Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Marine Occurrence Investigation No. 217 & 219
Final

Independent investigation into the grounding of the sail training ship

Leeuwin II

in Prince Frederick Harbour, Western Australia
22 July 2005
and in Shark Bay, Western Australia
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CONTENTS

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Photographs of *Leeuwin II* courtesy of Leeuwin Ocean Adventure Foundation and staff.

Abstract

At about 1600 on 22 July 2005 *Leeuwin II* grounded on an uncharted shoal during a voyage under motor from Careening Bay to Hunter River in the Kimberly region of Western Australia.

Less than two months later, on 16 September, *Leeuwin II* again grounded on an uncharted shoal. On this occasion in Shark Bay, Western Australia, during a passage from Denham to Monkey Mia.

Both groundings were investigated by the ATSB, and because of the similarities in the key factors which led to both incidents, the reports have been combined.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The Bureau is pleased to report positive safety action in its final reports rather than make formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

1 SUMMARY

At about 1600 on 22 July 2005 *Leeuwin II* grounded on an uncharted shoal during a voyage under motor from Careening Bay to Hunter River in the Kimberly region of Western Australia. Less than two months later, on 16 September, *Leeuwin II* again grounded on an uncharted shoal. On this occasion in Shark Bay, Western Australia, during a passage from Denham to Monkey Mia.

Both groundings were investigated by the ATSB, and because of the similarities in the key factors which led to both incidents, the reports have been combined.

The report concludes that:

- On both occasions the vessel grounded on uncharted shoals in poorly or inadequately surveyed areas.
- The masters' lack of local knowledge of the areas in which they were navigating may have led to an over reliance on the survey information presented on the navigation charts, without taking note of the quality indicators embedded within the chart.
- Proper passage planning was not used in the preparation of the voyages and there was a lack of effective communication and understanding of the objectives.

It is also considered that:

- An effective risk management strategy could have led to the development of procedures and practices which may have reduced the risk of these groundings occurring.
- The echo sounder was not effective in warning that the vessel was about to ground.
- Had the existence of the shoal in Prince Frederick Harbour been reported to the Australian Hydrographic Service prior to *Leeuwin II*'s grounding, the navigation chart would have reflected its position. The master could then have planned the voyage accordingly.

The report recommends that:

- The Australian Hydrographic Service, in consultation with local commercial vessel operators, should consider implementing a schedule for the complete survey of the Bonaparte Archipelago to ensure that priority is given to those areas most highly trafficked.
- Masters of vessels navigating in areas which are inadequately surveyed should ensure that they are aware of the limitations of the information displayed on the navigation charts.
- The Leeuwin Ocean Adventure Foundation, in consultation with *Leeuwin II*'s masters, should undertake an analysis of the risks involved in operating the vessel in areas that are unsurveyed or inadequately surveyed, with the intention of developing effective risk management strategies and local knowledge.

- The Leeuwin Ocean Adventure Foundation should consider the practicalities of installing a forward scanning depth indicating device on board *Leeuwin II*.
- Masters and skippers of vessels of all sizes are encouraged to forward hydrographic notes to the Australian Hydrographic Service when they discover any navigational anomalies that are not displayed on the chart.

2 SOURCES OF INFORMATION

The master and officers of *Leeuwin II*

The Leeuwin Ocean Adventure Foundation, Fremantle

The Australian Maritime Safety Authority (AMSA)

The Australian Hydrographic Service (AHS)

References

Australian Maritime Safety Authority Marine Notice No. 34/2002 (superseding 7/1994).

Australian Pilot Volume V (NP17), HM Hydrographic Office, Seventh Edition 1992.

Hydrographic and Oceanographic Scheme (HydrOcscheme) 2005–2008, Australian Hydrographic Service 2005.

Maritime Safety Authority of New Zealand Shipping Notice 10/1997.

R Nijjer,. *Bridge Resource Management: The Missing Link*, Sea Australia, Sydney, 2000.

Seafarer's Training, Certification and Watchkeeping (STCW) Code, International Maritime Organization, 1995.

The International Convention for the Safety of Life at Sea, 1974, and its Protocol of 1988 (SOLAS), the International Maritime Organization.

3 NARRATIVE

3.1 *Leeuwin II*

Leeuwin II is an Australian registered, sail training ship (Figure 1). The ship is owned and managed by the Leeuwin Ocean Adventure Foundation, Fremantle, Western Australia. The ship was designed and constructed in accordance with class 1A, 1B, 1C and 1D of the Uniform Shipping Laws (USL) Code and is in full Australian Maritime Safety Authority (AMSA) survey.

Leeuwin II was designed by Randall Naval Architects and built in 1986 by Australian Shipbuilding Industries in Fremantle. The ship is a steel hulled barquentine[1]. It has a main mast height of 33.5 metres, and carries 810 square metres of sail. The ship has an overall length of 55 metres, a beam of 9.01 metres and a depth of 5.01 metres. It has a displacement of 344 tonnes at a draught of 3.4 m.

Auxiliary propulsive power is provided by two Volvo Penta six cylinder diesel engines, delivering a total power output of 400 kilowatts. The ship's service speed when motoring is seven knots.

Figure 1: *Leeuwin II*

Leeuwin II is equipped with navigational equipment that includes an Anritsu radar and Furuno global positioning system (GPS), automatic identification system (AIS) and Furuno FCV-581L digital readout echo sounder. The ship is also fitted with a Tsunami electronic chart system (ECS) and a complete global maritime distress and safety system (GMDSS) communications set.

The ship is not fitted with an auto-pilot and hence is hand steered at all times.

