Managing Growth and Channel Risk - Port Hedland
Why is the Port Hedland Channel so important

• Western Australia produces over one quarter of the World’s iron ore (26% in 2012)
• Importantly WA export volumes account for 42% of global shipments
• WA has averaged annual export growth of 11% over 10 years to 2012-13
• In 2012-13 WA contributed 47% of Australia’s merchandise exports ($), more than NSW, Victoria & Queensland combined (45%) (Source DSD WA)
• Will it continue?
Australia confirms its position as the world's largest iron ore exporter
Port Hedland’s contribution

- 2012-13 throughput 288.4MT (280.2MT Iron Ore)
- Represents ~ 57% of Australia’s gross exports
- 4140 Ship movements in 2012-13
- 2013-14 forecast is 340+MT
- Forecasting 4800+ ship movements in 2013-14
- Averaged 20% growth 2009-2014
- Port Hedland is responsible for approximately 24% of global seaborne iron ore trade
Port Hedland is the world's largest bulk export port.

Iron Ore Exports

- Australia
- Brazil
- South Africa
- Canada
- Other

Other Sources: BREE; Bloomberg; UNCTAD
Iron Ore Resources (million tonnes)

<table>
<thead>
<tr>
<th>Region</th>
<th>Demonstrated</th>
<th>Inferred</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pilbara</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable</td>
<td>18,991</td>
<td>22,475</td>
</tr>
<tr>
<td>Sub-economic</td>
<td>4,718</td>
<td>15,665</td>
</tr>
<tr>
<td>Magnetite</td>
<td>5,644</td>
<td>6,775</td>
</tr>
<tr>
<td><strong>Kimberley</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable</td>
<td>66</td>
<td>16</td>
</tr>
<tr>
<td>Sub-economic</td>
<td>577</td>
<td>19</td>
</tr>
<tr>
<td><strong>Mid West</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable</td>
<td>335</td>
<td>178</td>
</tr>
<tr>
<td>Sub-economic</td>
<td>75</td>
<td>156</td>
</tr>
<tr>
<td>Magnetite</td>
<td>5,729</td>
<td>7,617</td>
</tr>
<tr>
<td><strong>Central Yilgarn</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketable</td>
<td>124</td>
<td>58</td>
</tr>
<tr>
<td>Sub-economic</td>
<td>372</td>
<td>123</td>
</tr>
<tr>
<td>Magnetite</td>
<td>2,067</td>
<td>4,947</td>
</tr>
<tr>
<td><strong>South Coast</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetite</td>
<td>510</td>
<td>711</td>
</tr>
</tbody>
</table>

Source: DSD, Current as at May 2013.
WA Iron Ore Export Volumes

Sources: ABS 5368.0 International Trade in Goods and Services; DMP, Resource Data Files
The China Story so far

- In 2012 China imports reached 745MT out of a total World trade of 1.12BT’s (66%)
- By 2018 China’s imports are expected to reach 998MT out of a total World trade of 1.49BT’s (67%)
- WA’s export volumes to China rose from 53MT to 380MT (dry) over the 10 years to 2012-13
- China now represents 74% of all WA iron ore exports
WA Iron Ore Export Volumes

Sources: ABS 5368.0 International Trade in Goods and Services; DMP, Resource Data Files
Iron Ore Exporter’s cost ratio’s

October 2013 CFR Cost of China’s Iron Ore Supply – August 2013
(including royalties & freight)

Source: Metalytics
Mining accounts for 35% of the WA Gross State Product (GSP)

Source: ABS 5220.0 State Accounts
Economic Impacts

• Treasury forecasts for 2013-14 indicate total Mineral/Petroleum Royalties to be $5.8B
• Represents 21% of State Budget revenue
• Iron Ore contributes 85%
• So if Port Hedland contributes ~57% of iron ore exports the Port generates ~$3B
• This equates to 10.7% of the State Budget
Port Hedland is a main contributor to WA state royalty receipts

Sources: DMP, WA Treasury
So what are we doing?

- Understand changing fleet mix
- Pilot training and competency
- Channel enhancements
- PPU project
- Towage operations
- Salvage study
Understanding Fleet Mix

- Iron Ore trade is dictating fleet design – WozMax
- Draft efficient ships result in increased throughput
- 2009-10 10% of ships > 200,000DWT, NIL >250,000
- 2013-14 33% of ships > 200,000DWT, 6% > 250,000
- Age profile has reduced significantly
- 100% Rightship vetting
- Regularly sail 6 cape vessels on a tide resulting in >1MT
- Current record 1,083,210 tonnes in Nov 2013
- Current ship record Hugo N 263,962t (19.65m) Nov 2013
Pilot Training & Competency

