

Western Australia
Marine Oil Pollution Risk Assessment

South Coast Zone Report

Prepared for Department of Transport
by Navigatus Consulting

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Prepared for:

Department of Transport Western Australia

Prepared by:

Navigatus Consulting Limited

347 Parnell Road

PO Box 137249

Parnell, Auckland 1052

+64 9 377 4132

www.navigatusconsulting.com

Quality Control

Prepared by: Celia Cunningham, Jessica Spinetto

Reviewed by: Kevin Oldham, Geraint Bermingham

Revision	Date	Authorised By	
		Name	Signature
Draft E	7 June 2018	Kevin Oldham	
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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 Kimberley Zone Report (*scheduled FY 2018*)
- ▶ WAMOPRA South West Zone Report (published)
- ▶ **WAMOPRA South Coast 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 South Coast Risk Assessment Zone. The other zones are: Pilbara, Kimberley, Swan, Midwest and South West.

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. South Coast Zone

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

Figure 2.1 Marine Oil Pollution Risk Assessment Zones



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 South Coast 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.
- ▶ **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 South Coast risk profile.
 - ▷ *Protection Priorities* – the primary output shown is a heat map of the overall protection priority ratings for the South Coast Zone as provided by Advisian. These ratings are combined with exposure to produce the South Coast 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 South Coast 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.

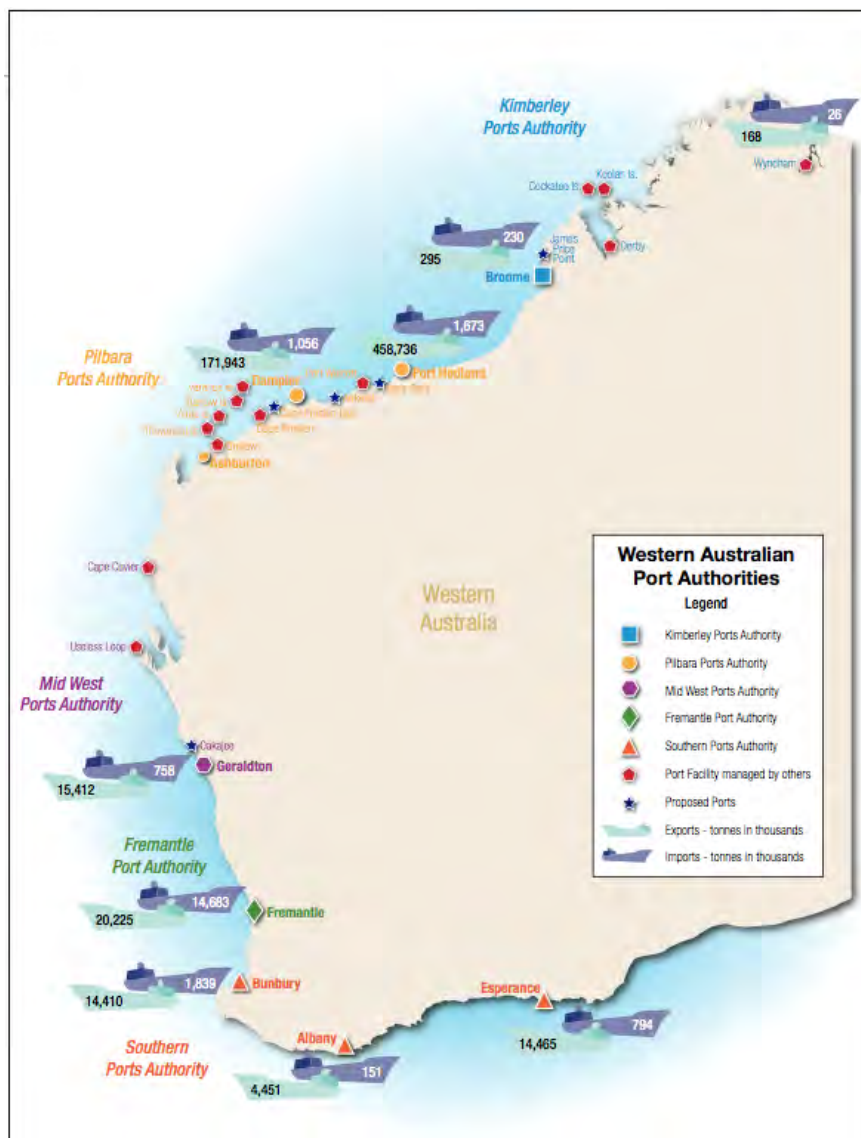
3. Context

3.1. Level of activity

The South Coast region has two commercial ports – Albany and Esperance. The overall level of trade is relatively low compared to some regions. While Albany is a small port, the Port of Esperance has trade levels similar to the Port of Bunbury (South West Zone) and the Port of Geraldton (Midwest zone). In addition, there are reasonably high levels of passing traffic transiting to ports in Victoria and Tasmania.

There are no current petroleum production permits in the South Coast region and no petroleum exploration activity offshore of the South Coast zone (based on forecasts obtained from operators in 2016 about current and planned future operations). In Stage 1 of this project (Navigatus 2016), possible petroleum exploration drilling in the Great Australian Bight was considered. However, due to the distance and the low likelihood of a blowout the effect was found to be low when modelled.

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

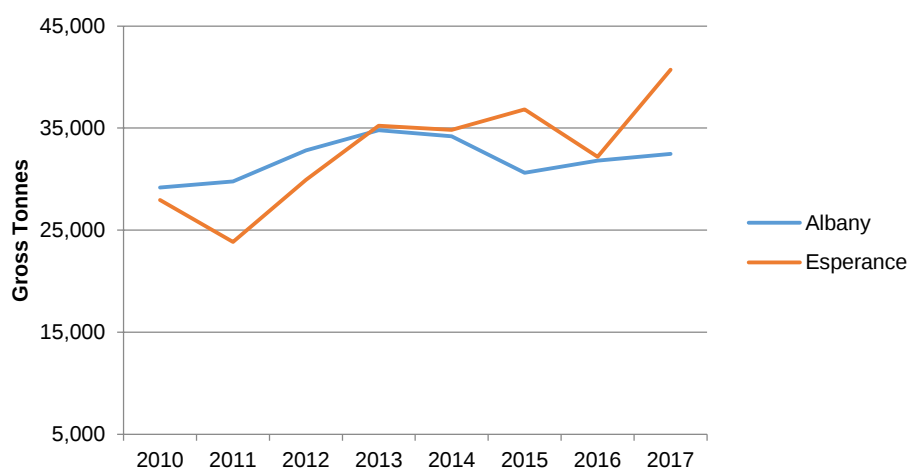


3.2. Vessel Trends

Vessel Size

There is a general trend in shipping towards larger vessels as industry strives to realise gains from economies-of-scale. This is illustrated in Figure 3.2, which shows the change in the average size of bulk carriers and general cargo vessels visiting the Ports of Albany and Esperance.

Figure 3.2 Average Bulk Carrier Size, 2010 – 2017

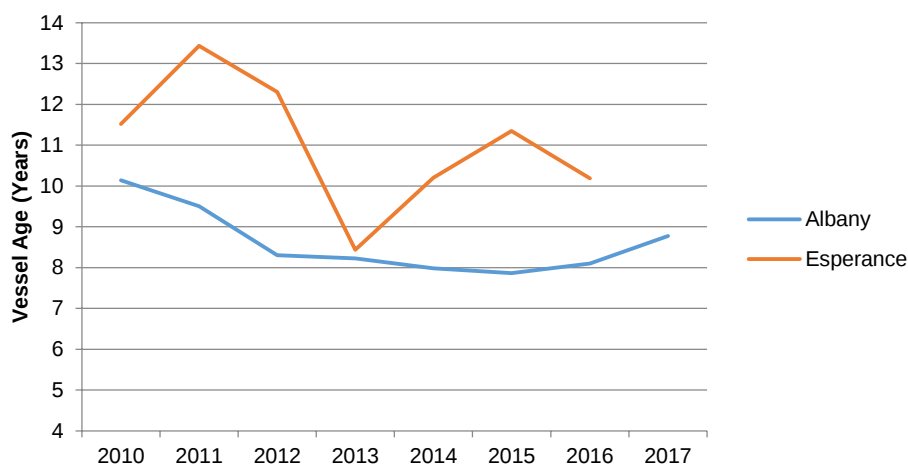


Data source: AMSA

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 a decline in the average vessel age for all vessels visiting the Ports of Albany and Esperance.

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

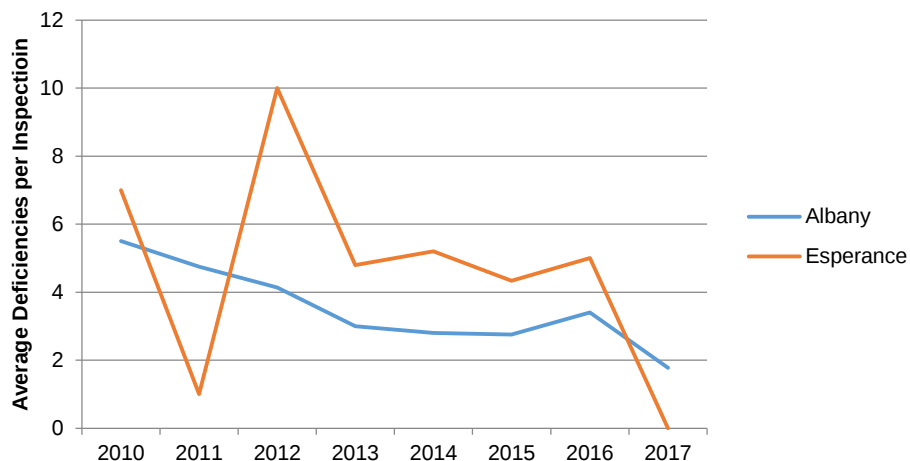


Data source: AMSA

Vessel Deficiencies

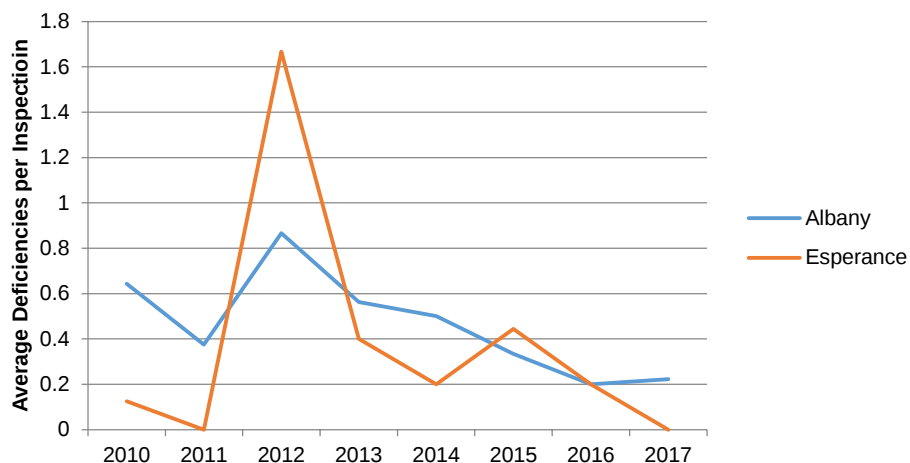
AMSA collects data on the numbers of vessel deficiencies found by the Port State Controls and Flag State Control inspections. Figure 3.4 shows the average number of deficiencies found per inspection at the Ports of Albany and Esperance. The trend is improving over time.

