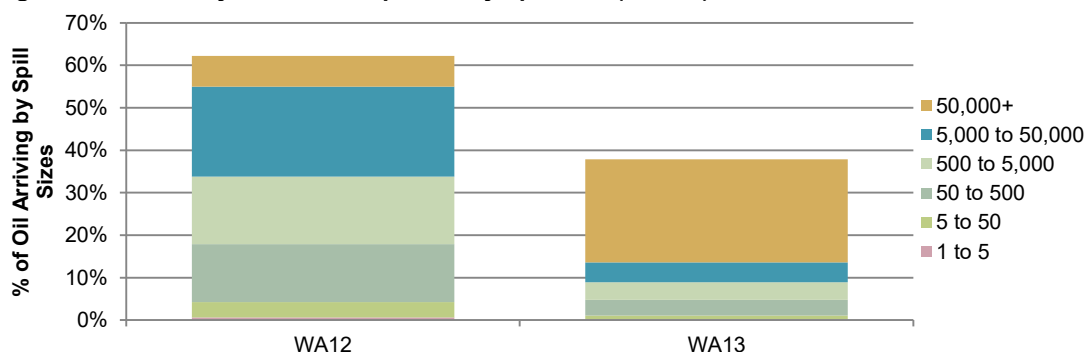


Figure 6.10 shows the proportion of shoreline exposure generated by each spill source. Around one third of the oil expected to arrive at the Kimberley shoreline is due to potential spills from petroleum facilities, and almost a third is from oil tankers.

Figure 6.10 Proportion of Shoreline Exposure by Source (tonnes)

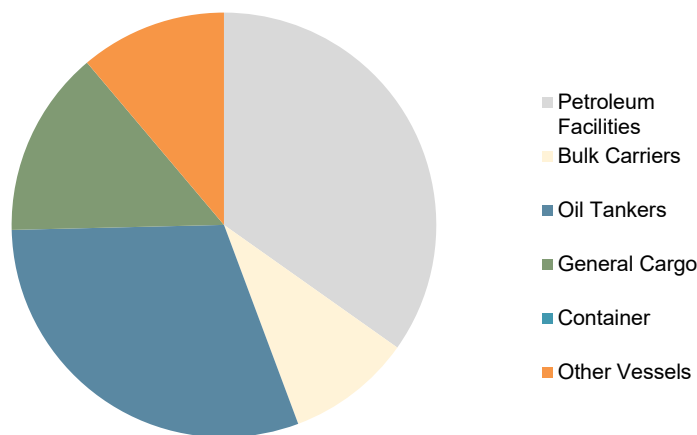
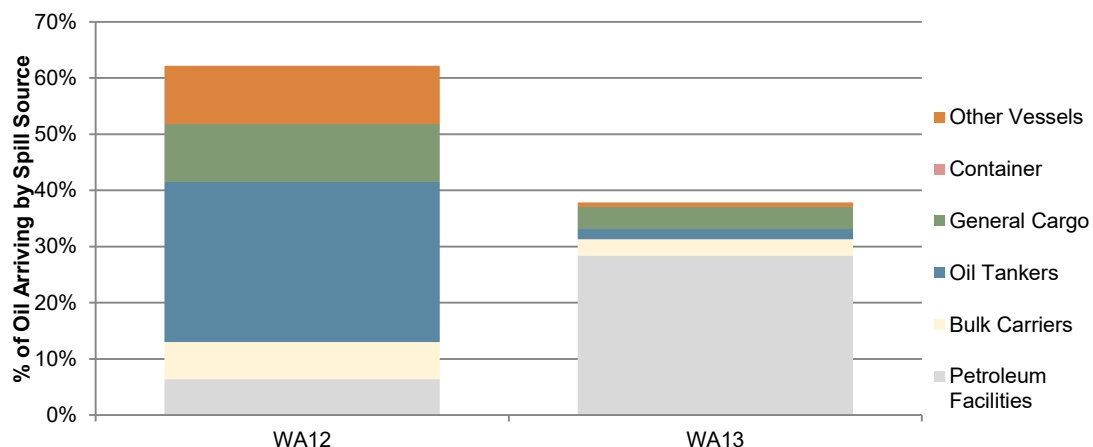


Figure 6.11 is similar to Figure 6.10 in that it shows the proportion of shoreline exposure generated by each spill source. However, this measure of exposure is further broken down by sub-zone. The “Other Vessels” category includes chemical tankers, gas carriers and passenger vessels.

Figure 6.11 Kimberley Shoreline Exposure by Source and Sub-Zone

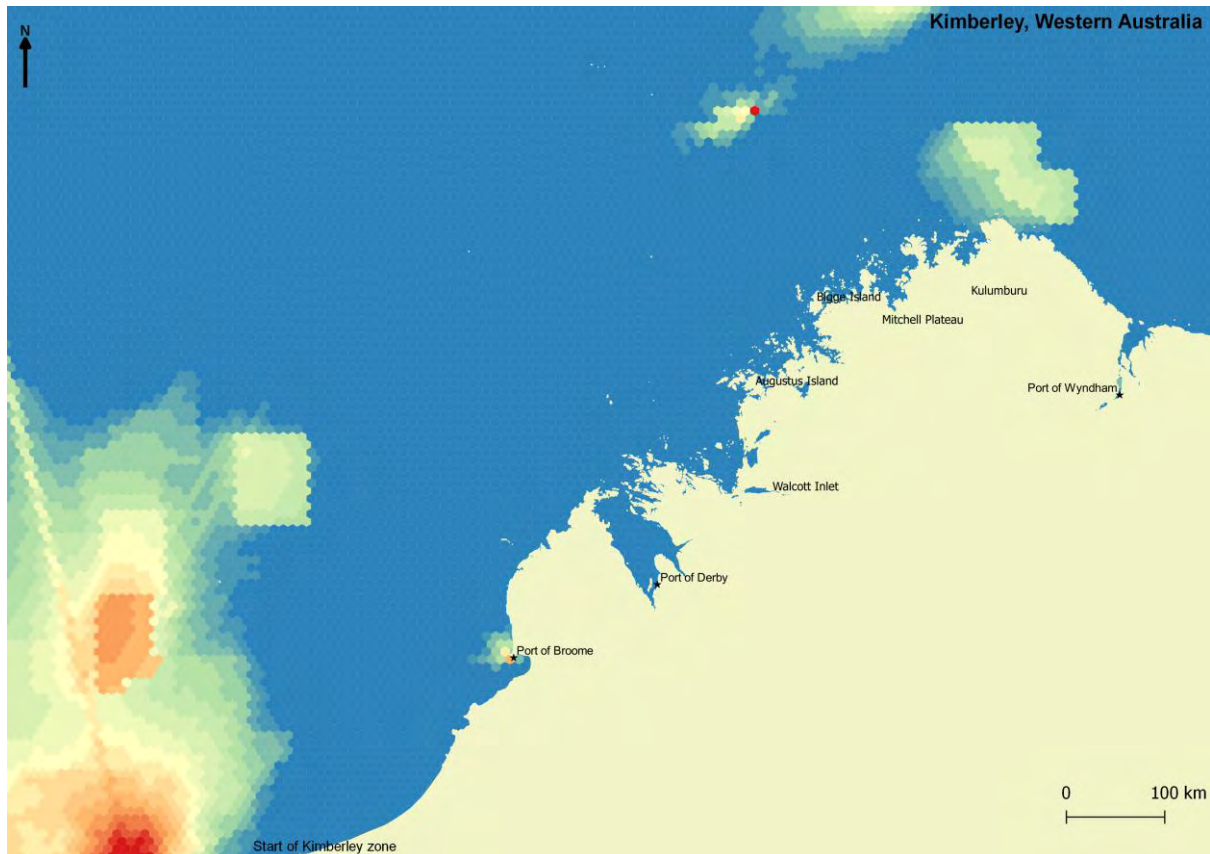


There is slightly lower shoreline exposure in subzones WA13 compared to WA12. Exposure in the WA13 subzone is driven by petroleum facilities. The biggest contributor in WA12 is oil tankers.