1 A sailing ship with three masts that is square rigged on the fore mast only, main and mizzen masts are fore and aft rigged.

3.2 Shipboard operations

Leeuwin II generally carries five paid crew; master, mate, second mate, engineer and cook, along with a number of volunteer crew.

Two of the volunteer crew sail in the position of watch officer. On voyages where suitably certificated watch officers are on board, the mate and second mate are excused from watchkeeping duties to attend to the voyage program and maintenance tasks. The master and watch keepers maintain a watchkeeping routine of fours hours on, eight hours off.

Four of the volunteers act as watch leaders, and are in charge of the volunteer crew and passengers on each watch. They report directly to the officer of the watch. Watch leaders are volunteers that have sailed on the ship previously, and in the opinion of the officers have the desired leadership qualities. They are invited back, and undergo special training on board, before sailing in the position of watch leader.

The remainder of the volunteers and the passengers are divided into four watches, which operate under the direction of the watch leaders. The watches rotate to ensure that all of the volunteers and passengers experience watch keeping throughout the day.

The volunteers and passengers fulfil tasks such as helmsman, helmsman's messenger, lookout and deck hand.

Figure 2: Helm position looking forward

At sea the helmsman steers the ship, while the messenger communicates between the helmsman and the officer of the watch. Two lookouts are posted port and starboard on the bow due to the lack of forward vision from the helm position (Figure 2). The remainder of each watch act as deck hands.

3.3 Prince Frederick Harbour, 22 July

3.3.1 Navigating officers

The master at the time of the incident held a master class one certificate with a square rig endorsement. He had extensive experience as master on board *Leeuwin II*, but had no experience navigating in the Prince Frederick Harbour area. He had joined the ship in Broome on 16 July, as an emergency replacement for the previous master. The previous master needed to return home for compassionate reasons.

The mate had 15 years experience in yachting and off-shore racing and held a master class five certificate. He had been employed as the permanent mate on board *Leeuwin II* for approximately one year.

The second mate had 11 years experience at sea, predominantly in sailing ships. He held a master class five certificate and had been working on *Leeuwin II* on and off over the previous 11 years.

The watch officer on duty at the time of the grounding held a master class four certificate and had been volunteering on board *Leeuwin II* for the past 15 years. He had over 30 years experience on fishing vessels, charter vessels and the offshore industry.

The second watch officer had started his seagoing career in 1994 on board *Leeuwin II*, and had spent most of his time at sea on sailing ships but now worked in the off-shore industry. At the time of the incident he held a master class four certificate.

In addition to the paid crew there were nine volunteer crew, two environment experts and 37 passengers on board at the time of the incident. All the passengers and crew were actively involved in the operation of the ship.

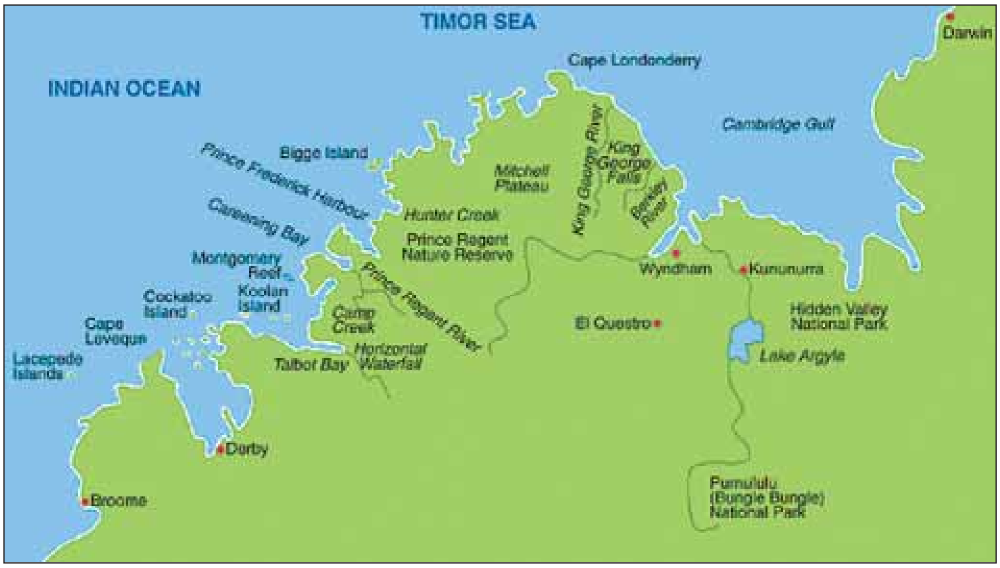
3.3.2 Prince Frederick Harbour

Prince Frederick Harbour is located in the Kimberley region of north-western Western Australia. It is a continuation of York Sound and extends approximately 15 nautical miles east-southeast from its western entry at Cape Torrens (Figure 4). In the east, the harbour divides into two rivers, the Hunter which leads to the northeast and the Roe, which leads to the east-southeast. The coastline is backed by irregular ranges of steep rocky hills.

Hydrographic survey data in Prince Frederick Harbour is either inadequate or, in some areas including the Hunter and Roe Rivers, non-existent. The largest scale marine navigation chart of the harbour, AUS730, and the Australian Pilot (NP17) both carry notes to mariners warning of the inadequacy or absence of survey information and state that mariners are warned to proceed with caution as uncharted dangers and hazards may exist.

The absence of reliable hydrographic survey data means that local knowledge is required when navigating within the harbour and rivers flowing into it.