Figure 3.4 Average Deficiencies per Inspection



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 Bunbury. This has trended down since 2012.

Figure 3.5 Average 'Safety of Navigation' Deficiencies per Inspection



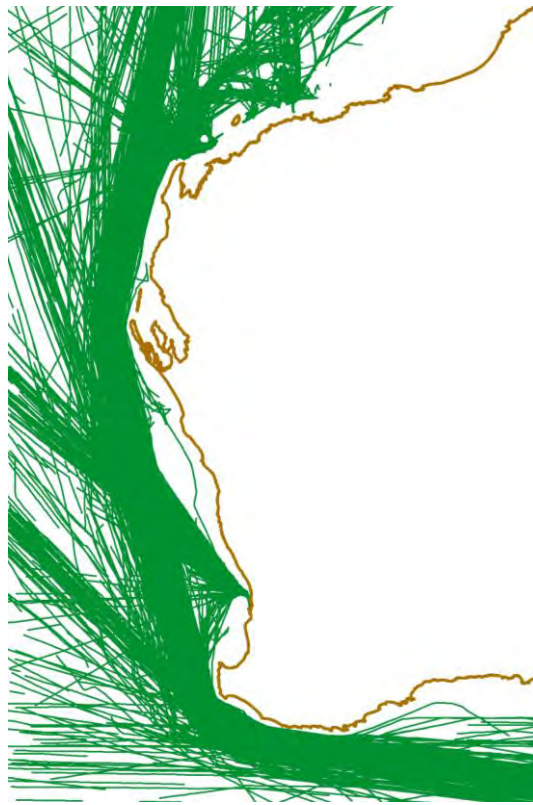
3.3. Vessel Routes

Figure 3.6 and Figure 3.7 show vessel tracks for medium and large tankers off the Western Australia coast. A relatively small proportion of these vessels visit the Ports of Albany and Esperance.

Figure 3.6 Medium Tankers



Figure 3.7 Large Tankers



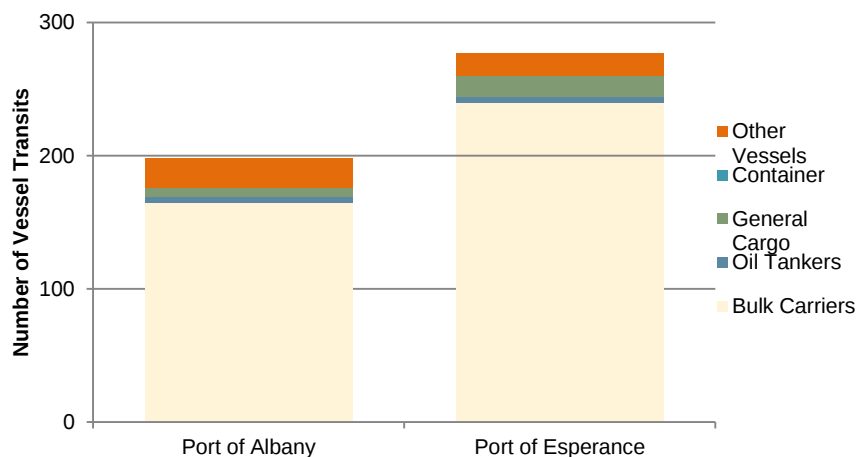
Trends such as changes from heavy bunker fuels to distillate fuels in response to International Maritime Organization (IMO) regulations are discussed in the state-wide report. It is not expected these will have an immediate effect on the risk profile for the South Coast zone.

3.4. Ports

The South Coast zone has two commercial ports – Albany and Esperance.

As an indication of activity levels at the ports, Figure 3.8 shows the numbers of transits¹ by different vessel types. The vast majority of port visits are by bulk carriers.

Figure 3.8 Annual Vessel Transits to and from Ports²



3.4.1. Port Albany

Port Albany is the smaller of the two main ports in the South Coast zone by throughput.

Figure 3.9 Map of Port Albany (Albany Port 2018)



¹ A transit is defined as a single movement. A ship visiting a port will usually comprise two transits.

² Data excludes commercial.

Port Albany is primarily a bulk products port. The major commodities are grain and woodchips. Albany is also a regular cruise ship destination (13 cruise ships were hosted in 2017). Freight traffic through the port is dominated by exports.

Figure 3.10 Exports and imports through Port Albany³



Figure 3.11 Annual imports through Port Albany⁴

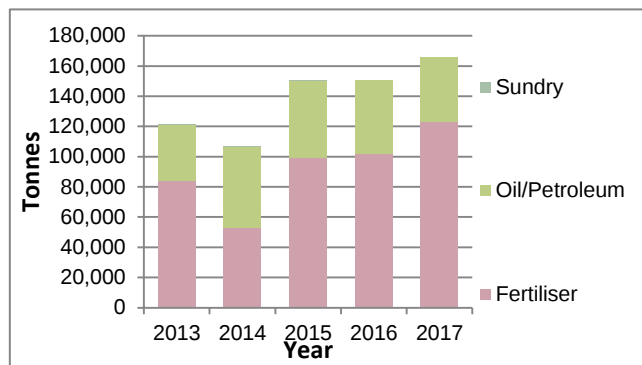
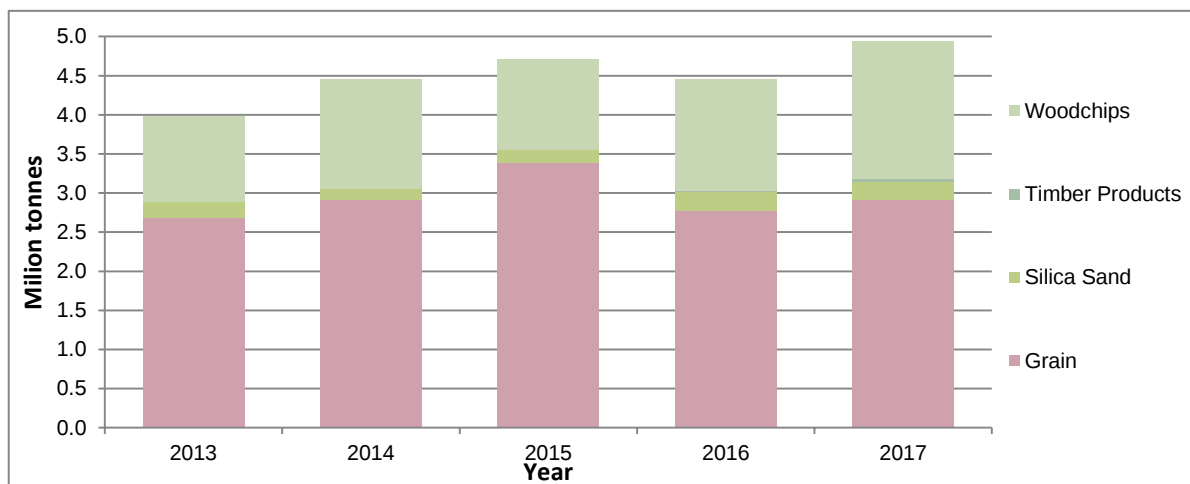


Figure 3.12 Annual exports from Port Albany⁵



The Port of Albany is on the north shore of Princess Royal Harbour in King George Sound. The Harbour is generally shallow, apart from the dredged approach to the port (Fremantle Sailing Club 2014). Pilotage is compulsory for all commercial vessels over 500 gross tonnage (GT).

3.4.2. Port Esperance

Port Esperance has the largest port throughput in the South Coast zone, being a major port for the mining activities of Kalgoorlie (Navigatus 2016).

³ Data: Southern Ports Authority 2017

⁴ Data: Southern Ports Authority 2017

⁵ Data: Southern Ports Authority 2017

Figure 3.13 Map of Port Esperance (Esperance Port 2018)



Port Esperance is primarily a bulk products port. The major commodities are nickel and grain. Esperance is also a cruise ship destination (11 cruise ships visited in 2017). Freight traffic through the port is dominated by exports.

Figure 3.14 Exports and imports through Port Esperance⁶

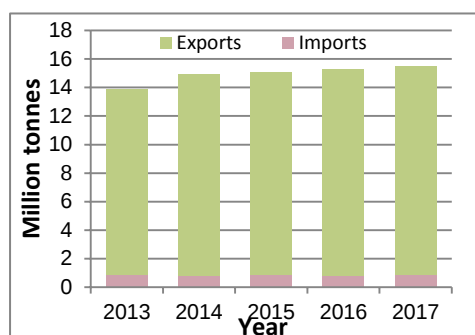
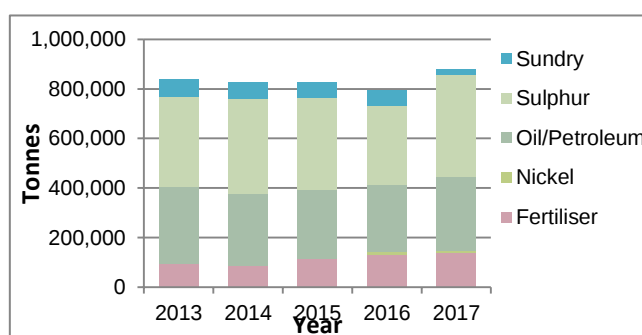


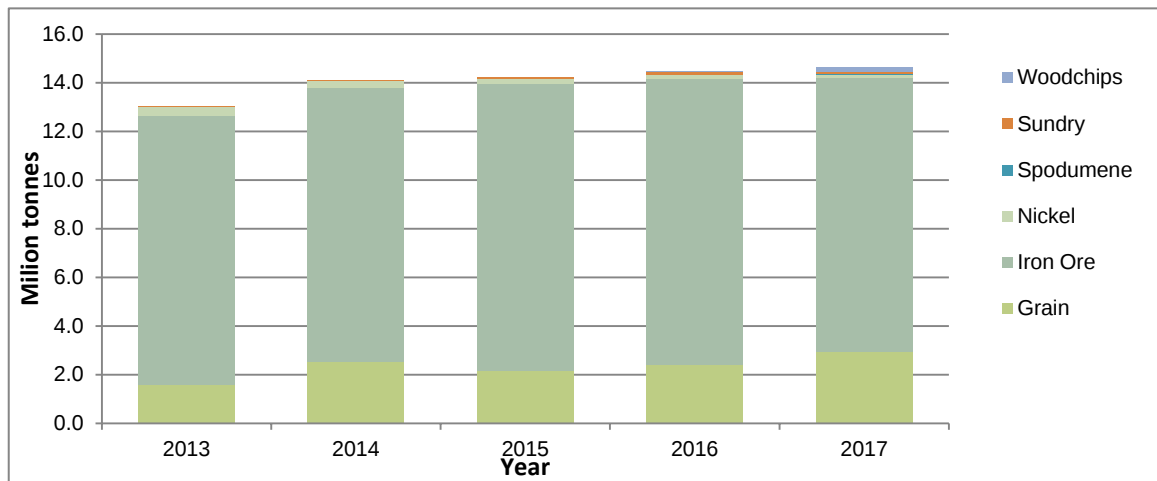
Figure 3.15 Annual imports through Port Esperance⁷



⁶ Data: Southern Ports Authority 2017

⁷ Data: Southern Ports Authority 2017

Figure 3.16 Annual exports from Port Esperance⁸



Port Esperance is situated on the North West shore of Esperance Bay. Harbour depths vary due to the natural movement of sand. Pilotage is compulsory for all vessels over 150 GT.