Sea Cell Exposure

Figure 6.12 shows the oil exposure profile for the hexagon sea cells within the Kimberley zone. The influence of shipping traffic to and from Port Hedland and offshore petroleum exploration and development can be seen.

Figure 6.12 Exposure Profile



Key for Exposure



Figure 6.13 shows the proportion of offshore exposure generated by each spill size band. The majority of exposure in the Kimberley zone is due to spills in the 50,000+ tonne range.

Figure 6.13 Proportion of Hexagon Cell Exposure by Spill Size (tonnes)

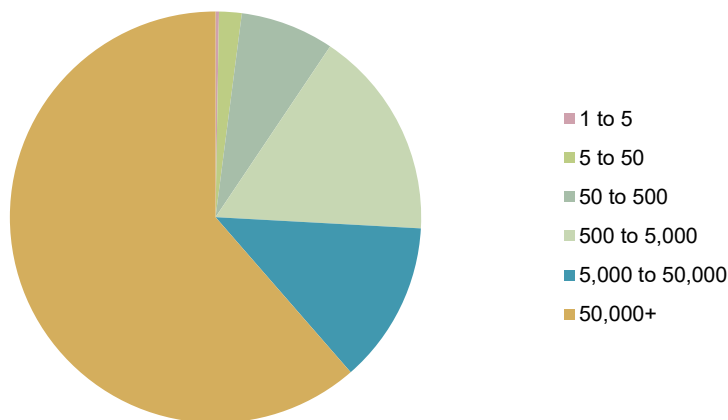
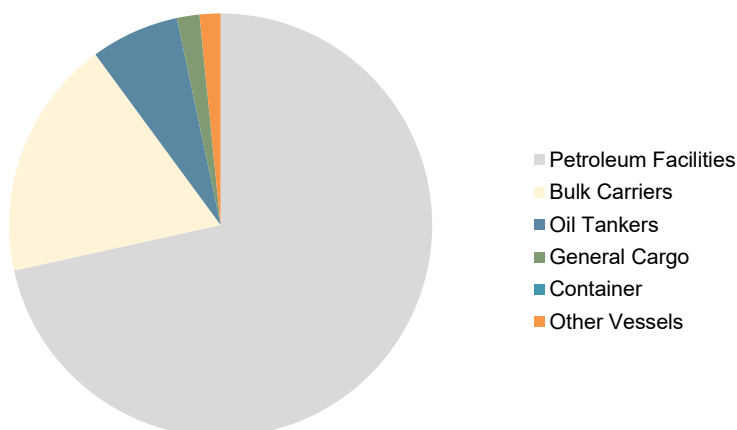


Figure 6.14 shows the proportion of offshore exposure generated by each spill source. The majority of exposure in the Kimberley zone is due to potential spills from oil petroleum facilities. Bulk carriers contribute nearly 20% of the exposure.

Figure 6.14 Proportion of Hexagon Cell Exposure by Source (tonnes)



The *Other Vessels* category includes chemical tankers, gas carriers and passenger vessels.

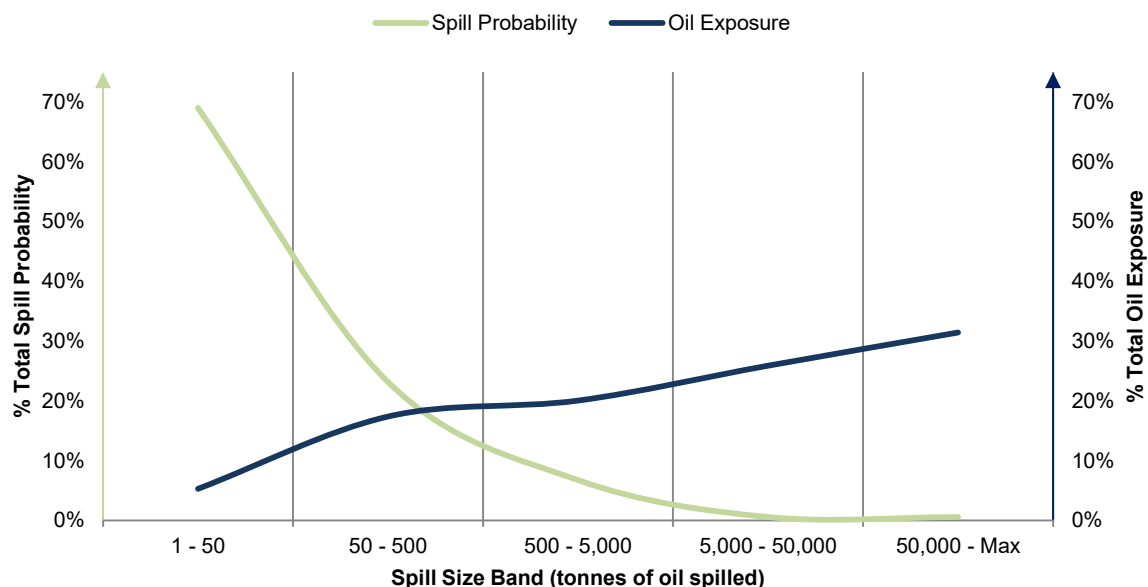
Exposure and Probability

The previous sections find that oil spill exposure in the Kimberley region is largely driven by spills in the 50,000+ tonne band. This would seemingly conflict with the typical experience of an oil spill responder who is likely to attend smaller spill events more frequently. However, the result is sound because exposure takes into account both the likelihood and size of spills. Exposure is the expectation of how much oil will arrive at a given area over a very long period of time.

Although smaller spills are much more frequent, over a very long time period, the majority of oil spilled in the Kimberley zone is likely to come from larger incidents.

This is conceptually illustrated in Figure 6.15. This chart shows relative spill probability (in green) and relative oil exposure (in blue) for different spill size bands. Spill probability is very high in the first spill size band. After the first band, spill probability decreases rapidly as spill size increases. Put simply; smaller spills are more frequent than larger spills.

Figure 6.15 Conceptual Comparison of Spill Probability vs. Expected Oil [is this updated?]