Figure 3: Kimberley region



3.3.3 The incident

Leeuwin II sailed from Broome at 1100 on 18 July 2005 on a Kimberley environmental discovery voyage and was due to arrive in Darwin on 29 July.

The aim of the voyage was for the passengers to experience the power of sail and to explore the Kimberley region. Areas visited during the voyage included, Careening Bay, Hunter River, King George River and waterfalls, Montgomery Reef and Bigge Island (Figure 3).

Passengers participated in shore expeditions with local environmental experts in an attempt to increase their awareness of both the natural and cultural heritage of the region.

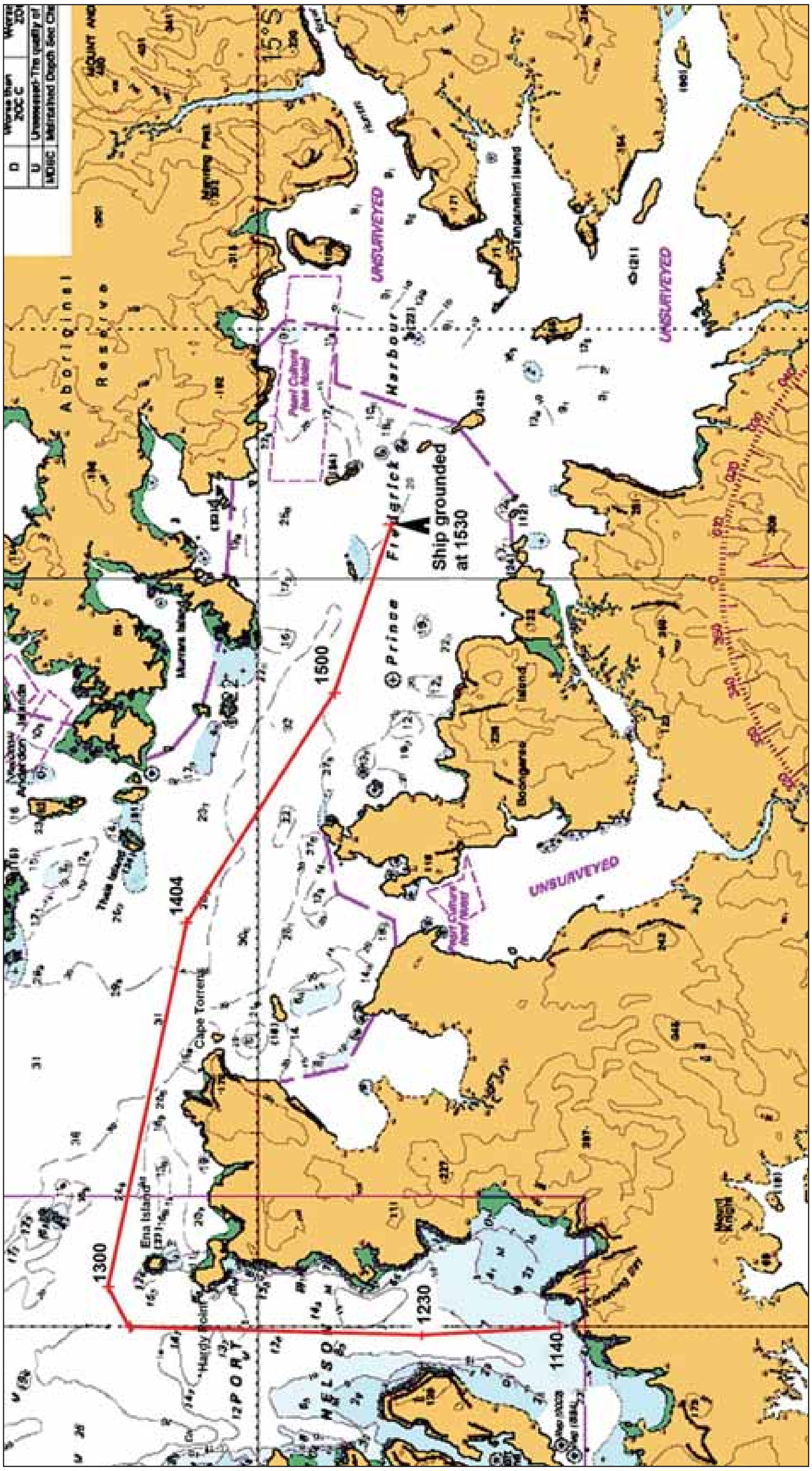
At 0800 on the morning of 22 July, the ship anchored in Careening Bay (Figure 4), and the passengers were landed for a shore excursion. One of the highlights of this shore excursion was a boab tree with the inscription '*HMC Mermaid*'. The Mermaid, under the command of Lieutenant Phillip Parker King, had been careened[2] in the bay for repairs in 1820.

At 1100, the passengers and crew returned to the vessel and at 1140 the ship began a planned six hour passage to Hunter River. The intention was for the ship to motor north, round Hardy Point, Ena Island and Cape Torrens, and then enter Prince Frederick Harbour before making its way into the mouth of the Hunter River (Figure 4). The plan was to be in the Hunter River before 1730, to observe the colour changes in the surrounding rock formations during the sunset. *Leeuwin II*, would then remain in the Hunter River at anchor overnight.

The watch officer had placed the course on the paper chart, and these courses were checked by the master. It was planned that the ship would follow a course of 125°(T) down the centre of Prince Frederick Harbour (Figure 4), south of a charted islet, before a course change that would bring *Leeuwin II* between another islet and a shoal further east, from there the ship would proceed into the Hunter River.