3.5. Petroleum Industry

In recent times there has been no petroleum exploration activity offshore of the South Coast zone (based on forecasts obtained from operators in 2016 about current and planned future operations).

⁸ Data: Southern Ports Authority 2017

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.⁹
- ▶ 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

⁹ Not present in the South Coast zone.

- ▶ Container
- ▶ Gas Carrier
- ▶ MODUs & FPSOs¹⁰ (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 workshop with expert mariners who are familiar with the Western Australian coastline facilitated by Navigatus and held in Fremantle.

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

4.4. Petroleum Industry

In recent times there has been no petroleum exploration activity offshore of the South Coast zone (based on forecasts obtained from operators in 2016 about current and planned future operations).

¹⁰ 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 large reduction in oil exploration activity as a result of the lower oil price, which has fallen significantly over the duration of this project¹¹,
- ▶ 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 52 shoreline cells in the South Coast region. For the purposes of this report, shoreline cells are also grouped into four 'sub-zones' to facilitate comparisons between wider areas in the South Coast zone.

The four sub-zones from West to East are: WA04, WA03, WA02, and WA01. The shoreline cells and sub-zones within the South Coast zone are shown in Section 5.2.

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.

¹¹ There is no oil exploration activity in the South Coast zone.

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 South Coast Shoreline Cells and Sub-Zones

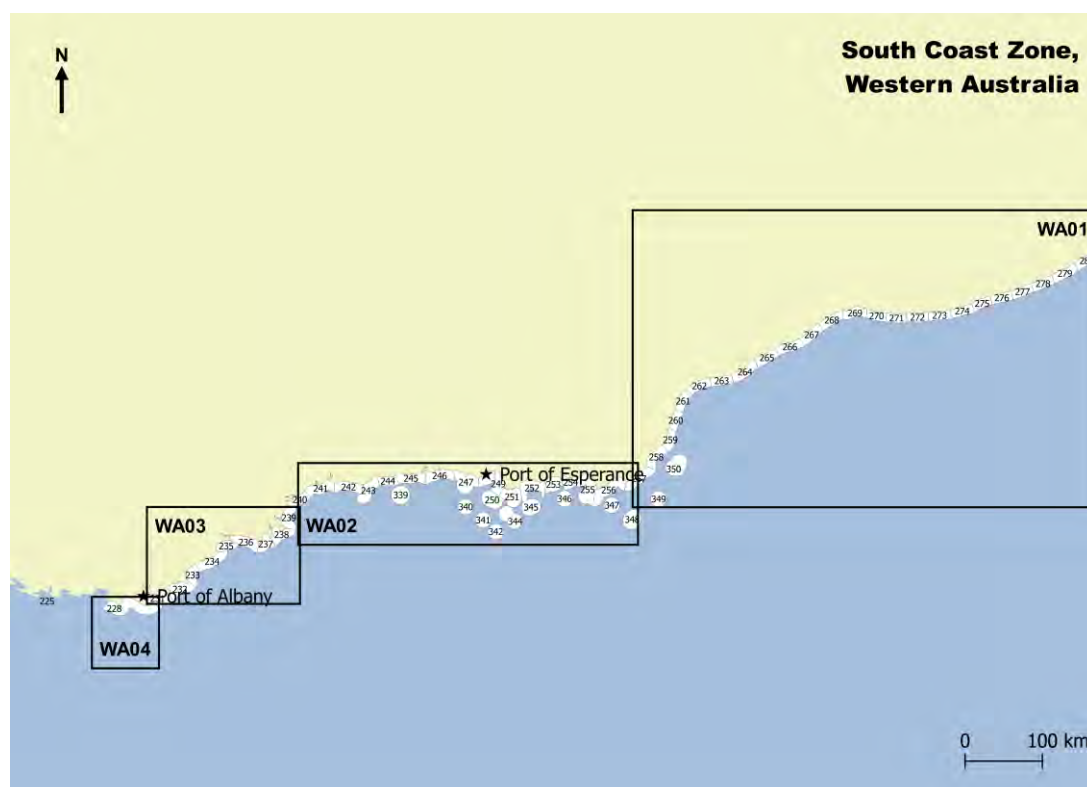


Table 5.1 Cell identity numbers to names listing

Cell ID	Cell Name	Cell ID	
	WA04	253	Cape Arid - Tagon Point (A)
228	Mutton Bird promontory - Torbay Head (A)	254	Cape Arid - Tagon Point (B)
229	Mutton Bird promontory - Torbay Head (B)	255	Cape Arid - Tagon Point (C)
230	Family Rocks - Mutton Bird promontory		WA01
	WA03	257	Israelite Bay N - Point Malcolm (A)
231	Cape Vancouver - Herald Point E	258	Israelite Bay N - Point Malcolm (B)
232	Hassell Beach NE - Bald Island (A)	259	Israelite Bay N - Point Malcolm (C)
233	Hassell Beach NE - Bald Island (B)	260	Wattle Camp - Israelite Bay N (A)
234	Cape Riche - Hassell Beach NE	261	Wattle Camp - Israelite Bay N (B)
235	Cape Knob - Groper Bluff (A)	262	Point Culver - Wattle Camp
236	Cape Knob - Groper Bluff (B)	263	Point Dover - Point Culver (A)
237	Point Henry - Cape Knob	264	Point Dover - Point Culver (B)
238	Point Ann - Point Hood (A)	265	Point Dover - Point Culver (C)
239	Point Ann - Point Hood (B)	266	Twilight Cove - Point Dover (A)
	WA02	267	Twilight Cove - Point Dover (B)
240	Edwards Point - Red Island	268	Scorpion Bight - Twilight Cove (A)

241	Mary Ann Point - Edwards Point	269	Scorpion Bight - Twilight Cove (B)
242	Munglinup Point - Mason Bay (A)	270	Scorpion Bight - Twilight Cove (C)
243	Munglinup Point - Mason Bay (B)	271	Scorpion Bight - Twilight Cove (D)
244	Shoal Cape - Munglinup Point	272	Scorpion Bight - Twilight Cove (E)
245	Coomalbidgup - Shoal Cape (A)	273	Red Rocks Point - Scorpion Bight
246	Coomalbidgup - Shoal Cape (B)	274	WA-SA Border - Red Rocks Point (A)
247	Coomalbidgup - Shoal Cape (C)	275	WA-SA Border - Red Rocks Point (B)
248	Observatory Point - Coomalbidgup	276	WA-SA Border - Red Rocks Point (C)
249	Wylie Head - Dempster Head	277	WA-SA Border - Red Rocks Point (D)
250	Cape Le Grand - Observatory Point	278	WA-SA Border - Red Rocks Point (E)
251	Hammer Head - Mississippi Point (A)	279	WA-SA Border - Red Rocks Point (F)
252	Hammer Head - Mississippi Point (B)	280	WA-SA Border - Red Rocks Point (G)

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 5.2.

Table 5.2 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.

Infrastructure¹²

The infrastructure probabilities were adopted from the International Association of Oil & Gas Production's Risk Assessment Data Directory: Blowout frequencies (OGP 2010b) and Riser and Pipeline release frequencies (Stantec 2014).

The infrastructure cumulative spill probability relationships were developed from several sources, including International Association of Oil & Gas Production, AMSA, and Stantec (Advisian 2018).

5.4. Exposure and Risk

Key measures of output 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.

¹² Not present in South Coast zone.

- 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.

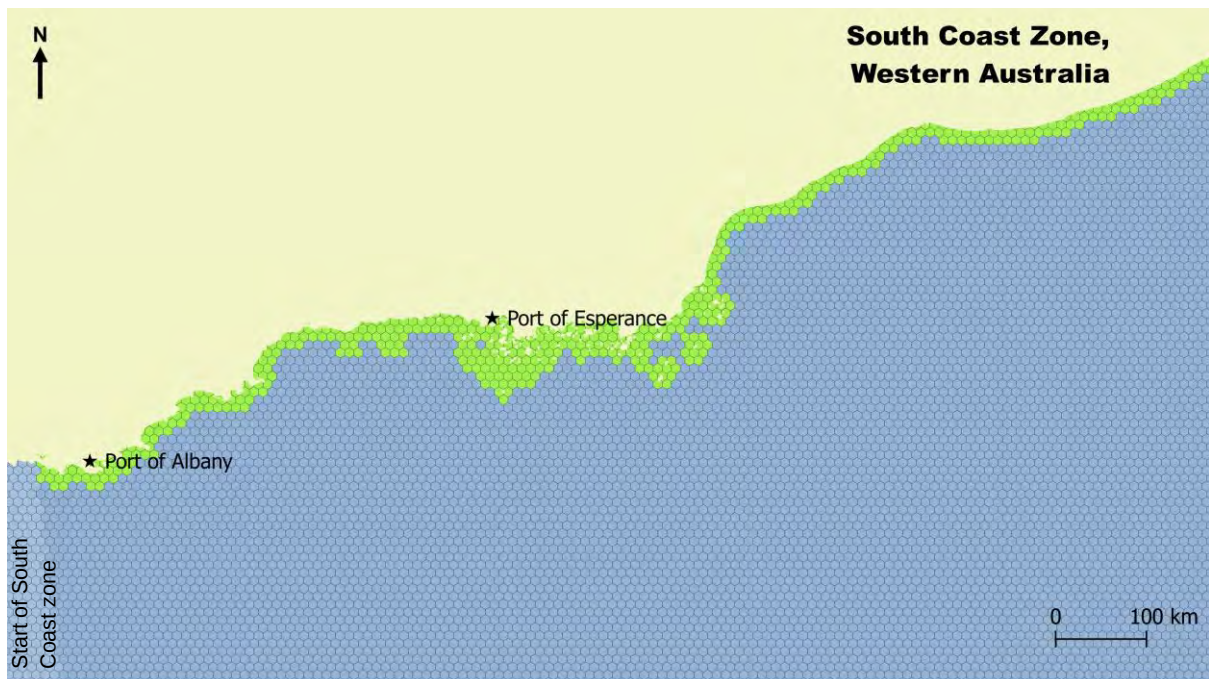
6. Results

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 6.2 and Figure 6.3. 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 for hexagon cells outside of the South Coast zone is not shown.