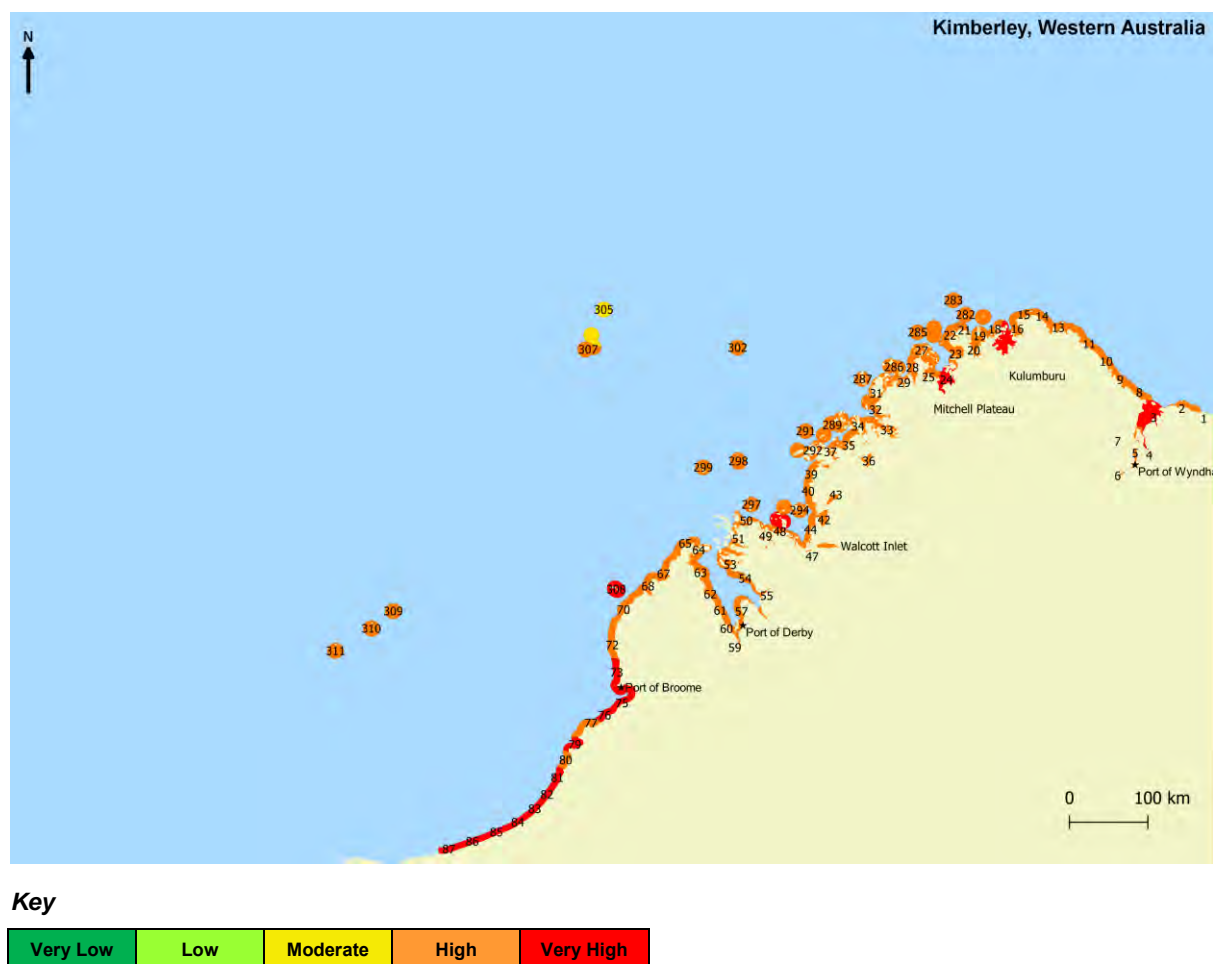
On the other hand, relative oil exposure (the blue curve) is very low for smaller spill sizes. Although these spills are more frequent, their contribution to the expected amount of oil is small. As spill size increases the contribution to total exposure also increases.

This leaves spill responders with the challenge of regularly dealing with small spills while also ensuring adequate training, capability and resources to respond effectively to larger spills.

6.3. Protection Priority Results

Protection Priority data was developed by Advisian and is fed into the risk model developed by Navigatus to create a picture of oil spill risk including likelihood and consequence. Figure 6.16 shows the overall ranking for Protection Priorities in the Kimberley zone.

Figure 6.16 Protection Priorities Overall Rankings



A sample of protection priority data is shown for the Port of Broome in Table 6.1. It shows the *overall* protection priorities ratings and comments for the Port of Broome. Ratings and comments are provided for potential spills of floating oils (e.g. bunker fuel) and dissolving oils (e.g. diesel).

Information on protection priorities can be viewed at the webmap application: <http://wamopra.navigatusconsulting.com> as well as in the Sub-Zone Drill Down sections of this report. The Kimberley zone report prepared by Advisian for the Department of Transport (Advisian 2018) should be consulted for more context and information.

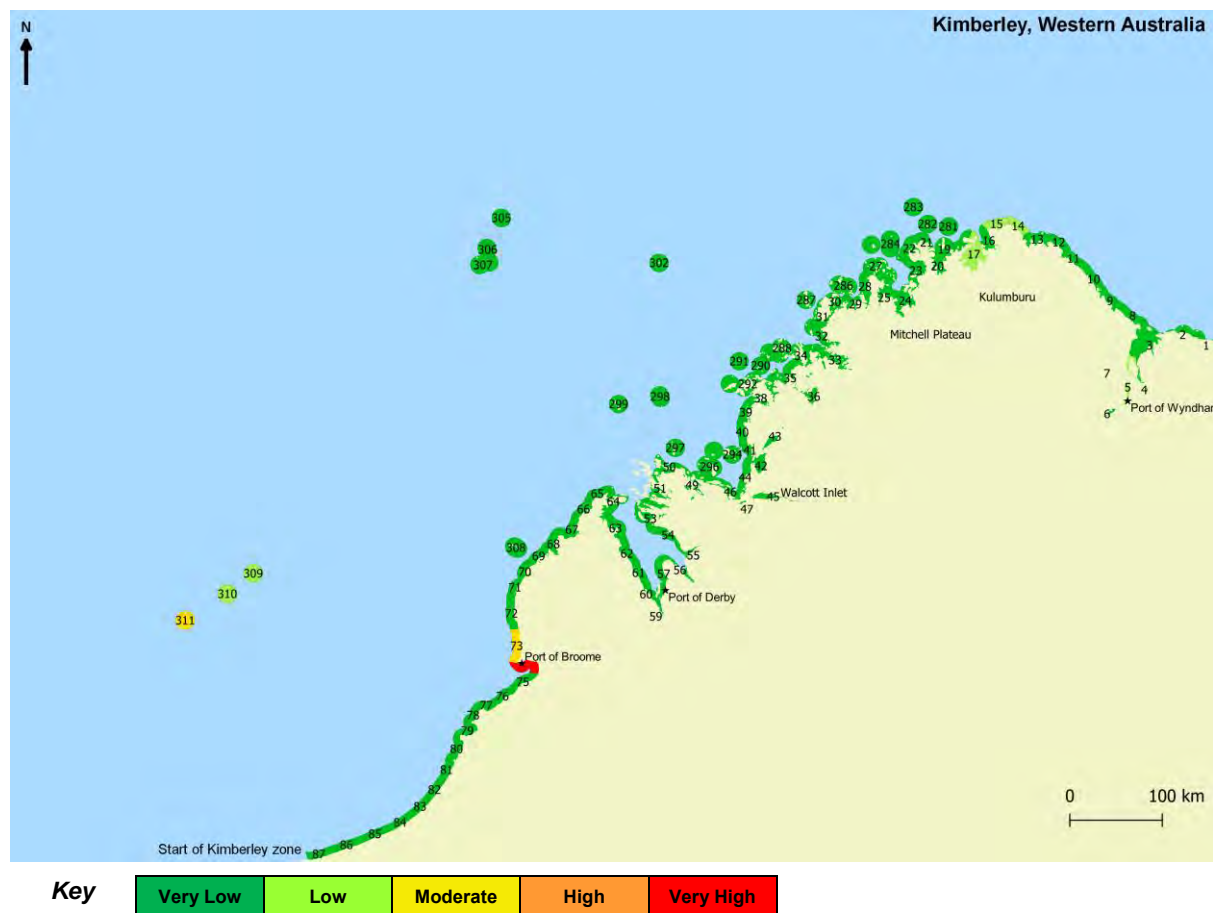
Table 6.1 Protection priorities for the Port of Broome (Cell 74) (based on Advisian 2018 data)