2 Intentionally beached or grounded.

Figure 4: Section of chart AUS 730 indicating the ship's route from Careening Bay (re-constructed from the deck log book)



The weather conditions on 22 July were clear, the sea was calm and there was little or no wind. At 1127 a high tide of 7.7 metres was predicted for White Island (60 nautical miles west of the mouth of the Hunter River). A low tide of 0.8 metres was expected at 1757. The tidal range of 6.9 metres was considered normal for spring tides at this time of the year.

During the passage from Careening Bay the watch officer had the conduct[3] of the ship and checked its position every 15 minutes. He used radar ranges and bearings and cross checked these against the position displayed on the ECS.

At approximately 1520 the master took the con of the ship and asked the watch officer to take the helm. The tide was ebbing at about two knots and the ship's speed was four knots over the ground.

At approximately 1528, the lookout positioned on the bow noticed a line of disturbed water to port. This sighting was brought to the attention of the watch officer. He then conferred with the mate, who had just come on deck. They considered that the disturbed water was a tide line or an up welling. Both these phenomenon are common in the Kimberley region.

The second mate, who was carrying out repairs in the rigging, commented that the disturbed water looked like an overflow of water across a shoal or reef. He also said that it was to port and he expected the ship to clear it. As he did not think it important, he did not bring his opinion to the attention of the watch officer or the master.

At 1530 the watch officer noticed the ship was not making head way. Thinking that the speed of the tidal flow had increased, he brought the engines to stop. He thought that the ship would now move astern with the tidal flow; however this was not the case. The ship had grounded so gently that no one on board had felt it.

Realising that the ship was aground, the watch officer informed the master. The master put the engines astern in an attempt to free the ship, however this proved ineffective.

The stern mounted rescue boat was lowered to the water and the second mate and the off duty watch officer started taking soundings of the water depths around the ship. The ship's freeboard was increasing quickly, and it was apparent that it would remain aground until the next high tide.

The master made a transmission on VHF channel 16 alerting vessels in the vicinity of his predicament, however he received no reply. There were no other vessels in sight at the time.

After about 20 minutes, when it was clear the ship would remain aground, the master discussed the situation with the officers. The consensus was that the ship would heel over as the tide went out and it was thought that the passengers would be safer on the reef then on the sloping deck of the ship. In the event that there were any further problems with the ship it was considered that the passengers could be easily transferred from the shoal to a near by islet. The decision was made to use the rescue boat to land the passengers on the shoal, which was becoming more exposed as the tide ebbed.

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3 Referred to as 'having the con'.

The master made an announcement to the passengers informing them that the ship would begin to heel over and that they would be landed with the crew on the shoal for their own safety. Just after making the announcement the ship started to list to port.

By 1715 all passengers, except two, had been landed on the shoal. The two remaining passengers did not believe that they would be safer on the reef, and after a discussion with the master were allowed to stay on board the ship.

The ship listed further to port as the tide continued to ebb. It eventually stabilised with the mast at an angle of approximately 26 degrees from the vertical (Figures 5 and 6). The movement of the ship to port had been gentle and occurred in a number of stages.

Figure 5: *Leeuwin II* aground

Figure 6: *Leeuwin II* aground

The master, engineer and the on duty watch officer stayed onboard the ship and continued to monitor the situation.

The passengers and most of the crew along with food and equipment were landed on the shoal, and the passengers and crew had a barbeque while waiting for the tide to turn. This proved to be a useful distraction as it kept everyone busy while waiting for the ship to refloat.

While waiting for the tide to turn the ship's officers inspected the hull externally and found no signs of damage. Those on board checked the ship internally. As the generator's sea inlet was still in the water lighting and power was maintained throughout the time aground.

The tide was continually monitored and at slack water low tide, the shoal was approximately two metres clear of the water (Figures 7, 8 and 9). When the flood started at about 1815, the passengers and crew were returned to the ship. By 1915 everyone was back on board. While waiting for the incoming tide to free the ship, a tourist vessel making its way towards the Hunter River was seen passing well to the south.

The crew continued to monitor the situation and take soundings around the ship as the water rose. At 2015 the ship was afloat. The incoming tide pushed the ship astern, and to port, until the ship came free of the shoal. This also had the effect of bringing the ship around 180 degrees.

The master decided not to continue into Hunter River, and set a reciprocal course to that which he had followed when entering Prince Frederick Harbour. He headed for Port Nelson, where he intended to anchor for the night, and by 2300 the ship was at anchor to the north off Hardy Point.

During the passage, and throughout the night, the crew regularly checked the ship's bilges, sounded tanks and generally monitored the ship's condition.

At 0730 on 23 July *Leeuwin II* resumed its voyage to Darwin, arriving there at 0830 on 29 July. On arrival an underwater inspection of the hull was organised. Little damage was noted, only the loss of some paint and the minor deformation of shell plating on the port side of the hull around the midships.