Figure 6.1 Physical Hazard Ratings



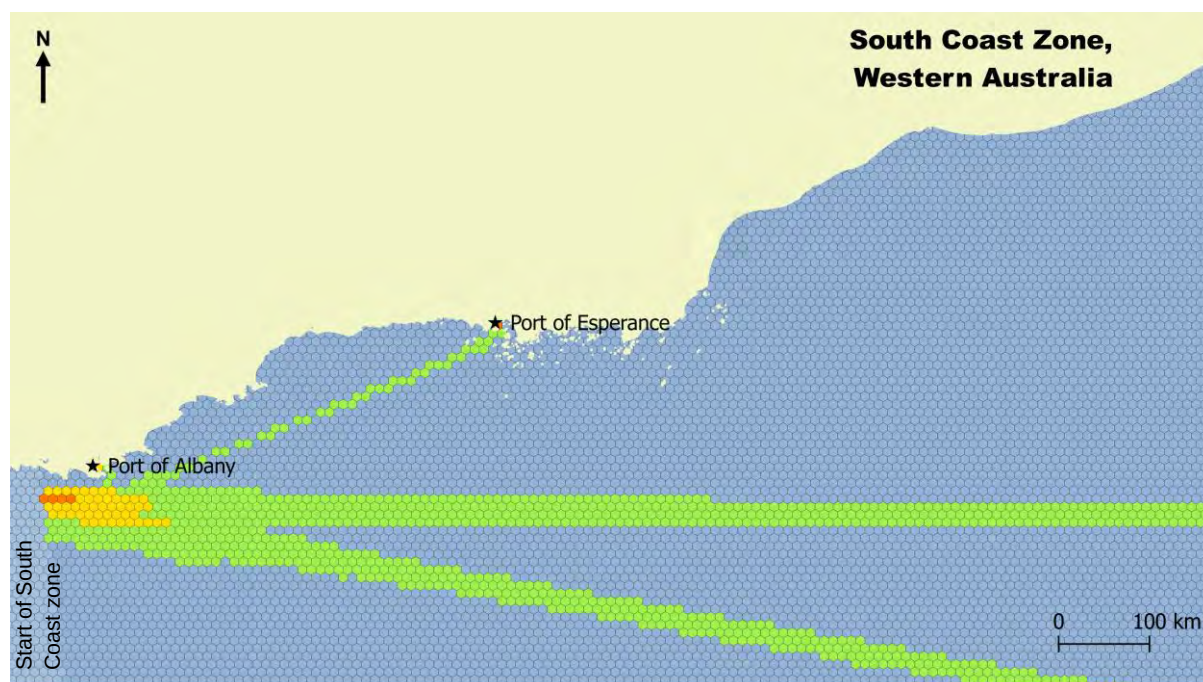
Cells near shore have a slightly increased physical hazard rating, however this rating is still low as there are no unusual (and therefore unexpected) navigational hazards in the South Coast zone.

Figure 6.2 Complexity Ratings



The only area of increased complexity is around the Port of Albany, however these cells still have a relatively low rating.

Figure 6.3 Activity Density Ratings



Activity density is highest at a transit point coming from the South Coast zone, which reduces as the traffic diverges in several directions near the Port of Albany. This is principally due to ships rounding the South Coast shore (eg. traffic transiting to ports in Victoria and Tasmania).

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 6.4 and a brief description of the driving factors is provided below.

Figure 6.4 Overall Navigational Hazard Ratings



Overall there is a lower assessed level of navigational hazard in the South Coast zone compared to some of the other zones (ie. Pilbara and Swan). The highest area of risk is within and slightly offshore from the Port of Albany.

Navigational hazard ratings for the Port of Albany is primarily driven by the complexity inherent in any port operation and access via a dredged channel. The offshore navigational hazard ratings are driven by activity density from ships transiting past the zone.

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 6.5 shows the shoreline exposure profile for the South Coast zone.

Figure 6.5 Shoreline Exposure



Key for Exposure



Figure 6.6 shows the proportion of shoreline exposure generated by each spill size band. More than a third of the oil expected to arrive at the South Coast zone shoreline is due to potential spills in the 500 – 5,000 tonne band. The 50 – 500 and 5,000 – 50,000 tonne bands each account for approximately a quarter of potential spills.

Figure 6.6 Proportion of Shoreline Exposure by Spill Size (tonnes)

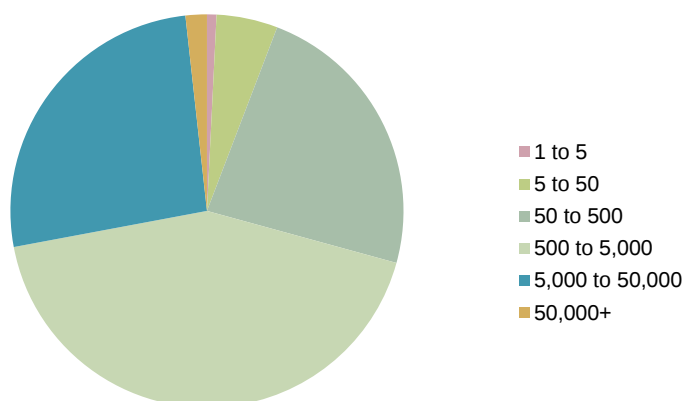


Figure 6.7 is similar to Figure 6.6 in that it shows the proportion of shoreline exposure generated by each spill size band. However, this measure of exposure is further broken down by sub-zone.

Sub-zone WA02 and WA04 have around 80% of the oil arriving between them. WA01 has no discernible percentage of oil arriving due to the low levels of shipping traffic in the vicinity of this coastline.

Figure 6.7 South Coast Shoreline Exposure by Spill Size (tonnes) and Sub-Zone

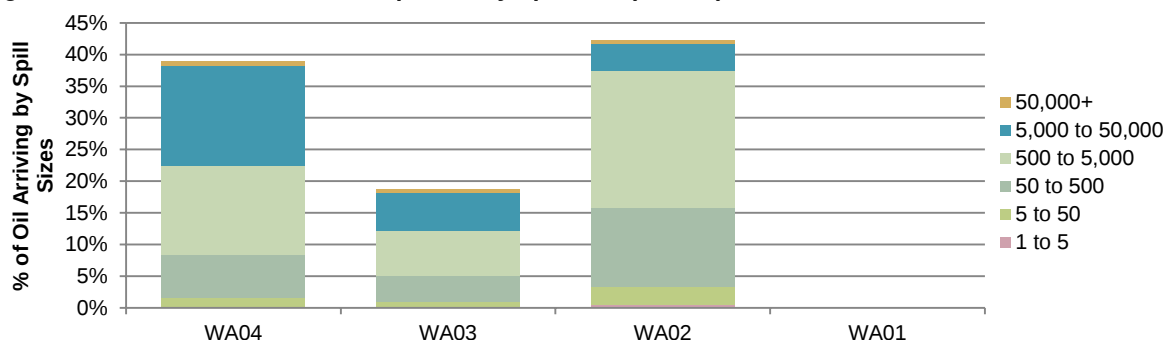
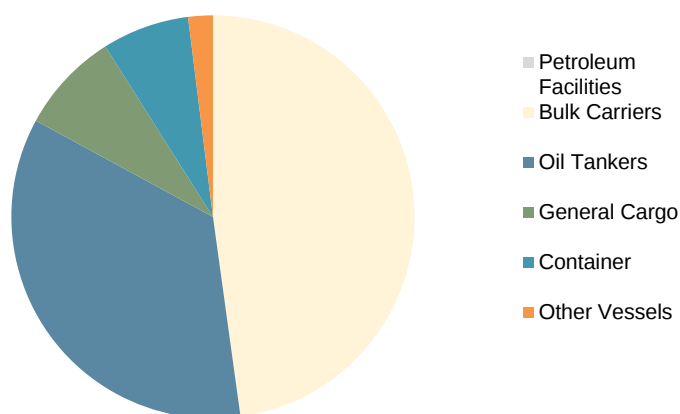


Figure 6.8 shows the proportion of shoreline exposure generated by each spill source. Almost half of the oil expected to arrive at the South Coast shoreline is due to potential spills from bulk carriers (mainly from transits through the zone). In addition, oil tankers make up over a third of the overall shoreline exposure.

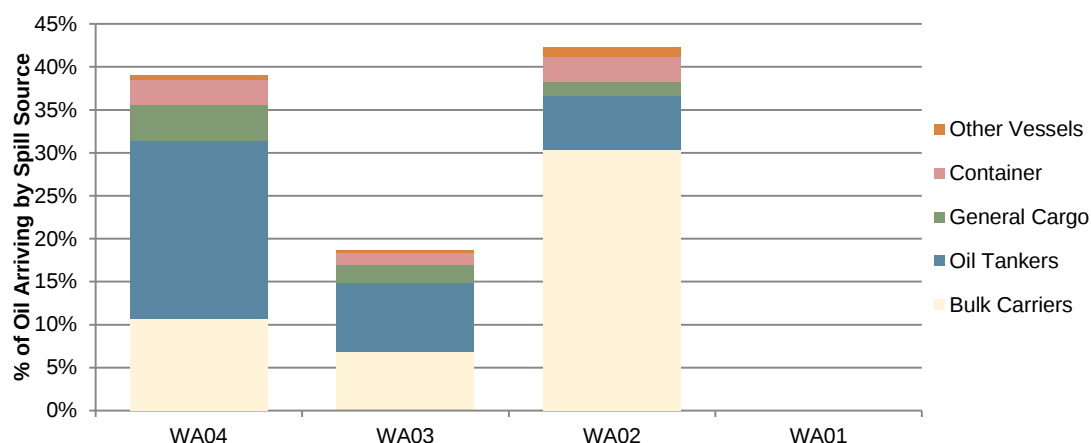
Figure 6.8 Proportion of Shoreline Exposure by Source (tonnes)



Note that the Other Vessels category includes chemical tankers, gas carriers and passenger vessels.

Figure 6.9 is similar to Figure 6.8 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.

Figure 6.9 South Coast Shoreline Exposure by Source and Sub-Zone



WA04 contains the Port of Esperance, and has a larger proportion of oil tankers contributing to shoreline exposure than other subzones, due to exports of petroleum from the port.

Sea Cell Exposure

Figure 6.10 shows the oil exposure profile for the hexagon sea cells within the South Coast zone.

Figure 6.10 Exposure Profile



Key for Exposure



Figure 6.11 shows the proportion of offshore exposure generated by each spill size band. The majority of exposure in the South Coast zone is due to spills in the 5,000 – 50,000 tonne range and in the 500 to 5,000 tonne range (about a third each).

Figure 6.11 Proportion of Hexagon Cell Exposure by Spill Size (tonnes)

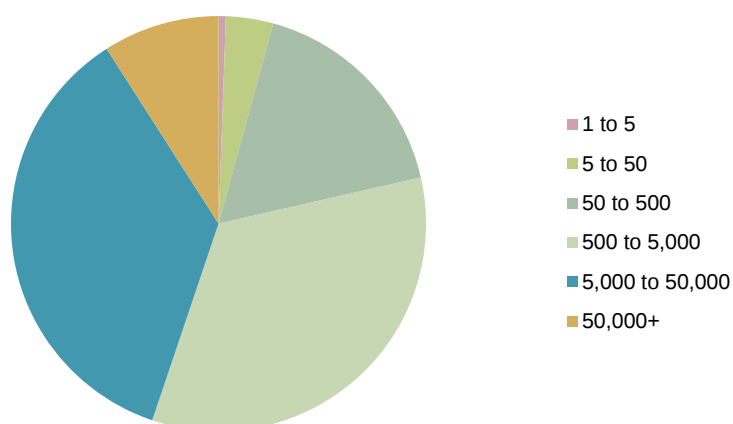
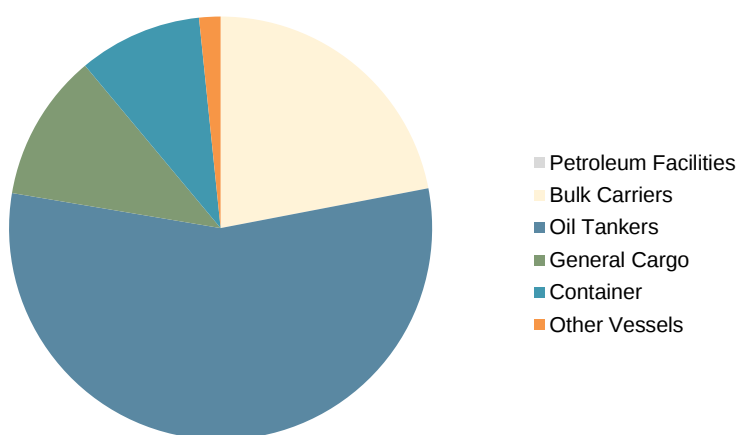


Figure 6.12 shows the proportion of offshore exposure generated by each spill source. The majority of exposure in the South Coast zone is due to potential spills from oil tankers.