Category	Protection Priorities Floating Ranking	Protection Priorities Dissolved Ranking	Protection Priorities Overall Ranking	Brief Description for Spills of Floating Oils / Dissolving Oils	Data Sources
Protected Fauna	Very High	High	Very High	Birds: Calidris ferruginea (curlew sandpiper) [CR] Day sighting (Certain), Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), Calidris tenuirostris (great knot) [CR] Day sighting (Certain), Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain)	DBCA fauna dataset 20171106
Protection Areas	Very High	Very High	Very High	RAMSAR wetlands: Roebuck Bay	RAMSAR wetlands 20171018
Cultural Heritage	High	High	High	National Heritage: The West Kimberley	DotE National Heritage List 20160211
Economic	Low	Moderate	Moderate	Pearling leases: Roebuck Bay A Pearl Farm Lease, Roebuck Bay B Pearl Farm Lease, Roebuck Bay C Pearl Farm Lease, Roebuck Bay D Pearl Farm Lease, Roebuck Bay E Pearl Farm Lease, Roebuck Bay F Pearl Farm Lease, Roebuck Bay G Pearl Farm Lease	DPIRD Pearling Leases 20171019
Social Amenity and Recreation	Low	Low	Low	AMP Draft Zoning: Draft Zone (Roebuck) Multiple Use Zone (IUCN VI), Beaches: Roebuck Bay near Broome, CAPAD Marine: 5(1)(h) Reserve (Unnamed WA51046) Unassigned (IUCN VI), Commonwealth Marine Reserve (Roebuck) Multiple Use Zone (IUCN VI)	Australian Marine Parks draft zoning 2017 20171018, Geomorphology smartline 20171212 (ABSAMP), Geonoma dataset 20171214, CAPAD 2016 Marine 20171018
Overall	Very High	Very High	Very High	Birds: Calidris ferruginea (curlew sandpiper) [CR] Day sighting (Certain), Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), Calidris tenuirostris (great knot) [CR] Day sighting (Certain), Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), RAMSAR wetlands: Roebuck Bay	DBCA fauna dataset 20171106, RAMSAR wetlands 20171018

6.4. Kimberley Risk Profile Results

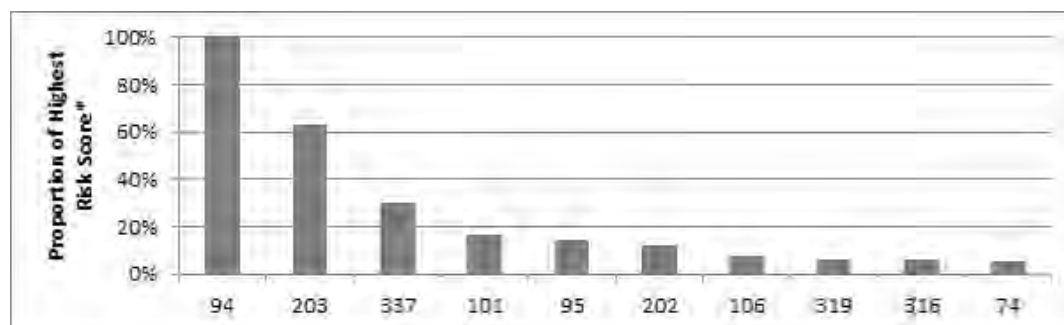
This section contains the main risk results for the Kimberley zone. Figure 6.17 shows a heat map of risk ratings in each of the Kimberley zone shoreline cells.

Figure 6.17 Kimberley Risk Profile Heat Map



Risk ratings in the heat map are determined relative to the risk score in the second highest shoreline cell for all Western Australia. This decision was made as the highest risk cell (94 – Port Hedland) would otherwise dominate the risk profile reducing the level of discrimination in other areas (see Figure 6.18). The second highest cell (203) is Fremantle Port.⁸

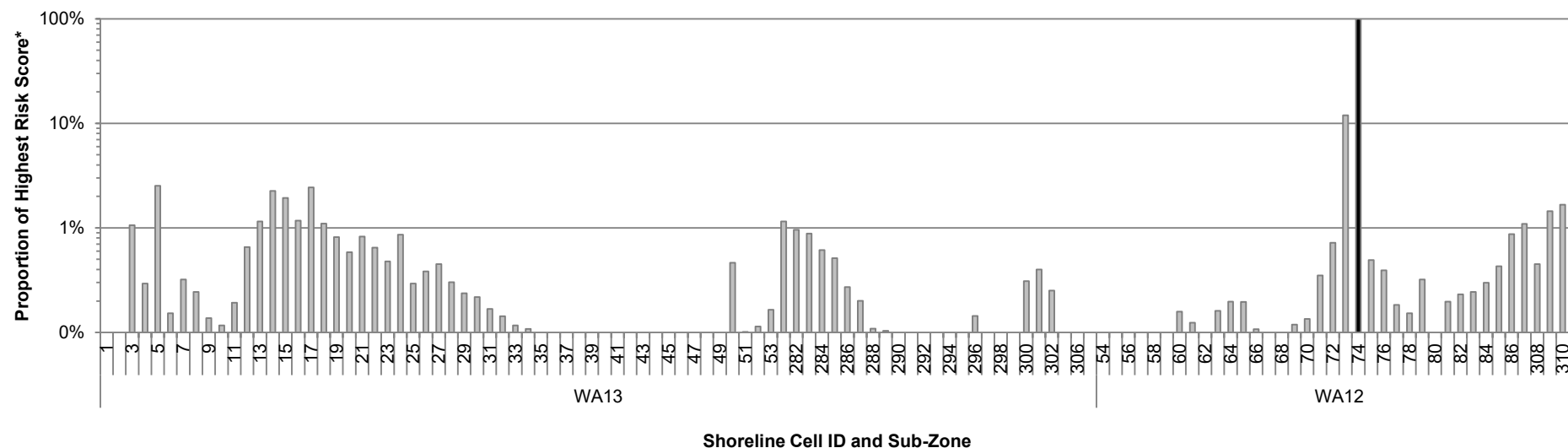
Figure 6.18 - Ten highest shoreline cells (all zones)



⁸ As the zones have been completed and the model has been adjusted, the second highest cell has changed from earlier zone reports. The second highest cell is reflected in this report and on the webmap.

Figure 6.19 shows a column chart of relative risk scores for each of the shoreline cells. The black column represents shoreline cell #74, the Port of Broome, being the cell with the highest risk score in the Kimberley zone. The chart uses a log scale for the vertical axis.

Figure 6.19 Kimberley Risk Profile Relative Risk Scores



* Note use of log scale. As with the heat map, risk is shown relative to the second highest cell.

The three cells with the highest risk levels are:

1. ID #74 Port of Broome (Entrance Point - Cape Boileau)
2. ID #73 Adjacent to Port of Broome (Cape Boileau - Coulomb Point (B))
3. ID #311 Cunningham Island (Imperieuse Reef)

6.5. Sub-Zone Drill Down

Overview

The following sections contain a brief summary for the two sub-zones within the Kimberley Zone (refer Section 5.2 for definition of sub-zones).

Cell counts and heat maps are presented for each of the sub-zones. A summary table is also presented for each sub-zone. The key benefit of these tables is to allow trends in risk drivers to be seen across multiple cells. The tables contain the following fields:

- ▶ **ID** – the shoreline cell identification number.
- ▶ **Name** – the name assigned to the shoreline cell.
- ▶ **Overall Risk Rating** – the primary measure of risk – shown on a five-step rating scale which ranges from Very Low to Very High.
- ▶ **Exposure** – represented as a colour on a continuous spectrum which transitions from blue – yellow – red as the level of exposure increases.
- ▶ **Overall Protection Priorities Rating** – as determined by Advisian, shown on a five-step rating scale which ranges from Very Low to Very High.
- ▶ **Protected Fauna; Protection Areas; Heritage; Economic; Social Amenity Recreation** – these fields show the ratings for each of the protection priority categories as determined by Advisian. The ratings are shown on a five-step rating scale which ranges from Very Low to Very High.
- ▶ **Brief Description of Overall Protection Priority Rating** – the protection priorities attribute table provided by Advisian contains a brief overall comment for spills of floating oils and spills of dissolving oils in each shoreline cell. This field represents each of the unique features mentioned in the two overall comments. It is intended to provide a brief overview of key protection priorities in the shoreline cell.
- ▶ **Key Drivers of Shoreline Exposure** – this field lists the potential spill sources which contribute most to the risk profile in the given shoreline cell.

WA13 Sub-Zone Summary

Figure 6.20 shows the count of each cell rating within the WA13 Sub-Zone (cells 1 to 53 and 281-307). Figure 6.21 depicts these cell ratings on a heat map.