Figure 7: Shoal and Leeuwin II at low tide

Figure 8: *Leeuwin II* and shoal

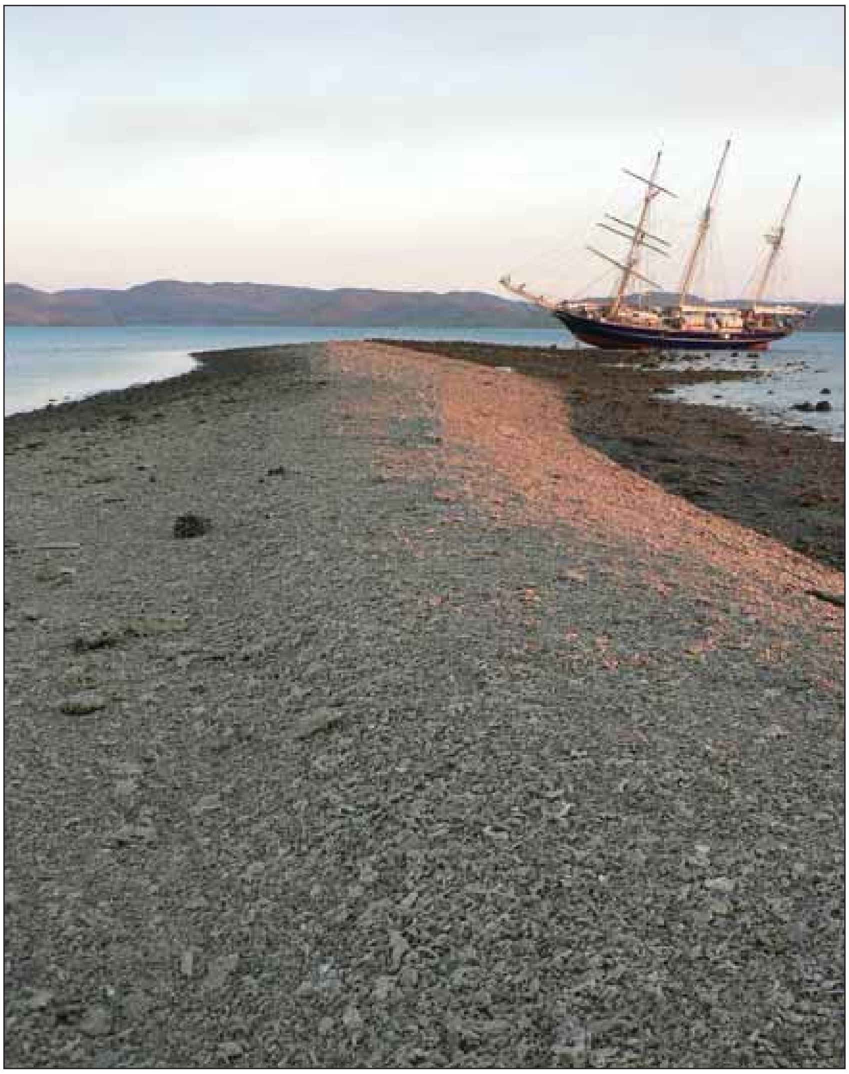
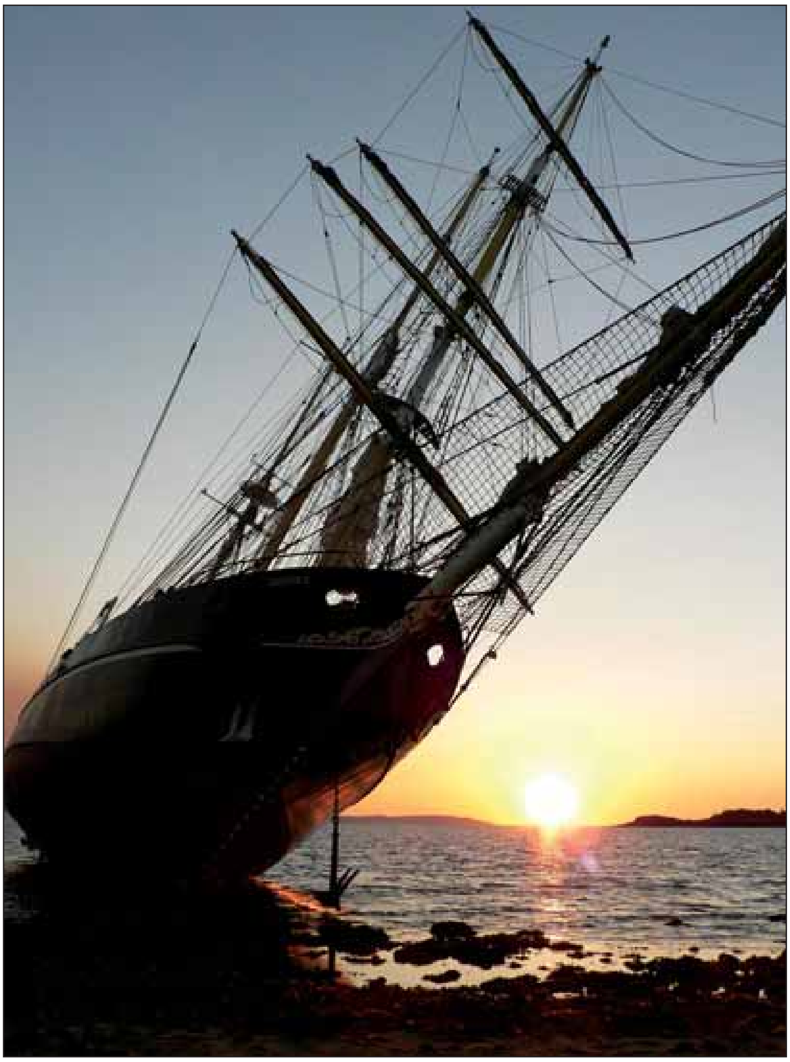


Figure 9: ***Leeuwin II*** **at low tide**



3.4 Shark Bay, 16 September

3.4.1 Navigating officers

Master

The master of *Leeuwin II* at the time of the grounding in Shark Bay had been appointed the permanent master of the vessel on 22 August 2005. It was his first time as master on the vessel and he joined in Broome on 26 August 2005. He had undertaken a familiarisation and handover period with the outgoing master after the vessel departed Broome, taking over command in Exmouth on 11 September 2005.