Figure 6.12 Proportion of Hexagon Cell Exposure by Source (tonnes)



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

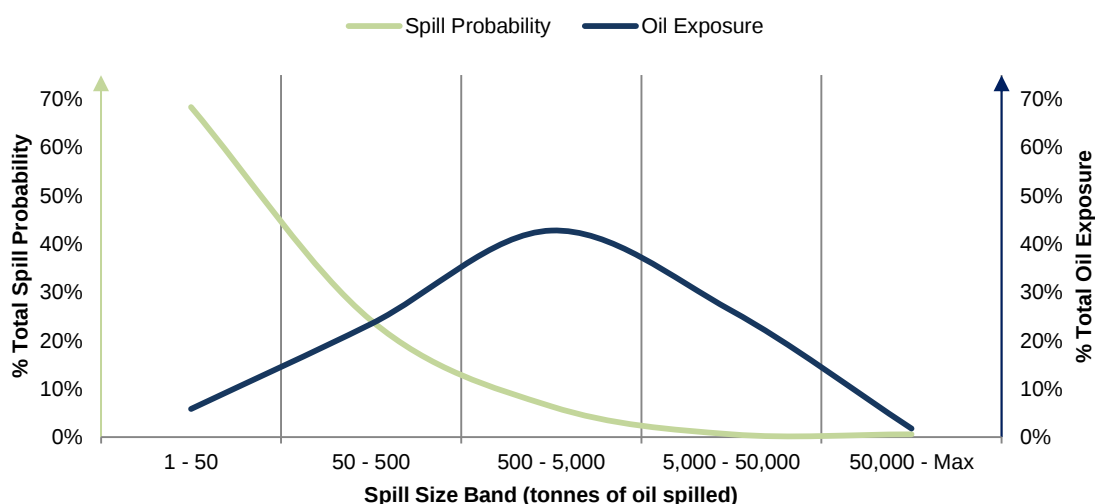
Exposure and Probability

The previous sections find that oil spill exposure in the South Coast region is largely driven by spills in the 500 – 5,000 tonne band, followed by the 50 – 500 and 5,000 – 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 South Coast zone is likely to come from larger incidents.

This is conceptually illustrated in Figure 6.13. 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 6.13 Conceptual Comparison of Spill Probability vs. Expected Oil



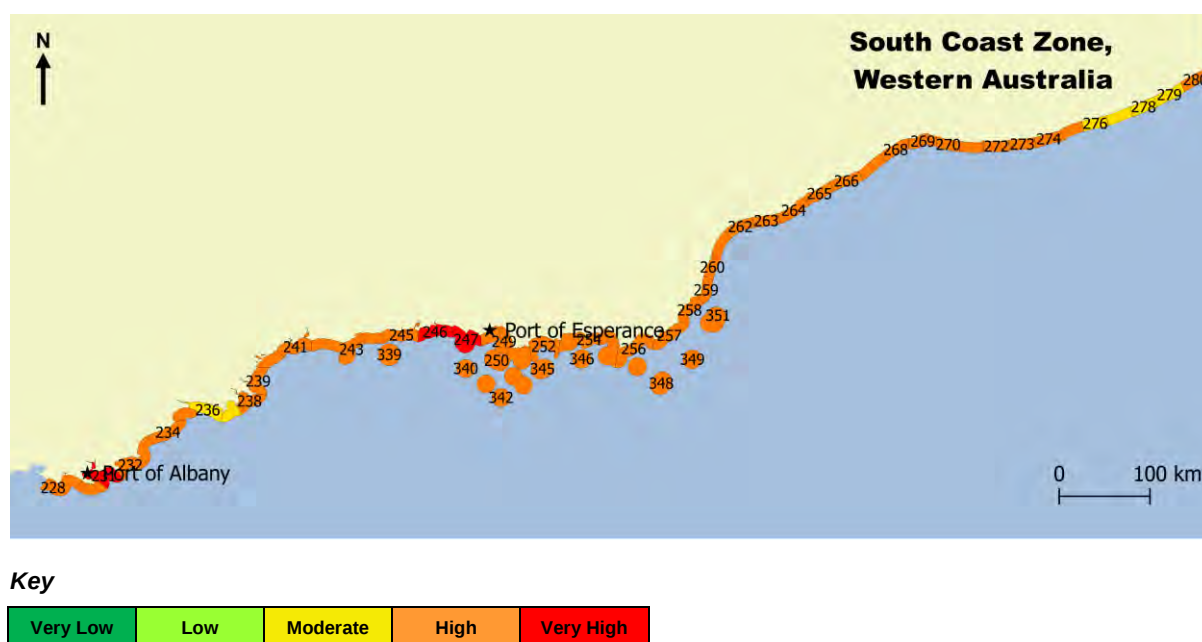
On the other hand, relative oil exposure (the blue curve) is very low for smaller spill sizes. Although these spills are more frequent, their contribution to the expected amount of oil is small. As spill size increases the contribution to total exposure also increases, peaking at the 500 – 5,000 spill size band and then decreasing.

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 6.14 shows the overall ranking for protection priorities in the South Coast zone.

Figure 6.14 Protection Priorities Overall Rankings



A sample of protection priority data is shown for the Port of Bunbury in Table 6.1. It shows the *overall* protection priorities ratings and comments for the Port of Bunbury. 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 South Coast zone report prepared by Advisian for the Department of Transport (Albany Port 2018) should be consulted for more context and information.

Table 6.1 Protection priorities for the Port of Esperance (based on Advisian 2017 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	Moderate	Low	Moderate	Birds: Cereopsis novaehollandiae grisea (Cape Barren Goose (south-western), Recherche Cape Barren Goose) :Breeding known to occur within area, Mammals: Eubalaena australis (Southern Right Whale) (EN) Breeding known to occur within area, Reptiles: Caretta caretta (Loggerhead Turtle) (EN) Breeding likely to occur within area, Dermochelys coriacea (Leatherback Turtle, Leathery Turtle, Luth) :Breeding likely to occur within area, Eubalaena australis (Southern Right Whale) :Species or species habitat known to occur within area, Puffinus carneipes (Ardenna carneipes) (flesh-footed shearwater, fleshy-footed shearwater): VU & IA: Specimen (WAM Vouchered), Puffinus huttoni (Hutton's shearwater) (EN) Observational (Moderately certain), Fish: Carcharodon carcharias (Great White Shark) (VU) Foraging, feeding or related behaviour known to occur within area and Species or species habitat known to occur within area, Geotria australis (pouched lamprey) (P1) Specimen (WAM Vouchered)	DPaW Protected Fauna (2 March 2017)
Protection Areas	High	High	High	Nature Reserve (Recherche Archipelago) (IUCN IA)	DotE CAPAD - Terrestrial and Marine (30 June 2014) with DPaW update (30 June 2016)
Cultural Heritage	Moderate	Moderate	Moderate	State Heritage: Tanker Jetty, Esperance Cmlth Protected Shipwreck: Ettie	State Register: State Protected Heritage (2016),DotE Australian National Shipwrecks Database (3 February 2016)
Economic	Moderate	Moderate	Moderate	Port: Esperance	Port
Social Amenity and Recreation	Low	Very Low	Low	Beaches (Esperance)	Proxy dataset Advisian created, April 2017
Overall	High	High	High	Nature Reserve (Recherche Archipelago) (IUCN IA)	DPaW Protected Fauna (2 March 2017) DoE CAPAD (2014)

Table 6.2 Protection priorities for the Port of Albany (based on Advisian 2017 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) Roosting known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Roosting known to occur within area	DPaW Protected Fauna (2 March 2017)
Protection Areas	High	High	High	Nature Reserve (Mistaken Island, Green Island, Breaksea Island, Michaelmas Island, Seal Island) (IUCN IA), Important Wetland: Oyster Harbour	DotE CAPAD - Terrestrial and Marine (30 June 2014) with DPaW update (30 June 2016) ,DPaW Managed Lands and Waters (2015)
Cultural Heritage	Moderate	Moderate	Moderate	State Heritage: Cheyne Beach Whaling Station, Ballymena, Whaling Cove (Ruins), Breaksea Island and Lighthouse, Quaranup Complex, Point King Lighthouse Ruin, Lower Kalgan River Bridge & Jetty Group, Albany Town Jetty, Frenchman Bay Whaling Station (fmr) Municipal Inventory Place: Shell Grit Mill, Cheyne Beach Whaling Station , Ballymena , Whaling Cove (Ruins), Ellen Cove Jetty & Norfolk Island Pine Trees, Government Jetty, Oyster Harbour Fish Trap Site, Middleton Beach, Lower Kalgan River Road Bridge, Quaranup Complex, Point Henty, Albany Deepwater Jetty, Point King Lighthouse Ruin, Lower Kalgan River Bridge & Jetty Group, Albany Town Jetty, Balgownie Cmlth Protected Shipwreck: Ada, Athena, Awhina, Ben Dearg, Bruce, Camel, Cheynes ex Toern, Cheynes II, Cheynes III, Cheynes IV, Colonna (ex Sierra Colonna), Copeland ex Jane Sprott ex Copeland Island, Fairy, Fram, Gio Batta Repetto, Goode Beach unidentified, Herschel, Jessie, Kingfisher, Lady Lyttleton, Lenita, Lighter, Lucy (Lucky), Margaret, Northumberland, Perth II HMAS, Rip, Sarah Burnyeat, St Laurence, St Lawrence, The Bruce, Unidentified Macey's Wreck	State Register: State Protected Heritage (2016),State Protected Heritage: Municipal Inventory 2016, DotE Australian National Shipwrecks Database (3 February 2016)
Economic	Low	Low	Low	Abalone Managed Fishery, Aquaculture Site, Seawater Intake: Albany Aquaculture Park - WA Shellfish Hatchery,Port: Albany	Dept of Transport (2016),Port
Social Amenity and Recreation	Low	Very Low	Low	Beaches (Albany)	Proxy dataset Advisian created, April 2017
Overall	Very High	High	Very High	Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Roosting known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Roosting known to occur within area, Important Wetland (Oyster Harbour)	DPaW Protected Fauna (2 March 2017)

6.4. South Coast Risk Profile Results

This section outlines the main risk results for the South Coast zone. Figure 6.16 shows a heat map of risk ratings in each of the South Coast zone shoreline cells.

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 6.15). The second highest cell (101) is Port Walcott. More detail can be found in the Pilbara Zone Report.