Figure 6.20 WA13 Sub-Zone Cell Counts

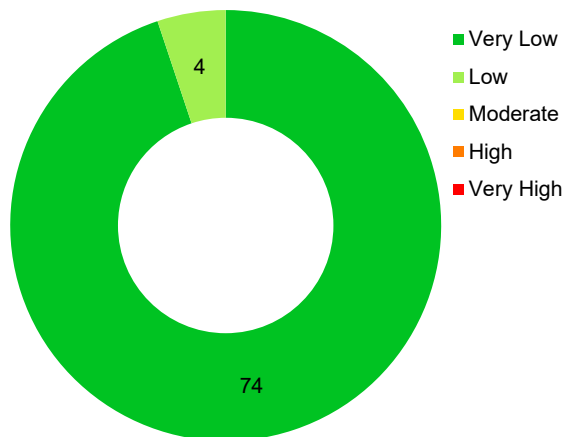
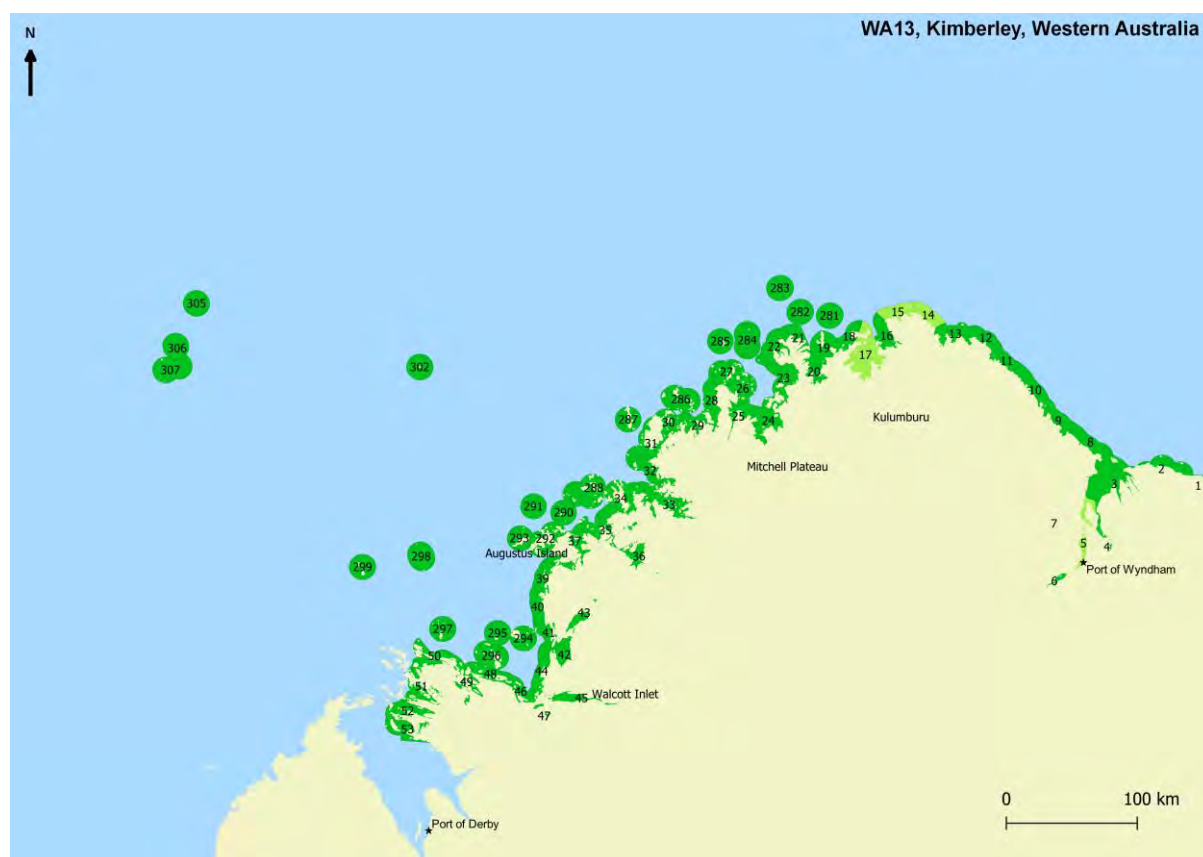


Figure 6.21 WA13 Sub-Zone Risk Profile



The overall risk in this sub-zone is relatively low, with the majority of cells having a very low rating. Four cells had a slightly higher rating (“low”); at the Port of Wyndham (5) and at the coastline north/northeast of Kalumburu – Honeymoon Bay (17) and round Cape Talbot – Cape Rulhieres (14, 15). The table on the following page summarises risk and protection priority information for this sub-zone.

WA13 Summary Table

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
1	East Cape Domett - WA-NT Border (A)	Very Low		High						Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltpan	Petroleum Facilities, General Cargo, Bulk Carriers, Oil Tankers
2	East Cape Domett - WA-NT Border (B)	Very Low		High						Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, Spring (Attack Spring), Terrestrial Protection Areas: Pelican Island Nature Reserve (IUCN IA) (Intertidal)	Petroleum Facilities, General Cargo, Bulk Carriers, Oil Tankers
3	East Cape Domett - WA-NT Border (C)	Very Low		Very High						RAMSAR wetlands: Ord River Floodplain	General Cargo, Oil Tankers, Bulk Carriers, Petroleum Facilities
4	Bare Hill - East Cape Domett (A)	Very Low		Very High						RAMSAR wetlands: Ord River Floodplain	General Cargo, Bulk Carriers, Oil Tankers
5	Bare Hill - East Cape Domett (B)	Low		High						Birds: <i>Calidris ferruginea</i> (curlew sandpiper) [CR] Sighting (Moderately certain), <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, Nationally Important Wetlands: Parry Floodplain, Terrestrial Protection Areas: Ord River Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley, Fishes: <i>Glyphis garricki</i> (Northern River Shark, New Guinea River Shark) [EN] Breeding known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, Nationally Important Wetlands: Parry Floodplain, National Heritage: The West Kimberley.	General Cargo, Bulk Carriers, Oil Tankers

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected	Fauna	Protection	Areas	Heritage	Economic	Social Amenity	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
6	Bare Hill - East Cape Domett (C)	Very Low		High								<p>Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley</p>	General Cargo, Bulk Carriers, Oil Tankers
7	Bare Hill - East Cape Domett (D)	Very Low		High								<p>Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley</p>	General Cargo, Bulk Carriers, Oil Tankers
8	Bare Hill - East Cape Domett (E)	Very Low		High								National Heritage: The West Kimberley	Bulk Carriers, General Cargo, Petroleum Facilities, Oil Tankers
9	Aunty Islet - Thurburn Bluff	Very Low		High								Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities, General Cargo, Bulk Carriers
10	Cape Bernier - Elsie Island N	Very Low		High								<p>Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, National Heritage: The West Kimberley</p>	Petroleum Facilities, General Cargo
11	Cape Rulhieres - Cape Bernier	Very Low		High								National Heritage: The West Kimberley	Petroleum Facilities
12	Un-named Head - Cape Rulhieres (A)	Very Low		High								National Heritage: The West Kimberley	Petroleum Facilities
13	Un-named Head - Cape Rulhieres (B)	Very Low		High								<p>Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Terrestrial Protection Areas: Lesueur Island Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley</p>	Petroleum Facilities

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
14	Un-named Head - Cape Rulhieres (C)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
15	Cape Talbot - Cape Londonderry (A)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
16	Cape Talbot - Cape Londonderry (B)	Very Low		High						Birds: <i>Calidris ferruginea</i> (curlew sandpiper) [CR] Sighting (Moderately certain), <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Calidris tenuirostris</i> (great knot) [CR] Sighting (Moderately certain), Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
17	Low Island Point - Anjo (A)	Low		Very High						Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Day sighting (Certain), Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
18	Low Island Point - Anjo (B)	Very Low		High						Coral Reefs: Intertidal, Subtidal, National Heritage: The West Kimberley	Petroleum Facilities
19	Cape Bougainville - Low Island Point (A)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
20	Cape Bougainville - Low Island Point (B)	Very Low		High						Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
21	Cape Bougainville - Low Island Point (C)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
22	Cape Bougainville - Low Island Point (D)	Very Low		High						Coral Reefs: Intertidal, Subtidal, Terrestrial Protection Areas: Low Rocks Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley	Petroleum Facilities
23	Crystal Head - Cape Bougainville	Very Low		High						Coral Reefs: Intertidal, Subtidal, National Heritage: The West Kimberley	Petroleum Facilities