He had sailed on the vessel as a volunteer in 2004. This voyage was his only experience on square rigged sailing ships before his appointment as permanent master.

He had held a master class one certificate of competency since 1988, and had served on large merchant vessels as master since 1989. He did not hold a square rig endorsement but was permitted to sail as master of *Leeuwin II* by AMSA while he gained the necessary knowledge and experience on board the vessel.

This voyage on the vessel was his first experience of inshore and shallow water navigation.

Chief mate

The chief mate on board at the time of the incident held a second mates class one certificate of competency. She had joined *Leeuwin II* for the first time in Darwin as second mate on 12 August 2005 before taking over as mate in Broome on about 26 August 2005. She had approximately seven years sailing experience on the slightly smaller, but similarly rigged, HM Bark Endeavour. She also had approximately six weeks experience serving as second mate on a small coasting bulk carrier in United Kingdom waters.

3.4.2 Shark Bay

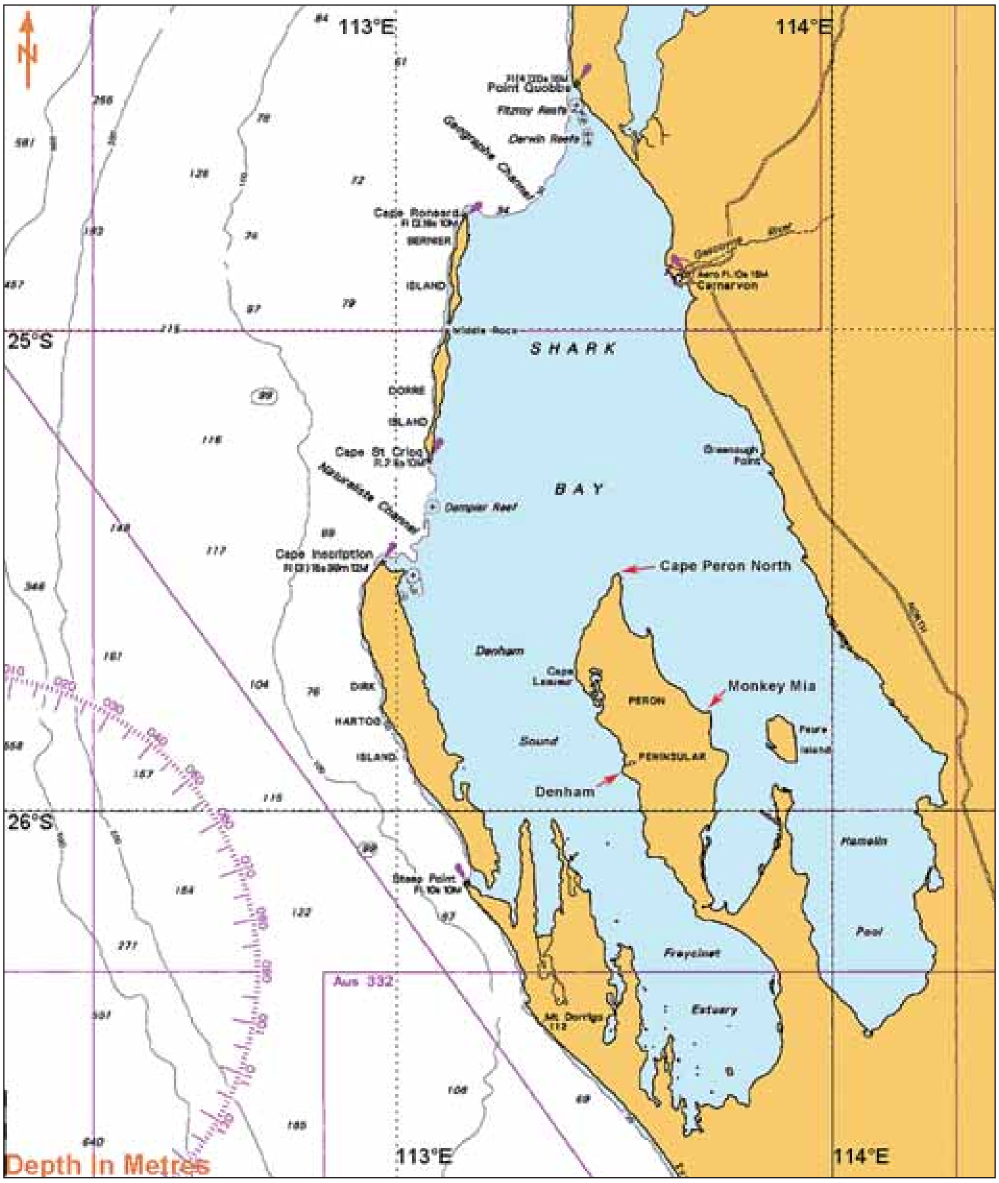
Shark Bay is a large body of water situated on the Western Australian coast, between the latitudes of 24° 30′S and 26° 30′S. The bay is bound to the west by Dirk Hartog Island and the peninsula of Edel Land. The Peron Peninsula extends into the centre of Shark Bay from the south. At the northern tip of the Peron Peninsula is Cape Peron North. The port of Carnarvon, located on the north-eastern shore of the bay, is the major population centre. Located on the western side of the Peron Peninsula is the town of Denham. The small tourist resort of Monkey Mia is located about 26 km to the north-east of Denham, on the eastern shore of the peninsula.

The bay is approached and entered through Geographe Channel in the north, and Naturaliste Channel in the west. Small craft can enter the bay from the south through South Passage.