Figure 6.15 - Pilbara Risk Profile (ten highest shoreline cells)

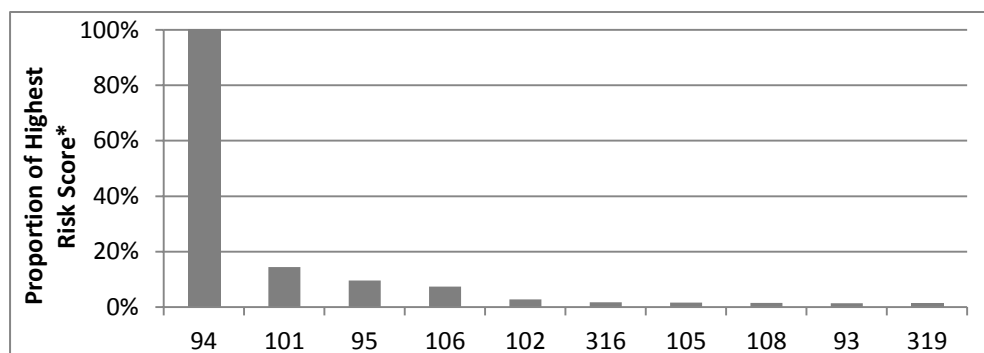


Figure 6.17 shows a column chart of relative risk scores for each shoreline cell in the South Coast Zone. The black column represents shoreline cell #248 (Observatory Point – Coomalbidgup (Port of Esperance)), the cell with the highest risk score in the South Coast zone. The chart uses a log scale for the vertical axis.

Figure 6.16 South Coast Risk Profile Heat Map

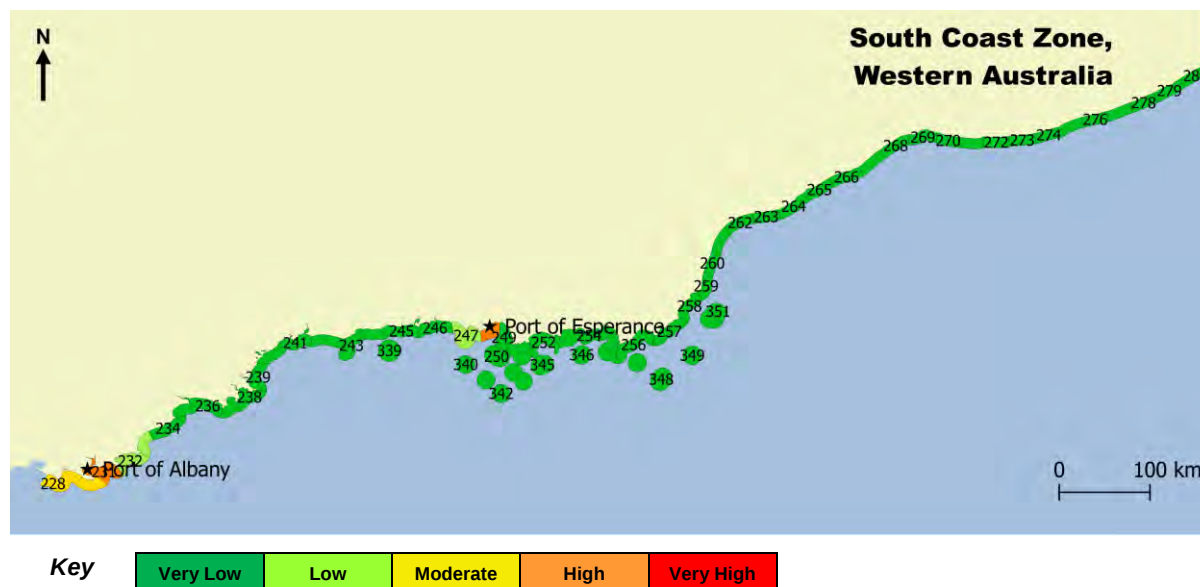
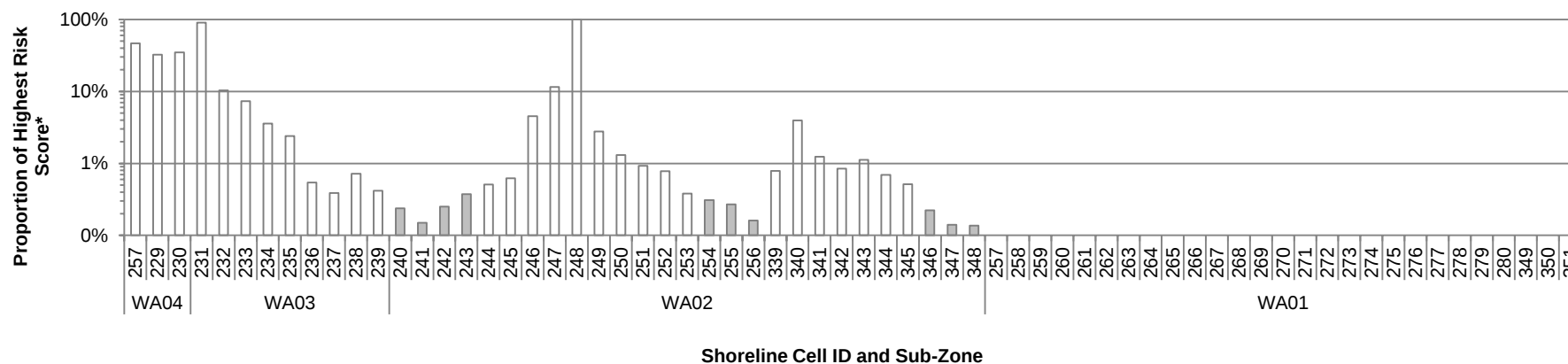


Figure 6.17 South Coast Risk Profile Relative Risk Scores



* 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 #248 Observatory Point – Coomalbidgup (Port of Esperance)
2. ID #231 Cape Vancouver - Herald Point E (Port of Albany)
3. ID #228 Mutton Bird promontory - Torbay Head (A)

6.5. Sub-Zone Drill Down

Overview

The following sections contain a brief summary for each of the three sub-zones within the South Coast 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.

WA01 Sub-Zone Summary

Figure 6.18 shows the count of each cell rating within the WA01 Sub-Zone (cells 257 to 280). Figure 6.19 depicts these cell ratings on a heat map.

Figure 6.18 WA01 Sub-Zone Cell Counts

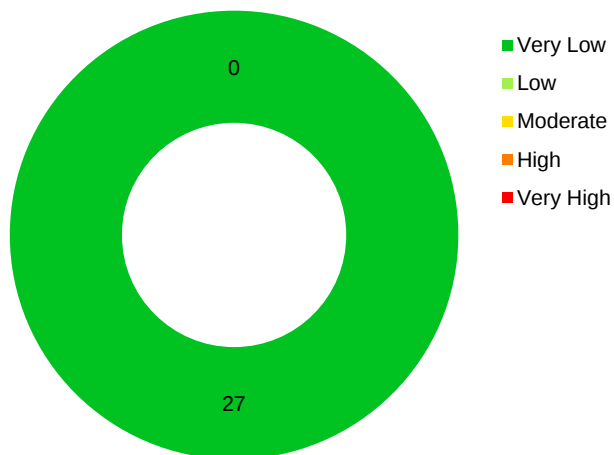


Figure 6.19 WA01 Sub-Zone Risk Profile



The overall risk in this sub-zone is low, with all cells having a very low risk rating. The table on the following page summarises risk and protection priority information for this sub-zone.

WA01 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
257	Israelite Bay N - Point Malcolm (A)	Very Low		High						Nature Reserve (Recherche Archipelago, Nuytsland) (IUCN IA)	Bulk Carriers, Oil Tankers
258	Israelite Bay N - Point Malcolm (B)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area Nature Reserve (Recherche Archipelago, Nuytsland) (IUCN IA)	Oil Tankers, Bulk Carriers, General Cargo
259	Israelite Bay N - Point Malcolm (C)	Very Low		High						Birds: Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area Nature Reserve (Recherche Archipelago, Nuytsland) (IUCN IA)	Oil Tankers, Bulk Carriers, General Cargo
260	Wattle Camp - Israelite Bay N (A)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area Mammals: Eubalaena australis (Southern Right Whale) (EN) Calving (high numbers) (Known to occur), Nature Reserve (Nuytsland) (IUCN IA), Seagrass	Oil Tankers, Bulk Carriers, General Cargo, Container
261	Wattle Camp - Israelite Bay N (B)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area Mammals: Eubalaena australis (Southern Right Whale) (EN) Calving (high numbers) (Known to occur) Nature Reserve (Nuytsland) (IUCN IA), Seagrass	Oil Tankers
262	Point Culver - Wattle Camp	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area, Mammals: Eubalaena australis (Southern Right Whale) (EN) Calving (high numbers) (Known to occur), Nature Reserve (Nuytsland) (IUCN IA), Seagrass	Oil Tankers
263	Point Dover - Point Culver (A)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	Oil Tankers
264	Point Dover - Point Culver (B)	Very Low		High						Nature Reserve (Nuytsland) (IUCN IA)	Oil Tankers
265	Point Dover - Point Culver (C)	Very Low		High						Nature Reserve (Nuytsland) (IUCN IA)	Oil Tankers

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
266	Twilight Cove - Point Dover (A)	Very Low		High						Nature Reserve (Nuytsland) (IUCN IA)	Oil Tankers
267	Twilight Cove - Point Dover (B)	Very Low		High						Nature Reserve (Nuytsland) (IUCN IA)	Oil Tankers, Bulk Carriers
268	Scorpion Bight - Twilight Cove (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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass Cmlth Protected Shipwreck: Swift	Oil Tankers, Bulk Carriers
269	Scorpion Bight - Twilight Cove (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) Species or species habitat known to occur within area, Reptiles: <i>Caretta caretta</i> (loggerhead turtle) (EN) Specimen (WAM Vouchered), Nature Reserve (Nuytsland) (IUCN IA), Seagrass Cmlth Protected Shipwreck: Unidentified Cargo Boat	
270	Scorpion Bight - Twilight Cove (C)	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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	Bulk Carriers
271	Scorpion Bight - Twilight Cove (D)	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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	
272	Scorpion Bight - Twilight Cove (E)	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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	
273	Red Rocks Point - Scorpion Bight	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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	
274	WA-SA Border - Red Rocks Point (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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA), Seagrass	

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
275	WA-SA Border - Red Rocks Point (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) Species or species habitat known to occur within area, Nature Reserve (Nuytsland) (IUCN IA)	
276	WA-SA Border - Red Rocks Point (C)	Very Low		Moderate						Reptiles: <i>Caretta caretta</i> (Loggerhead Turtle) (EN) Breeding likely to occur within area, <i>Dermochelys coriacea</i> (Leatherback Turtle, Leathery Turtle, Luth) (EN) Breeding likely to occur within area, Mammals: <i>Eubalaena australis</i> (Southern Right Whale) (EN) Breeding known to occur within area, Sheltered rocky shores	
277	WA-SA Border - Red Rocks Point (D)	Very Low		Moderate						Reptiles: <i>Caretta caretta</i> (Loggerhead Turtle) (EN) Breeding likely to occur within area, <i>Dermochelys coriacea</i> (Leatherback Turtle, Leathery Turtle, Luth) (EN) Breeding likely to occur within area, Mammals: <i>Eubalaena australis</i> (Southern Right Whale) Breeding known to occur within area, Seagrass, Sheltered rocky shores	
278	WA-SA Border - Red Rocks Point (E)	Very Low		Moderate						Reptiles: <i>Caretta caretta</i> (Loggerhead Turtle) (EN) Breeding likely to occur within area, <i>Dermochelys coriacea</i> (Leatherback Turtle, Leathery Turtle, Luth) (EN) Breeding likely to occur within area, Mammals: <i>Eubalaena australis</i> (Southern Right Whale) (EN) Breeding known to occur within area, Seagrass, Sheltered rocky shores	
279	WA-SA Border - Red Rocks Point (F)	Very Low		Moderate						Reptiles: <i>Caretta caretta</i> (Loggerhead Turtle) Breeding likely to occur within area, <i>Dermochelys coriacea</i> (Leatherback Turtle, Leathery Turtle, Luth) Breeding likely to occur within area Mammals: <i>Eubalaena australis</i> (Southern Right Whale) Breeding known to occur within area, Seagrass	
280	WA-SA Border - Red Rocks Point (G)	Very Low		High						CAPAD: IUCN IB (Wilderness Protection Area), CAPAD: IUCN IA(Marine Park) Marine Park (Far West Coast) (IUCN IA)	
349	Point Culver - Cape Pasley	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Oil Tankers, Bulk Carriers, General Cargo, Container
350	Israelite Bay N - Point Malcolm (D)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers, General Cargo
351	Israelite Bay N - Point Malcolm (E)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Oil Tankers, Bulk Carriers, General Cargo
Key for Risk and Protection Priorities											Key for Exposure
Very LowLowModerateHighVery High											LowestHighest

WA02 Sub-Zone Summary

Figure 6.20 shows the count of each cell rating within the WA02 Sub-Zone (Cells 204 to 256). Figure 6.21 depicts these cell ratings on a heat map.