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected	Fauna	Protection	Areas	Heritage	Economic	Social Amenities	Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
24	Davidsons Point - Crystal Head (A)	Very Low		Very High									Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Day sighting (Certain), Coral Reefs: Intertidal, Habitats: Mangroves >3,000 ha, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
25	Davidsons Point - Crystal Head (B)	Very Low		High									Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, Nationally Important Wetlands: Mitchell River System, National Heritage: The West Kimberley	Petroleum Facilities
26	Davidsons Point - Crystal Head (C)	Very Low		High									Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
27	Davidsons Point - Crystal Head (D)	Very Low		High									Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
28	Sw ift Bay - Davidsons Point (A)	Very Low		High									Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
29	Sw ift Bay - Davidsons Point (B)	Very Low		High									Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
30	Augereau Island - Combe Hill Point (A)	Very Low		High									Mammals: <i>Balaenoptera borealis</i> (Sei Whale) [EN] Sighting (Certain), Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
31	Augereau Island - Combe Hill Point (B)	Very Low		High									Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
32	Augereau Island - Combe Hill Point (C)	Very Low		High									Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected	Fauna	Protection	Areas	Heritage	Economic	Social Amenity	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
33	Cape Torrens - Anderdon Islands Point	Very Low		High								Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Habitats: Mangroves >3,000 ha, National Heritage: The West Kimberley	Petroleum Facilities
34	Cape Wellington - Cape Torrens (A)	Very Low		High								Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
35	Cape Wellington - Cape Torrens (B)	Very Low		High								Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, Nationally Important Wetlands: Prince Regent River System, National Heritage: The West Kimberley	Petroleum Facilities
36	High Bluff - Cape Wellington (A)	Very Low		High								Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Mangroves >3,000 ha, Saltmarsh, Saltmarsh/Saltflat, Nationally Important Wetlands: Prince Regent River System, National Heritage: The West Kimberley	Petroleum Facilities
37	High Bluff - Cape Wellington (B)	Very Low		High								Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
38	Battery Point - High Bluff (A)	Very Low		High								Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
39	Un-named Promontory - Battery Point	Very Low		High								Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Mammals: <i>Balaenoptera physalus</i> (Fin Whale) [EN] Day sighting (Certain), Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
40	Raft Point - Un-named Promontory (A)	Very Low		High								Coral Reefs: High Intertidal, Intertidal, Habitats: Spring (Winjingaribatbatgun Spring), National Heritage: The West Kimberley	Petroleum Facilities, Other Vessels

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
41	Raft Point - Un-named Promontory (B)	Very Low		High						Coral Reefs: High Intertidal, Intertidal, National Heritage: The West Kimberley	Petroleum Facilities, Other Vessels
42	Raft Point - Un-named Promontory (C)	Very Low		High						Birds: Numenius madagascariensis (eastern curlew) [CR] Sighting (Moderately certain), Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Mangroves >3, 000 ha, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities, Other Vessels
43	Raft Point - Un-named Promontory (D)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Mangroves >3, 000 ha, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
44	Marnebulorgne Community N point - Shale Island (A)	Very Low		High						Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
45	Shale Island - Raft Point	Very Low		High						Birds: Numenius madagascariensis (eastern curlew) [CR] Sighting (Moderately certain), Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Mangroves >3, 000 ha, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
46	Marnebulorgne Community N point - Shale Island (B)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities
47	Marnebulorgne Community N point - Shale Island (C)	Very Low		High						Habitats: Mangroves >3, 000 ha, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Petroleum Facilities

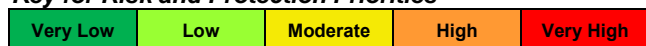
ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected	Fauna	Protection	Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
48	Marnebulorgne Community N point - Shale Island (D)	Very Low		High								Birds: <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: High Intertidal, Intertidal, National Heritage: The West Kimberley	Petroleum Facilities, Other Vessels, General Cargo, Bulk Carriers
49	Nares Point - Un-named Peninsular (A)	Very Low		High								Coral Reefs: High Intertidal, Intertidal, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	Other Vessels, General Cargo, Bulk Carriers, Petroleum Facilities
50	Nares Point - Un-named Peninsular (B)	Very Low		High								Coral Reefs: High Intertidal, Intertidal, Nationally Important Wetlands: Yampi Sound Training Area, Terrestrial Protection Areas: Tanner Island Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley	Bulk Carriers, General Cargo, Other Vessels
51	Point Usborne - Sir Richard Island (A)	Very Low		High								Coral Reefs: Intertidal, Habitats: Marshy muddy sediment flats to below sea level, National Heritage: The West Kimberley	General Cargo, Bulk Carriers, Other Vessels, Petroleum Facilities
52	Point Usborne - Sir Richard Island (B)	Very Low		High								Coral Reefs: Intertidal, Habitats: Marshy muddy sediment flats to below sea level, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	General Cargo, Bulk Carriers, Petroleum Facilities
53	Point Usborne - Sir Richard Island (C)	Very Low		High								Birds: <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Habitats: Marshy muddy sediment flats to below sea level, Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	General Cargo
281	Low Island Point - Anjo (C)	Very Low		High								Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
282	Davidsons Point - Cape Bougainville (A)	Very Low		High						Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Subtidal, National Heritage: The West Kimberley	Petroleum Facilities
283	Davidsons Point - Cape Bougainville (B)	Very Low		High						Coral Reefs: Intertidal	Petroleum Facilities
284	Davidsons Point - Cape Bougainville (C)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
285	Davidsons Point - Cape Bougainville (D)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
286	Augereau Island - Combe Hill Point (D)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
287	Augereau Island - Davidsons Point	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
288	Cape Wellington - Cape Torrens (C)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
289	Cape Wellington - Cape Torrens (D)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
290	Battery Point - High Bluff (B)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
291	Battery Point - Cape Wellington	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
292	Battery Point - High Bluff (C)	Very Low		High						Reptiles: <i>Lepidochelys olivacea</i> (olive ridley turtle) [EN] Caught or trapped (Certain), <i>Lepidochelys olivacea</i> (olive ridley turtle) [EN] Specimen (WAM Vouchered), <i>Lepidochelys olivacea</i> (Olive Ridley Turtle, Pacific Ridley Turtle) [EN] Caught or trapped (Very Certain), Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
293	Marnebulorgne Community N Point - Battery Point (A)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities
294	Raft Point - Un-named Promontory (E)	Very Low		High						Coral Reefs: High Intertidal, Intertidal, National Heritage: The West Kimberley	Petroleum Facilities, Bulk Carriers
295	Raft Point - Un-named Promontory (F)	Very Low		High						Coral Reefs: High Intertidal, Intertidal, National Heritage: The West Kimberley	Petroleum Facilities, Bulk Carriers, General Cargo, Other Vessels
296	Raft Point - Un-named Promontory (G)	Very Low		Very High						Birds: Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), Coral Reefs: Intertidal, National Heritage: The West Kimberley	Petroleum Facilities, Other Vessels, Bulk Carriers, General Cargo
297	Marnebulorgne Community N Point - Battery Point (B)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Bulk Carriers, General Cargo, Petroleum Facilities, Other Vessels
298	Marnebulorgne Community N Point - Augereau Island (A)	Very Low		High						Coral Reefs: Intertidal	Petroleum Facilities, Bulk Carriers
299	Point Usborne - Marnebulorgne Community N Point	Very Low		High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Sighting (Moderately certain), Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Calidris tenuirostris (great knot) [CR] Sighting (Moderately certain), Numenius madagascariensis (eastern curlew) [CR] Sighting (Moderately certain), Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Terrestrial Protection Areas: Adele Island Nature Reserve (IUCN IA) (Intertidal)	Bulk Carriers, Petroleum Facilities
300	Point Usborne - Nares Point (A)	Very Low		High						Coral Reefs: Intertidal, National Heritage: The West Kimberley	Bulk Carriers, General Cargo
301	Point Usborne - Nares Point (B)	Very Low		High						Coral Reefs: Intertidal, Habitats: Marshy muddy sediment flats to below sea level, National Heritage: The West Kimberley	General Cargo, Bulk Carriers
302	Marnebulorgne Community N Point - Augereau Island (B)	Very Low		High						Habitats: Exposed tidal flats, KEF: Ancient coastline at 125 m depth contour, Continental Slope Demersal Fish Communities, Terrestrial Protection Areas: Browse Island Nature Reserve (IUCN IA) (Intertidal), Cmlth Protected Shipwreck: Browse Island Unident.	Petroleum Facilities, Oil Tankers