Marine navigation charts of the bay and the Australian Pilot (NP17) carry notes to mariners warning of the inadequacy or absence of survey information and state that mariners are warned to proceed with caution as uncharted dangers and hazards may exist. Like Prince Frederick Harbour, hydrographic survey data in Shark Bay is either inadequate or, in some areas, non-existent.

Because of the absence of reliable hydrographic survey data, local knowledge, while not essential, is preferred when navigating within Shark Bay.

Figure 10: Portion of chart AUS416 showing Shark Bay



3.4.3 The incident

On the morning of 16 September 2005, *Leeuwin II* was anchored off Denham taking on diesel fuel. While at anchor, the master prepared a plan for the 81 nautical mile voyage from Denham to Monkey Mia that afternoon. His intention was to proceed north of Cape Peron Flats – an area of shallow water to the north of Cape Peron North. This plan was made using the ECS and the route was displayed on the monitor.

At 1230, the vessel departed Denham and at 1540, it cleared Denham Channel and entered Denham Sound. The master, in accordance with the route plan, set a course of 020°(T). This course would take the vessel up the western side of the Peron Peninsula to an alteration position north of Cape Peron Flats.

The weather *Leeuwin II* experienced, as it was proceeding to Monkey Mia was observed to be fine with light, variable south-easterly winds and a calm sea with a swell of less than half a metre. Visibility was in excess of 12 nautical miles. The lack of wind meant that the vessel was motoring and had no sails rigged. Low tide in the

Cape Peron North area was estimated to be just before 1700 (one hour before the estimated time of arrival at Monkey Mia).

At 1600, the master discussed the possibility of changing the voyage plan to bring the vessel through an inshore route immediately to the north of Cape Peron North with the chief mate and the second mate (Figure 11).

By transiting the inshore channel dividing the cape and the shallow flats to the north, the passage would be reduced by 13 nautical miles or approximately two hours steaming. The master reasoned that the reduction in the steaming time would save fuel and he also thought that, as this was to be his first trip to Monkey Mia, he might be able to anchor *Leeuwin II* off the shore in daylight. Both mates concurred with the master's suggestion, given the forecast sea state and excellent visibility.

The master set about altering the courses on the paper chart to reflect the change in route. He did not make any change to the ECS route and plan.

At 1625 the mate, on watch, altered the vessel's course to 052°(T). The master went to the chartroom and began to monitor the vessel's position by radar and GPS on the ECS display. The mate retained the con and *Leeuwin II* remained on this course for approximately one hour.

At about 1725, the master stated he reduced the speed of the vessel to about five knots, to reduce any squat effect as it passed through the shallow area. The master recalled that the depth under the keel was, at this point in time, about four metres.

As the vessel approached Cape Peron North, the master plotted its position on the chart every ten minutes. The engineer went forward to act as a lookout, positioning himself on the bowsprit looking into the water for shallow patches and discolouration which may indicate that the vessel was entering shallow water.

Throughout the passage, the vessel's echo sounder was running and the master was monitoring it as he was position fixing in the chartroom. As the vessel approached Cape Peron North, the tide was beginning to flood and the direction of the flood was to the north-east, astern of *Leeuwin II*.

At about 1745, with Cape Peron North about one nautical mile off *Leeuwin II*'s starboard beam, the course was altered to 090°(T). However, as the engineer had reported discolouration on the vessel's starboard side, the master adjusted this course to 080°(T), to keep clear of any possible shallow patch. The master altered another ten degrees to port as the vessel approached a charted 4.8 m shallow patch which was to the north-east of the cape. This shallow patch was passed at about 1755.

Figure 11: Portion of chart AUS749 showing Cape Peron North, Cape Peron Flats and the inshore route