Figure 6.20 WA02 Sub-Zone Cell Counts

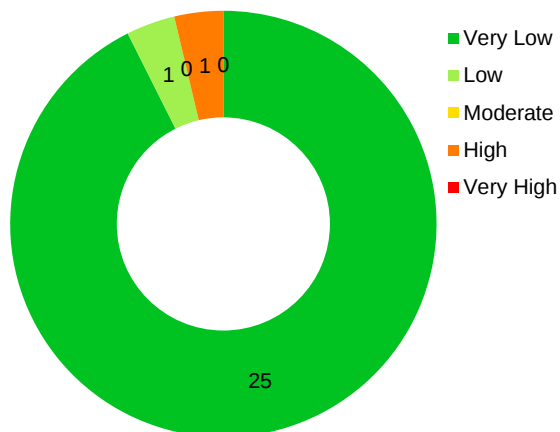
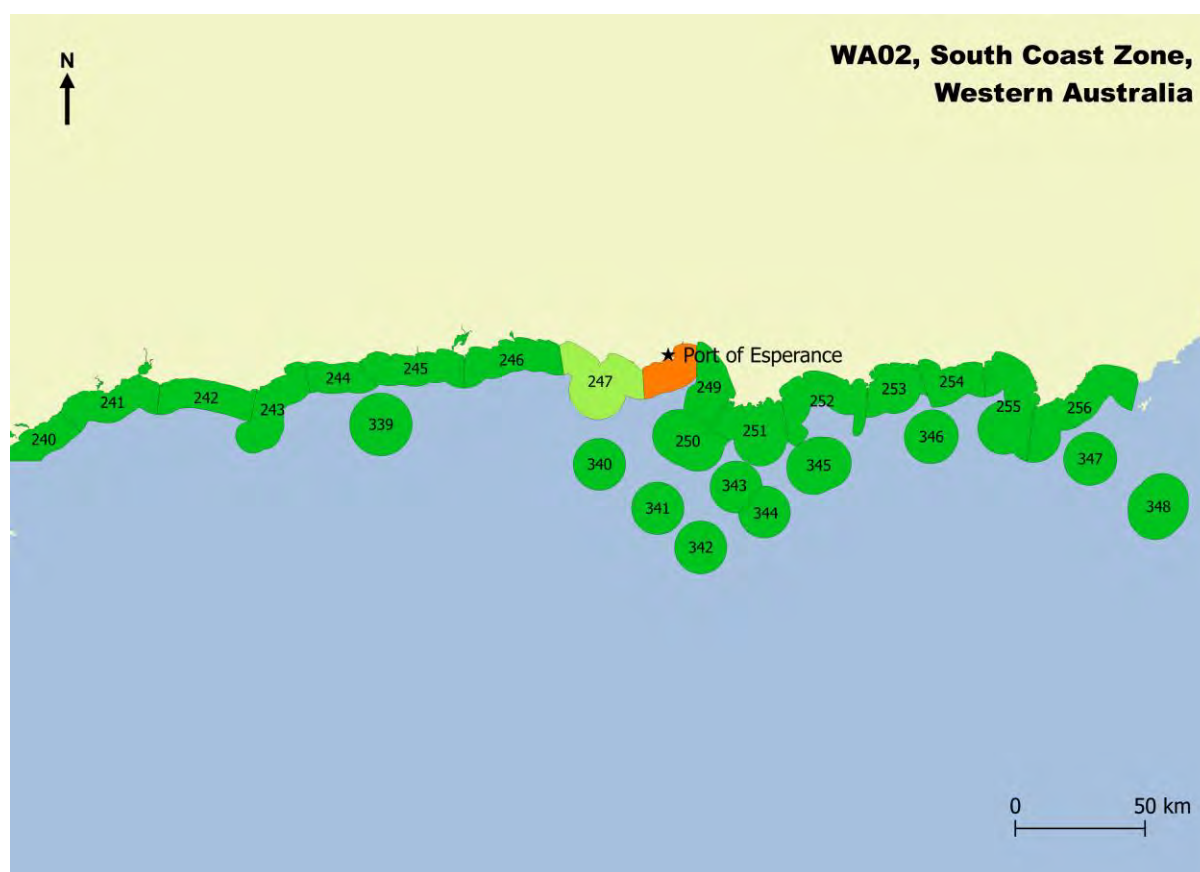


Figure 6.21 WA02 Sub-Zone Risk Profile



The risk in this sub-zone is relatively low, with the majority of cells having a very low risk rating. The table on the following page summarises the risk and protection priority information for this sub-zone. There is one cell with a high risk, which contains the Port of Esperance.

WA02 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
240	Edwards Point - Red Island	Very Low		High						Important Wetland (Fitzgerald Inlet System) National Heritage, Fitzgerald River-Ravensthorpe Range Area	Oil Tankers, Bulk Carriers, Container, General Cargo
241	Mary Ann Point - Edwards Point	Very Low		High						Important Wetland (Culham Inlet System) National Heritage, Fitzgerald River-Ravensthorpe Range Area	Bulk Carriers, Oil Tankers, Container
242	Munglinup Point - Mason Bay (A)	Very Low		High						Nature Reserve (Jerdacuttup Lakes) (IUCN IA), Seagrass, Sheltered rocky shores & Sheltered seawalls	Bulk Carriers, Oil Tankers
243	Munglinup Point - Mason Bay (B)	Very Low		High						Nature Reserve (Lake Shaster) (IUCN IA), Seagrass	Bulk Carriers, Oil Tankers
244	Shoal Cape - Munglinup Point	Very Low		High						Nature Reserve (Lake Shaster) (IUCN IA), Seagrass	Bulk Carriers, Oil Tankers
245	Coomalbidgup - Shoal Cape (A)	Very Low		High						Birds: Calidris ferruginea (Curlew Sandpiper) (CR) Species or species habitat known to occur within area, Numenius madagascariensis (Eastern Curlew) (CR) Species or species habitat known to occur within area, Nature Reserve (Lake Shaster) (IUCN IA), Seagrass, Broadscale Seagrass, Sheltered rocky shores Cmlth Protected Shipwreck: Dunster Castle	Bulk Carriers, Oil Tankers
246	Coomalbidgup - Shoal Cape (B)	Very Low		Very High						Ramsar Wetland (Lake Gore)	Bulk Carriers, Oil Tankers
247	Coomalbidgup - Shoal Cape (C)	Low		Very High						Ramsar Wetland (Lake Gore)	Bulk Carriers, Oil Tankers
248	Observatory Point - Coomalbidgup	High		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
249	Wylie Head - Dempster Head	Very Low		High						Nature Reserve (Recherche Archipelago, Woody Island) (IUCN IA)	Bulk Carriers, Oil Tankers
250	Cape Le Grand - Observatory Point	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
251	Hammer Head - Mississippi Point (A)	Very Low		High						Reptiles: Caretta caretta (loggerhead turtle) (EN) Specimen (WAM Voucher), Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
252	Hammer Head - Mississippi Point (B)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
253	Tagon Point - Ben Island	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
254	Cape Arid - Tagon Point (A)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
255	Cape Arid - Tagon Point (B)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
256	Cape Arid - Tagon Point (C)	Very Low		High						Nature Reserve (Recherche Archipelago) (IUCN IA)	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
339	Shoal Cape - Red Island	Very Low									
340	Cape Pasley - Shoal Cape (A)									Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
341	Cape Pasley - Shoal Cape (B)									Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
342	Cape Pasley - Shoal Cape (C)									Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
343	Cape Pasley - Shoal Cape (D)									Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
344	Cape Pasley - Shoal Cape (E)									Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers
										Nature Reserve (Recherche Archipelago) (IUCN IA)	Bulk Carriers, Oil Tankers, Container, General Cargo
										Day sighting (Certain) Nature Reserve (Recherche Archipelago) (IUCN IA)	Oil Tankers, Bulk Carriers, General Cargo, Container

Key

Very Low	Low	Moderate	High	Very High
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Key for Exposure



WA03 Sub-Zone Summary

Figure 6.22 shows the count of each cell rating within the WA03 Sub-Zone (Cells 231 to 239). Figure 6.23 depicts these cell ratings on a heat map.

Figure 6.22 WA03 Sub-Zone Cell Counts

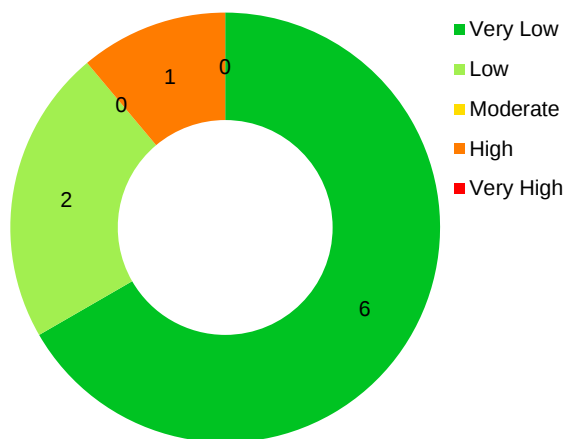
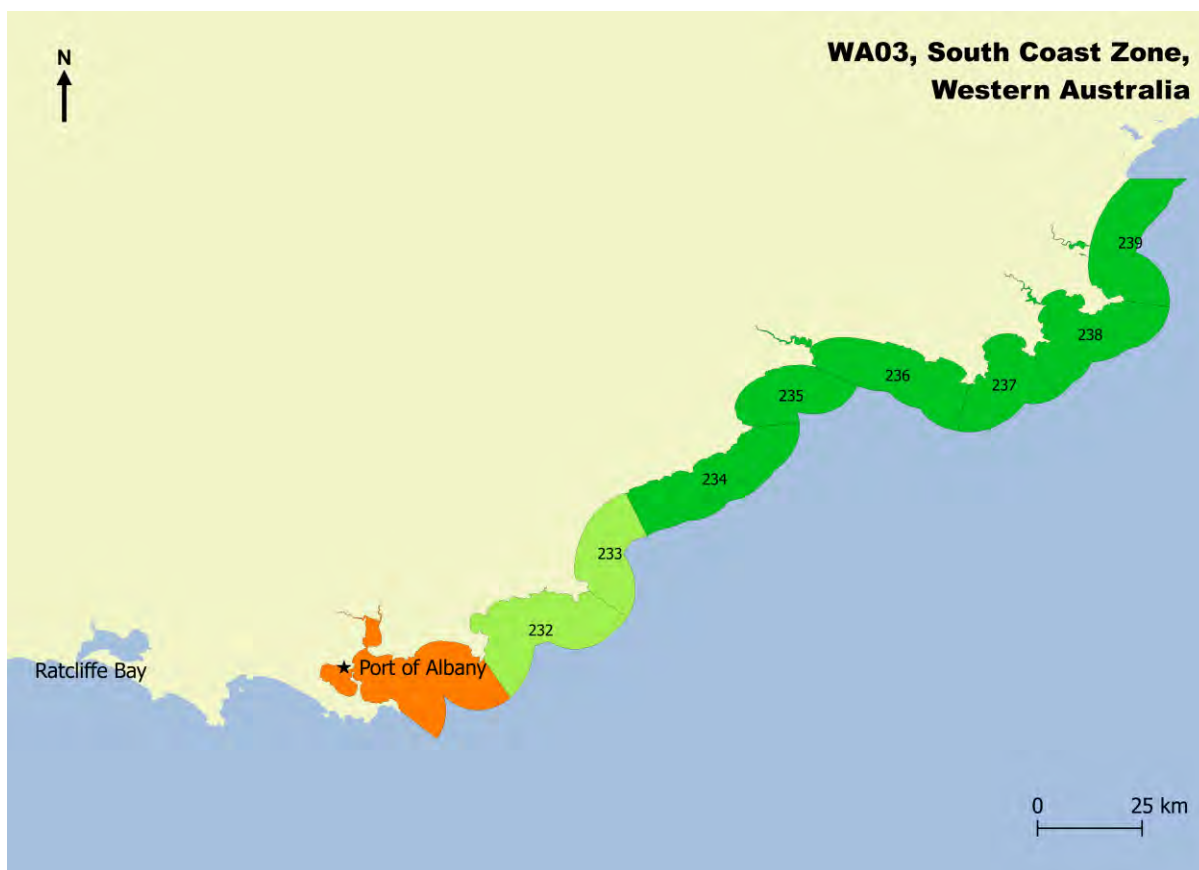