- ISPO Accreditation – Systems Approach
- Standard Operating Procedures Implemented
- 8 Licence levels based upon DWT
- Formal Competency Assessments and Check Pilot runs for every licence progression
- 2 years to gain unrestricted licence – 750+ jobs
- Training Matrix
- Compulsory simulation exercises – 3x2 days within first 24 months and manned model
- All pilots attend simulation every 2 years
- Contracted simulator provider – ship & 4 tugs
Channel Enhancements

• Drivers – Trade growth, reduced separation, services cycle times etc.
• Channel escape areas
• 400m Survey outside channel
• Identify passing areas
• Real time data feed to PPU’s
• Improved tidal network
• DUKC Series V
• **Significantly improving channel transit management**
Channel Escape Management

Typical Draft Restricted Vessels-Departure Sequence
Engine failure:
- Reduced Power
- Max. Speed: 4 knots
Emergency Management pre-2012
1 hour between Vessel Departures
Emergency Management pre-2012
1/2 hour between Vessel Departures
Emergency Management 2012
1/2 hour between Vessel Departures

400m Wide Survey

Channel Escape Areas

400m Wide Survey
PPU Integration Project

Goals:
• Real time data to Portable Pilot Units (Navicom)
• Ability to interrogate data and predict outcomes
• Provide options for incident management
• Understand possible outcomes and consequences
• Improved transit management
• DUKC (OMC) integration
• One system – Qastor (QPS) connect server
• Protect Integrity of the Channel
Alpha Prudence Engine Failure
Series 1 Chart Overlay
No Channel Escape Possible
Light Shaded Safe Area
Vessel Monitoring With Breach

**OMC TEST**

<table>
<thead>
<tr>
<th>HP</th>
<th>B38</th>
<th>B30</th>
<th>B24</th>
<th>B16</th>
<th>B12</th>
<th>B8</th>
<th>B4</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>4.1</td>
<td>5.9</td>
<td>6.8</td>
<td>8.0</td>
<td>8.2</td>
<td>8.6</td>
<td>8.8</td>
<td>9.0</td>
</tr>
</tbody>
</table>

**Plan Status:**
- Initial
- Preliminary
- Approved
- Underway
- Finalised

**SOG (km):** 17/1616, 17/1635, 17/1707, 17/1733, 17/1735, 17/1814, 17/1849, 17/1907, 17/1928

**Squat (m):** 0.09, 0.09, 0.18, 0.23, 0.34, 0.36, 0.38, 0.42, 0.41

**Heel (m):** 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.01, 0.01, 0.00

**Tide (m):** 5.08, 4.83, 4.39, 4.03, 3.71, 3.43, 3.01, 2.86, 2.74

**WR (m):** 0.00, 0.07, 0.11, 0.14, 0.19, 0.23, 0.20, 0.44, 0.51

**UKC (m):** 1.43, 1.50, 1.92, 0.54, 0.11, 0.32, 1.29, -0.05, 1.49

**Source:** OMC
Vessel Monitoring Breach Resolved

Source: OMC
Chart Overlay

Source: OMC
Chart Overlay

Source: OMC
Chart Overlay
Chart Overlay

Source: OMC
Chart Overlay

Source: OMC
Towage Operations
Tugs at Port Hedland

Port Hedland Channel and Towage Overview

<table>
<thead>
<tr>
<th>Port Location</th>
<th>Number of harbour tugs escorting</th>
<th>Number of escort tugs escorting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 6: B1/2 to B15/16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zone 5: B15/16 to B30/31</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zone 4: B30/31 to B36/37</td>
<td>1*</td>
<td>0</td>
</tr>
<tr>
<td>Zone 3: B36/37 to Hunt Point</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Zone 2: South West Creek</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Zone 1: Inner Harbour</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

*1 tug with line attached, 2 tugs following without lines attached

Source: BHPB
Ship Control Failures per Manoeuvring Hour

The likelihood of a ship control failure per manoeuvring hour is 0.11%, predominantly as a result of engine failures.

Likelihood of Ship Control Failure

- 0.11%

Engine Failures

- 0.09%

Rudder Failures

- 0.02%

Root Causes

1. Minor machinery issues would could have been avoided through thorough maintenance and vetting
2. Foreign objects sucked into filters
3. Human error sighted as a leading cause

2. MyOSH Jun ‘11 to Jan ‘13
4. “Main Engine Damage Study”, 2012
Insights from surveying and track analysis
Profile: Zone 3 (Hunt Point to B36/37)

While travelling at moderate speeds, vessels correct to the west side in anticipation of the upcoming bend, while rudder angles can be maximum