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
305	Seringapatam Reef	Very Low		Moderate						Reptiles: <i>Aipysurus apraefrontalis</i> (Short-nosed Seasnake) [CR] Species or species habitat likely to occur within area, Mammals: <i>Balaenoptera musculus</i> (Blue Whale) [EN] Migration route known to occur within area, <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Distribution (Known to occur), <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Foraging (Known to occur), <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Migration (Known to occur), KEF: Continental Slope Demersal Fish Communities, Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	Bulk Carriers, Petroleum Facilities, Oil Tankers
306	Scott Reef North	Very Low		Moderate						Reptiles: <i>Aipysurus apraefrontalis</i> (Short-nosed Seasnake) [CR] Species or species habitat likely to occur within area, Mammals: <i>Balaenoptera musculus</i> (Blue Whale) [EN] Migration route known to occur within area, <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Distribution (Known to occur), <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Foraging (Known to occur), <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) [EN] Migration (Known to occur), Habitats: Exposed tidal flats, KEF: Continental Slope Demersal Fish Communities, Seringapatam Reef and Commonwealth waters in the Scott Reef Complex, Seagrasses: Intertidal, Commonwealth Heritage: Scott Reef and Surrounds - Commonwealth Area	Petroleum Facilities, Bulk Carriers, Oil Tankers
307	Scott Reef South	Very Low		High						Marine Protection Areas: Scott Reef Nature Reserve Unassigned (IUCN IA) (Intertidal)	Petroleum Facilities, Oil Tankers, Bulk Carriers

Key for Risk and Protection Priorities



Key for Exposure



WA12 Sub-Zone Summary

Figure 6.22 shows the count of each cell rating within the WA12 Sub-Zone (Cells 54 to 87 and 308-311). Figure 6.23 depicts these cell ratings on a heat map.

Figure 6.22 WA12 Sub-Zone Cell Counts

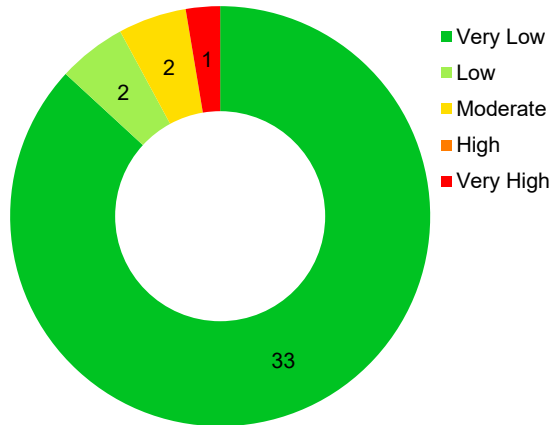


Figure 6.23 WA12 Sub-Zone Risk Profile



The majority of cells in this subzone have a very low risk rating. The highest risk is in the vicinity of the Port of Broome (high and moderate ratings) and Cunningham Island/Imperieuse Reef (cell 311) has a moderate rating. Bedwell Island/Clerke Reef (cell 310) and Mermaid Reef (cell 309) also have a slightly increased risk (“low” rating) compared to the majority of the coastline in WA12. The table on the following page summarises the risk and protection priority information for this sub-zone.

WA12 Summary Table

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
54	Meda River mouth spit SW - Helpman Island (A)	Very Low		High						Habitats: Mangroves >3, 000 ha, Marshy muddy sediment flats to below sea level, National Heritage: The West Kimberley	General Cargo, Petroleum Facilities
55	Meda River mouth spit SW - Helpman Island (B)	Very Low		High						Fishes: <i>Glyphis garricki</i> (northern river shark) [EN] Caught or trapped (Very Certain), Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	General Cargo
56	Point Torment - Meda River mouth spit SW (A)	Very Low		High						Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Fishes: <i>Glyphis garricki</i> (northern river shark) [EN] Caught or trapped (Very Certain), Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley.	General Cargo
57	Point Torment - Meda River mouth spit SW (B)	Very Low		High						Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Fishes: <i>Glyphis garricki</i> (northern river shark) [EN] Caught or trapped (Very Certain), National Heritage: The West Kimberley.	General Cargo

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected	Fauna	Protection	Areas	Heritage	Economic	Social Amenity	Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
58	Jangerie - Point Torment (A)	Very Low		High									Birds: <i>Calidris ferruginea</i> (curlew sandpiper) [CR] Sighting (Moderately certain), <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Fishes: <i>Glyphis garricki</i> (northern river shark) [EN] Caught or trapped (Very Certain), Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley.	General Cargo
59	Jangerie - Point Torment (B)	Very Low		High									Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (eastern curlew) [CR] Sighting (Moderately certain), <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	General Cargo, Oil Tankers, Other Vessels
60	Malaburra Spring - Jangerie (A)	Very Low		High									Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, <i>Numenius madagascariensis</i> (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Fishes: <i>Glyphis garricki</i> (northern river shark) [EN] Caught or trapped (Very Certain), Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley.	General Cargo, Oil Tankers
61	Malaburra Spring - Jangerie (B)	Very Low		High									Habitats: Spring (Jangan Spring), Spring (Kallumbarrit Spring), Spring (Midgeguna Spring), Spring (Wahja Spring), National Heritage: The West Kimberley	General Cargo, Oil Tankers

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
62	Malaburra Spring - Jangerie (C)	Very Low		High						Habitats: Spring (Lamaragorick Spring), National Heritage: The West Kimberley	General Cargo, Oil Tankers, Other Vessels
63	Swan Island - Cornambie Point	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew , Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, National Heritage: The West Kimberley	General Cargo, Oil Tankers, Other Vessels
64	Packer Island - Swan Island (A)	Very Low		High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Sighting (Moderately certain), Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Calidris tenuirostris (great knot) [CR] Sighting (Moderately certain), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Moderately Certain), Numenius madagascariensis (eastern curlew) [CR] Sighting (Moderately certain), Numenius madagascariensis (Eastern Curlew , Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: High Intertidal, Intertidal, Terrestrial Protection Areas: Swan Island Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley, Coral Reefs: High Intertidal, Intertidal, Subtidal.	General Cargo, Bulk Carriers, Petroleum Facilities
65	Packer Island - Swan Island (B)	Very Low		High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Sighting (Moderately certain), Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew , Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Coral Reefs: Intertidal, Subtidal, Terrestrial Protection Areas: Swan Island Nature Reserve (IUCN IA) (Intertidal), National Heritage: The West Kimberley	General Cargo, Bulk Carriers, Petroleum Facilities, Other Vessels