Figure 6.23 WA03 Sub-Zone Risk Profile



The majority of cells in this subzone have a very low risk rating, with one high risk rating in the cell containing the Port of Albany. The table on the following page summarises the risk and protection priority information for this sub-zone.

WA03 Summary Table

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
231	Cape Vancouver - Herald Point E									Birds: <i>Calidris ferruginea</i> (Curlew Sandpiper) (CR) Roosting known to occur within area, <i>Numenius madagascariensis</i> (Eastern Curlew) (CR) Roosting known to occur within area,	Oil Tankers, Bulk Carriers, General Cargo
232	Hassell Beach NE - Bald Island (A)									Nature Reserve (Bald Island, Mount Manypeaks) (IUCN IA), Important Wetlands (Moates Lake System)	Oil Tankers, Bulk Carriers, General Cargo
233	Hassell Beach NE - Bald Island (B)									(black-browed albatross) (EN & IA) Day sighting (Certain), Nature Reserve (Bald Island) (IUCN IA), Seagrass, State	Oil Tankers, Bulk Carriers, General Cargo
234	Cape Riche - Hassell Beach NE										
		Very Low		Moderate							
237	Point Henry - Cape Knob	Very Low								Reptiles: <i>Caretta caretta</i> (Loggerhead Turtle) (EN) Breeding likely to occur within area & Foraging, feeding or related behaviour known to occur within area & Species or species habitat known to occur within area, <i>Dermochelys coriacea</i> (Leatherback Turtle, Leathery Turtle, Luth) (EN) Breeding likely to occur within area, Mammals: <i>Eubalaena australis</i> (Southern Right Whale) (EN) Breeding known to occur in the area & Species or species habitat known to occur within area, <i>Balaenoptera musculus brevicauda</i> (Pygmy Blue Whale) (EN) as <i>Balaenoptera musculus</i> Distribution (Known to occur), National Park (Fitzgerald River) (IUCN II), Seagrass	Oil Tankers, Bulk Carriers, General Cargo, Container
238	Point Ann - Point Hood (A)									Nature Reserve (Glasse Island) (IUCN IA) National Heritage, Fitzgerald River-Ravensthorpe Range Area	Oil Tankers, Bulk Carriers, Container, General Cargo
239	Point Ann - Point Hood (B)									Nature Reserve (Doubtful Islands) (IUCN IA), National Heritage, Fitzgerald River-Ravensthorpe Range Area	Oil Tankers, Bulk Carriers, Container, General Cargo

Key

Very Low	Low	Moderate	High	Very High
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Key for Exposure

Lowest		Highest
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WA04 Sub-Zone Summary

Figure 6.18 shows the count of each cell rating within the WA04 Sub-Zone (cells 228 to 230). Figure 6.24 depicts these cell ratings on a heat map.

Figure 6.24 WA04 Sub-Zone Cell Counts

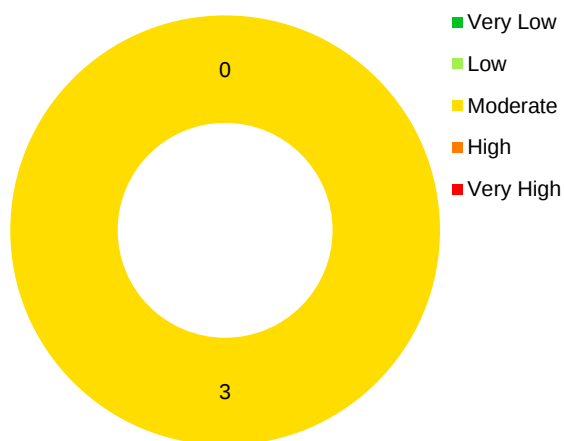
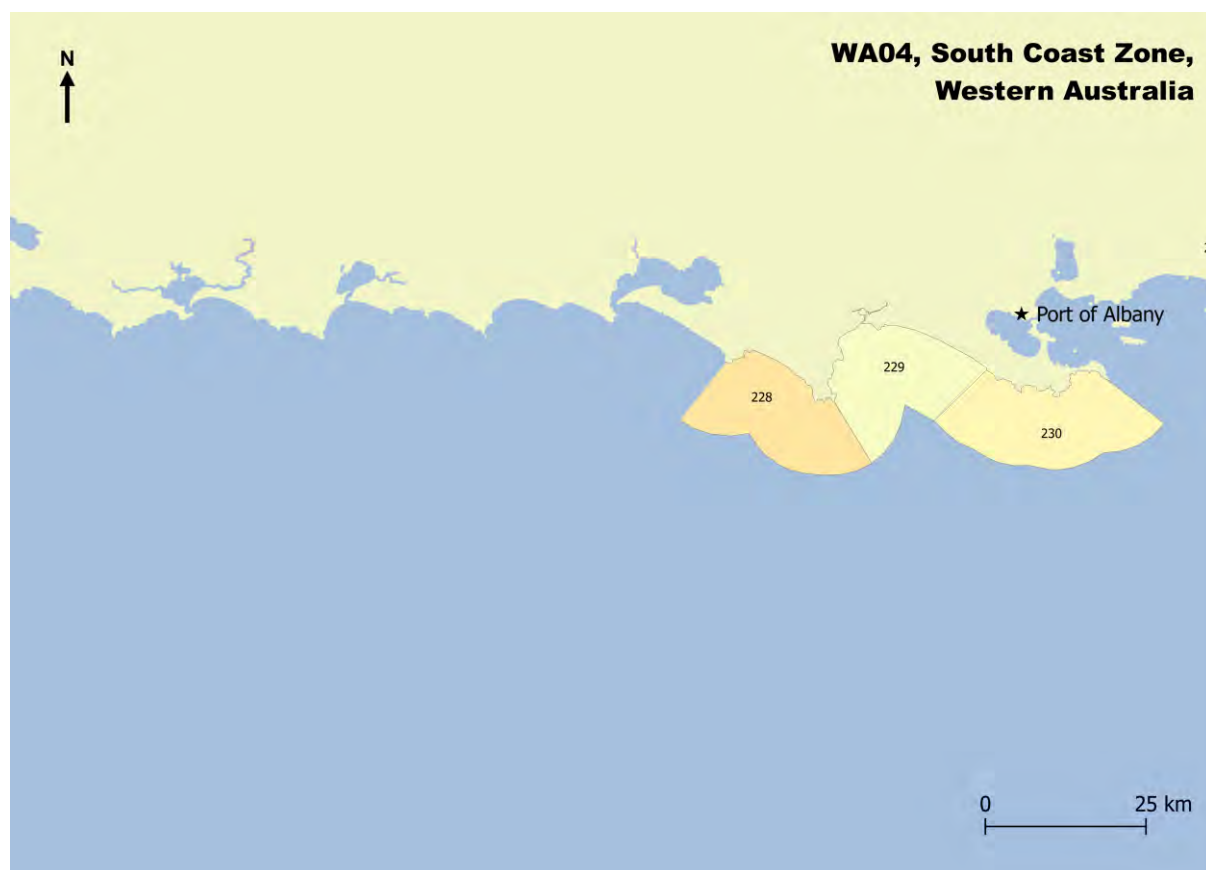


Figure 6.25 WA04 Sub-Zone Risk Profile



The overall risk in this sub-zone is moderate, with all cells having a moderate risk rating. The table on the following page summarises risk and protection priority information for this sub-zone.

WA04 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
228	Mutton Bird promontory - Torbay Head (A)									Reptiles: <i>Caretta caretta</i> (loggerhead turtle) (EN) Caught or trapped (Certain) Seagrass, Sheltered rocky shores Cmlth Protected Shrublands: <i>Vitex</i>	Oil Tankers, Bulk Carriers, General Cargo
229	Mutton Bird promontory - Torbay Head (B)									Nature Reserve (Shelter Island) (IUCN IA), Seagrass, Sheltered rocky shores	Oil Tankers, Bulk Carriers, General Cargo
230	Family Rocks - Mutton Bird promontory	Moderate								Birds: <i>Phoebastria fusca</i> (sooty albatross) (EN & IA) Day sighting (Certain), <i>Thalassarche carteri</i> (Indian yellow-nosed albatross) (EN & IA) Day sighting (Certain), <i>Thalassarche melanophris</i> (black-browed albatross) (EN & IA) Day sighting (Certain) Fish: <i>Carcharodon carcharias</i> (great white shark) (VU) Caught or trapped (Certain) Nature Reserve (Eclipse Island) (IUCN IA), Seagrass State Heritage: Eclipse Island & Lighthouse	Oil Tankers, Bulk Carriers, General Cargo

Key

Very Low	Low	Moderate	High	Very High
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Key for Exposure

Lowest	Highest
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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 South Coast zone. This report summarises the context, methodology and results for the South Coast Risk Assessment Zone. It builds on the work undertaken in the preliminary state-wide assessment.

Most sub-zones in the South Coast region have a relatively low risk profile. The highest risk area is around the Port of Esperance, followed by the Port of Albany. While Esperance port does not pose unusual levels of navigational challenges (other than the inherent complexity of any port operation), there are a significant number of oil tanker and bulk carrier movements at the port. Other high risk areas include the coast between Ratcliffe Bay and the Port of Albany.

The overall the level of risk-generating activity in the South Coast region is relatively low. There is no petroleum production in this region, although there are exploration permits (Bight Basin).

This companion report summarises the WAMOPRA results for the South Coast 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).

8. References

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