<table>
<thead>
<tr>
<th>Vessel Centroid Transverse Position</th>
<th>60-100m W of CL</th>
<th>20-60m W of CL</th>
<th>+/-20m CL</th>
<th>20-60m E of CL</th>
<th>60-100m E of CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2%</td>
<td>9.7%</td>
<td>87.5%</td>
<td>2.5%</td>
<td>0.1%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessel Speed (knots)</th>
<th>Less than 4</th>
<th>4 to 5</th>
<th>5 to 6</th>
<th>6 to 7</th>
<th>7 to 8</th>
<th>8 to 9</th>
<th>9 to 10</th>
<th>10 to 11</th>
<th>More than 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>55%</td>
<td>32%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure Breakdown</th>
<th>Engine</th>
<th>Rudder 20°</th>
<th>Rudder 35°</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09%</td>
<td>0.016% (80%)</td>
<td>0.004% (20%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: BHPB
Insights from surveying and track analysis
Profile: Zone 4 (B30/31 to B36/37)

Vessels stray to east travelling on average faster than 9 knots; if a rudder failure occurs, it’s more likely to be at 20°

<table>
<thead>
<tr>
<th>Vessel Centroid Transverse Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-100m W of CL</td>
</tr>
<tr>
<td>0.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessel Speed (knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4</td>
</tr>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
</tr>
<tr>
<td>0.09%</td>
</tr>
</tbody>
</table>

Channel Cross Section

Source: BHPB
Insights from surveying and track analysis
Profile: Zone 5 (B30/31 to B15/16)

Vessels remain close to the channel centre line while travelling around 10 knots

<table>
<thead>
<tr>
<th>Vessel Centroid Transverse Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-100m W of CL</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessel Speed (knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
</tr>
<tr>
<td>0.09%</td>
</tr>
</tbody>
</table>

Source: BHPB
Insights from surveying and track analysis

Profile: Zone 6 (B15/16 to B1/2)

Vessels travel at speeds greater than 11 knots, a few shoal reefs present risks

<table>
<thead>
<tr>
<th>Vessel Centroid Transverse Position</th>
<th>60-100m W of CL</th>
<th>20-60m W of CL</th>
<th>+/-20m CL</th>
<th>20-60m E of CL</th>
<th>60-100m E of CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0%</td>
<td>1.8%</td>
<td>69.1%</td>
<td>28.9%</td>
<td>0.2%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vessel Speed (knots)</th>
<th>Less than 4</th>
<th>4 to 5</th>
<th>5 to 6</th>
<th>6 to 7</th>
<th>7 to 8</th>
<th>8 to 9</th>
<th>9 to 10</th>
<th>10 to 11</th>
<th>More than 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>9%</td>
<td>38%</td>
<td>50%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Failure Breakdown</th>
<th>Engine</th>
<th>Rudder 20°</th>
<th>Rudder 35°</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09%</td>
<td>0.019% (95%)</td>
<td>0.001% (5%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: BHPB
Ship Grounding Tests – Used to analyse likelihood of ship grounding if channel toe line crossed

**Challenge**
- Likelihood of channel toe-line crossing well understood from real-time simulations, but consequences of crossing and impact of collision uncertain
  - Limited research done historically
  - Subject matter experts presenting different and even opposing opinions
    - “Bowling ball” effect vs Riding up and grounding

**Physical Model**
- Council for Scientific and Industrial Research (CSIR), South Africa
- 12m x 30m basin (1:100 scale)
- ~3m model Wozmax vessel
- Testing the effect of vessel collision with channel edge
  - Different speeds and angles of impact
  - Measuring the force required to ‘pull’ the vessel off

**Hunt Point**
- Batter slope of ~25°
- Narrow distribution of possible impact speeds; 3 tested
  - 2, 4 and 6 knots
- Three possible impact angles tested
  - 5°, 15°, and 30°

**Outer Channel**
- Batter slope of ~15°
- Wider distribution of possible impact speeds; 4 tested
  - 4, 8, 10 and 12 knots
- Four possible impact angles tested
  - 5°, 10°, 15°, and 30°
Ship Grounding Tests – Results

Force required from tug fleet\(^1\) to pull vessel off post grounding

<table>
<thead>
<tr>
<th>Mean Sea Level (MSL)</th>
<th>Mean High Water Springs (MHWS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angle of Impact</strong></td>
<td><strong>Speed (knots)</strong></td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10(^\circ)</td>
</tr>
<tr>
<td></td>
<td>15(^\circ)</td>
</tr>
<tr>
<td></td>
<td>30(^\circ)</td>
</tr>
<tr>
<td><strong>Angle of Impact</strong></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>10(^\circ)</td>
</tr>
<tr>
<td></td>
<td>15(^\circ)</td>
</tr>
<tr>
<td></td>
<td>30(^\circ)</td>
</tr>
</tbody>
</table>

• Though at high speed and high angles a large force was required, MSL tests with rising water also showed that even the largest impact is reduced to ‘Minor’

• Minimal rising water assistance at MHWS

• At Hunt Point, tug force with water buoyancy should be sufficient to lift a grounded vessel off

• In the outer channel, impact at an angle greater than 5\(^\circ\) usually results in a ‘Major’ incident. At 5\(^\circ\) it mostly results in a ‘bounce off’

Notes: A. Inferred, B. Post water level increase, 1. Tug fleet likely to exert 750T force max.