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
66	Packer Island - Swan Island (C)	Very Low		High						Birds: Calidris canutus (red knot, knot) [EN] Day sighting (Certain), Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Terrestrial Protection Areas (Wilson - Proposed): Borda Nature Reserve, National Heritage: The West Kimberley	General Cargo, Petroleum Facilities, Other Vessels, Oil Tankers
67	Packer Island - Swan Island (D)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Terrestrial Protection Areas (Wilson - Proposed): Borda Nature Reserve, National Heritage: The West Kimberley	General Cargo, Petroleum Facilities, Oil Tankers, Other Vessels
68	Chimney Rocks - Packer Island	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Spring (Dominic Spring), National Heritage: The West Kimberley	Petroleum Facilities, Oil Tankers, Other Vessels
69	Red Bluff - Chimney Rocks (A)	Very Low		High						National Heritage: The West Kimberley	Petroleum Facilities, Oil Tankers, Other Vessels
70	Coulomb Point - Red Bluff (A)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, Spring (Carnot Bay Spring), Nationally Important Wetlands: Bunda-Bunda Mound Springs, National Heritage: The West Kimberley	Petroleum Facilities, Oil Tankers, Other Vessels
71	Coulomb Point - Red Bluff (B)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Habitats: Saltmarsh, Saltmarsh/Saltflat, Terrestrial Protection Areas: Coulomb Point Nature Reserve - Nature Reserve (IUCN 1a) (Intertidal), Coulomb Point Nature Reserve (IUCN 1A) (Intertidal), National Heritage: The West Kimberley	Oil Tankers, Other Vessels, General Cargo

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
72	Cape Boileau - Coulomb Point (A)	Very Low		High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Sighting (Moderately certain), Calidris ferruginea (Curlew Sandpiper) [CR] Species or species habitat known to occur within area, Calidris tenuirostris (great knot) [CR] Sighting (Moderately certain), Limosa lapponica menzbieri (Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)) [CR] Species or species habitat known to occur within area, Numenius madagascariensis (eastern curlew) [CR] Sighting (Moderately certain), Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, National Heritage: The West Kimberley	Oil Tankers, Other Vessels, General Cargo
73	Cape Boileau - Coulomb Point (B)	Moderate		Very High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Limosa lapponica menzbieri (bar-tailed godwit (northern Siberian)) [CR] Specimen (WAM Vouchered), Closed waters: Prohibition on commercial fishing (Roebuck Bay), Nationally Important Wetlands: Willie Creek Wetlands, National Heritage: The West Kimberley	Oil Tankers, Other Vessels, General Cargo
74	Entrance Point - Cape Boileau	Moderate		Very High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Day sighting (Certain), Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), Calidris tenuirostris (great knot) [CR] Day sighting (Certain), Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), RAMSAR wetlands: Roebuck Bay	Oil Tankers, Other Vessels, General Cargo
75	Cape Gourdon - Cape Villaret (A)	Very Low		Very High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), RAMSAR wetlands: Roebuck Bay	Oil Tankers, Other Vessels, General Cargo

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
76	Cape Gourdon - Cape Villaret (B)	Very Low		Very High						RAMSAR wetlands: Roebuck Bay	Oil Tankers, Other Vessels, General Cargo
77	Saddle Hill - Cape Gourdon (A)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Closed waters: Prohibition on commercial fishing (Roebuck Bay)	Oil Tankers, Other Vessels, General Cargo, Bulk Carriers
78	Saddle Hill - Cape Gourdon (B)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [CR] Species or species habitat known to occur within area, Closed waters: Prohibition on commercial fishing (Roebuck Bay)	Oil Tankers, Other Vessels, Bulk Carriers, General Cargo
79	Tryon Point - False Cape Bossut (A)	Very Low		Very High						Birds: Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Closed waters: Prohibition on commercial fishing (Roebuck Bay), National Heritage: The West Kimberley	Oil Tankers, Bulk Carriers, Other Vessels, General Cargo
80	Tryon Point - False Cape Bossut (B)	Very Low		High						Birds: Limosa lapponica menzbieri (Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)) [CR] Species or species habitat known to occur within area, Closed waters: Prohibition on commercial fishing (Roebuck Bay)	Bulk Carriers, Oil Tankers
81	Cape Jaubert - Tryon Point	Very Low		Very High						RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
82	Samphire bore coast - Cape Jaubert (A)	Very Low		Very High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Specimen (WAM Vouchered), RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
83	Samphire bore coast - Cape Jaubert (B)	Very Low		Very High						RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
84	Samphire bore coast - Cape Jaubert (C)	Very Low		Very High						RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
85	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (A)	Very Low		Very High						Birds: Calidris tenuirostris (great knot) [CR] Specimen (WAM Vouchered), Limosa lapponica menzbieri (bar-tailed godwit (northern Siberian)) [CR] Specimen (WAM Vouchered), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers

ID	Name	Overall Risk Rating	Exposure	Overall Protection Priorities Rating	Protected Fauna	Protection Areas	Heritage	Economic	Social Amenity Recreation	Brief Description of Overall Protection Priority Rating	Key Drivers of Shoreline Exposure
86	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (B)	Very Low		Very High						Birds: Limosa lapponica menzbieri (bar-tailed godwit (northern Siberian)) [CR] Specimen (WAM Vouchered), RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
87	Cooraidegel Well coast - Eighty Mile Beach Caravan Park NE (C)	Very Low		Very High						RAMSAR wetlands: Eighty-mile Beach	Bulk Carriers, Oil Tankers
308	Red Bluff - Chimney Rocks (B)	Very Low		Very High						Birds: Calidris ferruginea (curlew sandpiper) [CR] Day sighting (Certain), Numenius madagascariensis (eastern curlew) [CR] Day sighting (Certain), National Heritage: The West Kimberley	Petroleum Facilities, Oil Tankers, Other Vessels
309	Mermaid Reef	Very Low		High						Coral Reefs: Intertidal, Subtidal, Marine Protection Areas: Mermaid Reef Commonwealth Marine Reserve Sanctuary Zone (IUCN IA) (Intertidal), Nationally Important Wetlands: Mermaid Reef	Bulk Carriers, Petroleum Facilities
310	Clerke Reef	Low		High						Closed waters: Prohibition on commercial fishing (Rowley Shoals Marine Park), Prohibition on recreational fishing (Rowley Shoals Marine Park), Coral Reefs: Intertidal, Subtidal, Marine Protection Areas: Rowley Shoals Marine Park Sanctuary Zone (IUCN IA) (Intertidal)	Bulk Carriers, Petroleum Facilities, Oil Tankers
311	Imperieuse Reef	Moderate		High						Closed waters: Prohibition on commercial fishing (Rowley Shoals Marine Park), Prohibition on recreational fishing (Rowley Shoals Marine Park), Coral Reefs: Intertidal, Subtidal, Marine Protection Areas: Rowley Shoals Marine Park Sanctuary Zone (IUCN IA) (Intertidal)	Bulk Carriers, Petroleum Facilities

Key for Risk and Protection Priorities



Key for Exposure



7. Summary

The WAMOPRA combines regional, national and international data for maritime activity and marine oil spills, levels of activity and protection priorities including environmental sensitivities to develop an overview of oil spill risk in the Kimberley zone. This report summarises the context, methodology and results for the Kimberley Risk Assessment Zone. It builds on the work undertaken in the preliminary state-wide assessment.

Both sub-zones in the Kimberley region have a similar risk profile, although oil spill risk is slightly higher in sub-zone WA12. The highest risk areas are at the Port of Broome and Cunningham Island. The port has strong and complex currents which create a difficult approach, with incidents occurring in the past. Cunningham Island has a relatively high (for the Kimberley zone) expected exposure to oil. This is driven by vessel transits to and from Port Hedland (in the Pilbara zone).

The overall the level of risk-generating activity in the Kimberley region is relatively low. There are exploration permits in the Browse Basin and Bonaparte Basin.

This companion report summarises the WAMOPRA results for the Kimberley Risk Assessment Zone. Further risk outputs are available via an interactive website at <http://wamopra.navigatusconsulting.com> (contact Team Leader Planning and Public Information for username and password).

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