Source: BHPB
Real Time Simulations – Used to analyse ability of tugs to prevent a ship going outside of channel

1 ship simulator

4 independent tug simulators

Simulation program in Denmark:
• 100+ simulations
• PH Pilots driving ships
• GM Operations of PHPA in attendance
• Realistic reaction times and operational interactions
• Used latest surveying and modelling information
• Tested different zones, tug configurations and tug types
• Tested different wind and wave conditions

Source: BHPB
Simulation Results - Zone 3: B46/47 to B36/37

Moderate fleet required to reduce most risk

Optimised Existing Fleet*

Moderate Fleet

Extended Fleet

RT80s only effective in moderate sea state and moderate speed

Configuration

Tug effectiveness at preventing incident

Remaining Exposure

~73%

~99%

>99%

Potential for Minor incident (~2-5 day blockage)

Potential for Major incident (~4 month blockage)

Potential for Minor incident (~2-5 day blockage)

Potential for Major incident (~4 month blockage)

Potential for Minor incident (~2-5 day blockage)

Potential for Major incident (~4 month blockage)

*Assumes existing fleet optimised to have one 80t Rotor tug aft on all large ships. If 60t Z-tech is used aft then mitigation effectiveness is minimal

Reaction time delay: 20s (50s before engine astern), Speed: 5kn, Tidal conditions: Large Spring (HW > 7m CD) -2hr HW

Source: BHPB
Simulation Results - Zone 4: B36/37 to B30/31

Moderate fleet required to address most risk

---

**Configuration**

**Optimised Existing Fleet***

- RT80s only effective in moderate sea state and moderate speed

- 60t
- 80t

**Moderate Fleet**

- 60t
- 60t
- 85t

**Extended Fleet**

- 85t
- 85t
- 80t

---

**Tug effectiveness at preventing incident**

- **~66%** Potential for Minor incident (~2-5 day blockage)
- **~0%** Potential for Major incident (~4 month blockage)
- **~88%** Potential for Minor incident (~2-5 day blockage)
- **~0%** Potential for Major incident (~4 month blockage)
- **~99%** Potential for Minor incident (~2-5 day blockage)

---

**Remaining Exposure**

- **~34%**
- **~12%**
- **~1%**

---

*Assumes existing fleet optimised to have one 80t Rotor tug aft on all large ships. If 60t Z-tech is used aft then mitigation effectiveness is minimal.

Reaction time delay: 30s, Speed: 8kn, Tidal conditions: Mean Spring -2hr HW

Source: BHPB
Simulation Results - Zone 5: B30/31 to B15/16

Moderate fleet required to eliminate major incident

**Optimised Existing Fleet***

- Tug effectiveness at preventing incident: ~0%
- ~10% Potential to miss channel edge (no incident)
- ~87% Potential for Minor incident (~2-5 day blockage)
- ~3% Potential for Major incident (~4 month blockage)

**Moderate Fleet**

- ~84%
- ~1% Potential to miss channel edge (no incident)
- ~15% Potential for Minor incident (~2-5 day blockage)
- ~0% Potential for Major incident (~4 month blockage)

**Extended Fleet**

- >99%
- <1% Potential to miss channel edge (no incident)
- <1% Potential for Minor incident (~2-5 day blockage)
- <1% Potential for Major incident (~4 month blockage)

*Existing towage parameters

Reaction time delay: 30s, Speed: 8kts, Tidal conditions: Mean Spring -2hr HW

Source: BHPB
Salvage Study

Conducted by London Offshore Consultants – Salvage Expert & Special Casualty Representative

Conclusions:
• Channel blockage is unlikely but possible
• Engine/steering failure would result in $10^\circ$ angle impact
• Significant risk strategies have been implemented
• Bow impact would not result in structural failure
• Port Emergency Plans exist
• Risk is well managed by PHPA
• However, consequences would be catastrophic
Salvage Study

Recommendations:
1. Charter Party terms offer enormous scope to implement risk strategies
2. Adequacy of ship bits/fairleads to handle tug 85T BP
3. Engage on-call contracted Salvage Organisation
4. Channel design improvements
5. Possibility of having Salvage equipment on/near site
6. Mandate use of certain Salvage Services
7. Understand “reasonable time” implications
8. Maintain a Salvage Plan with prior knowledge of equipment and expertise availability
9. Provision of a dedicated dredging assets
Typical Ship
Because we don’t want this in our channel!
Questions?

Captain John Finch
GM Operations / Harbour Master
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08 9173 9018