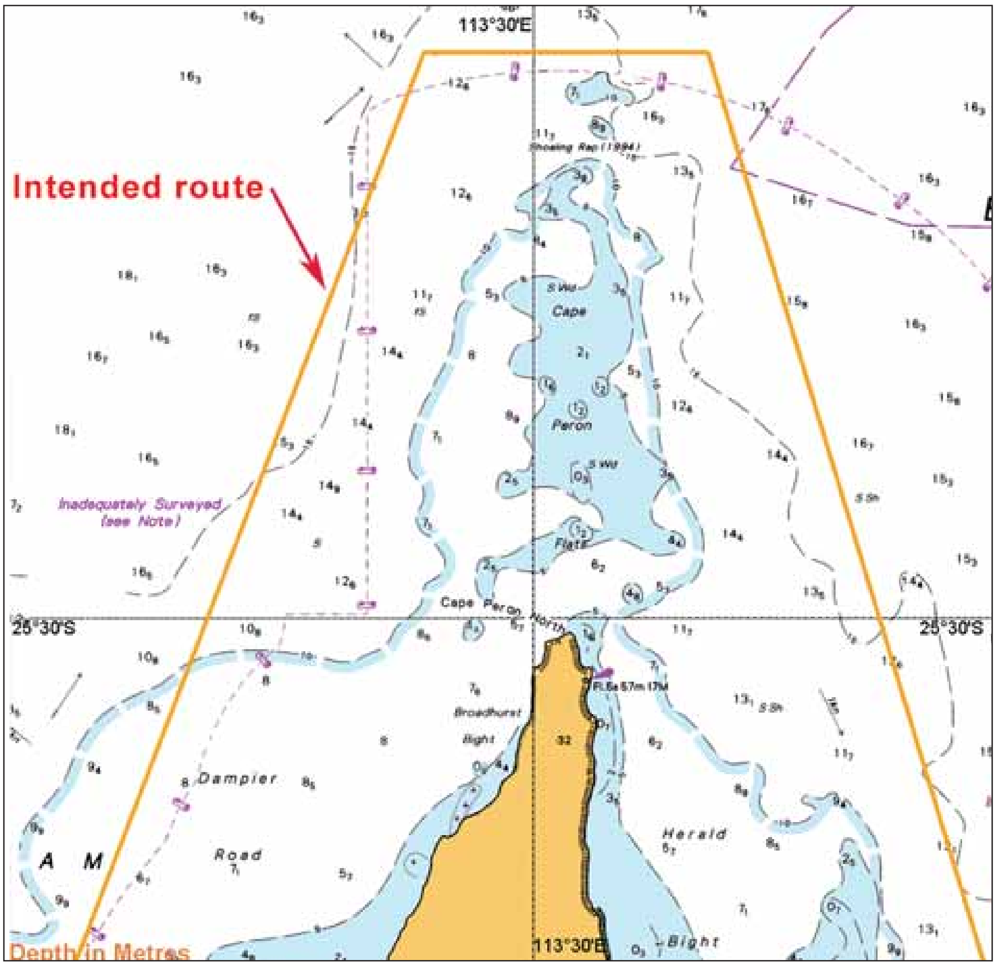
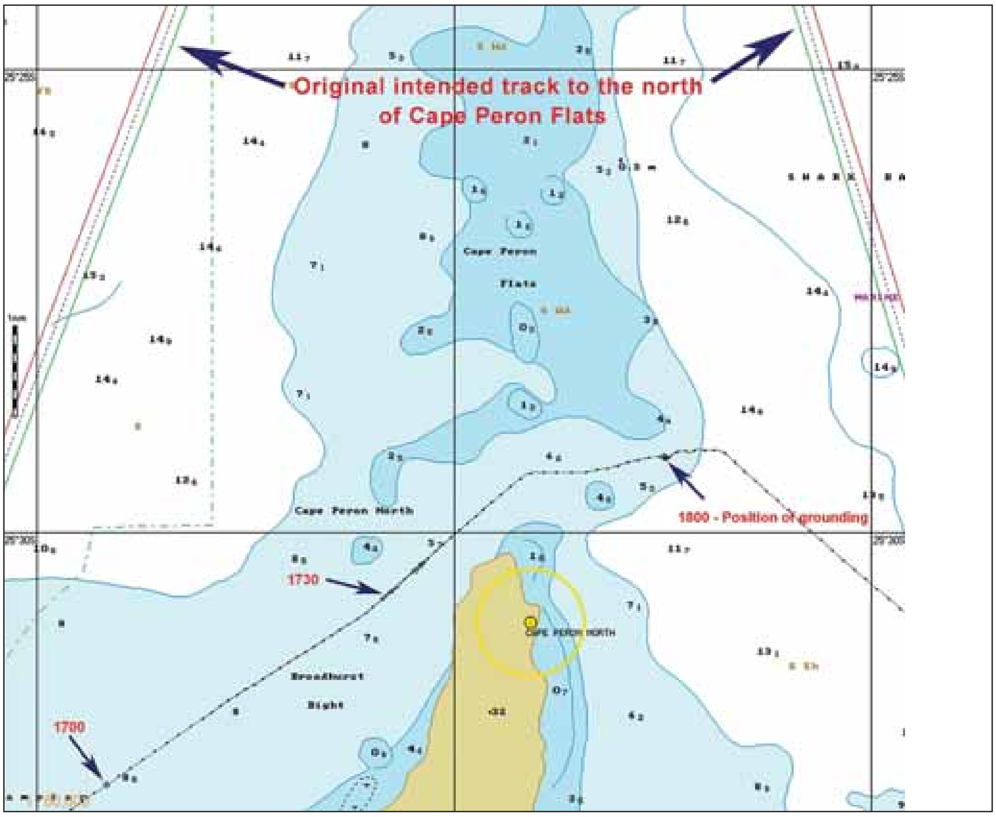


Figure 12: *Leeuwin II*'s track and grounding position at 1800



Based on the chart soundings, the master then told the mate that they had cleared the shallow areas in the passage. He told her to alter course to come to a new south-easterly heading which would join the original voyage plan for the remaining passage to the anchorage off Monkey Mia. The mate told the helmsman to steer a new course of 132°(T) at 1756. This new course would take *Leeuwin II* close to a charted 5.3 m patch. However, with a draught of 3.5 m, there would be an under keel clearance of about 1.8 m, should the vessel pass close to the patch.

At about 1757, on a heading of 108°(T), the vessel shuddered. The engines began to race and the vessel's gyro stopped swinging to starboard. The master immediately checked the GPS and radar and, noting that the position was not changing, realised that the vessel had grounded near the 5.3 m charted shoal.

The position of the grounding was recorded by the master from the GPS as being 25° 29.18′S 113° 32.51′E.

The master then attempted to move the vessel off the shoal, the engines were put to stop, then to full astern, but this was unsuccessful.

The emergency signal was sounded to muster the crew. An internal inspection of all spaces was made immediately after the grounding and all were found to be free of water.

Soundings were taken around the vessel to see what the depth of water was at various locations. The soundings confirmed that the vessel had grounded at about midships, with the shoal running from the starboard quarter to just forward of the port beam. While *Leeuwin II* was aground, the crew continued to take soundings at 30 minute intervals, to determine the rate of the rise of tide.

At about 1940, the engines were again used in another unsuccessful attempt to refloat the vessel.

At 2000, the vessel floated on the incoming tide, without further assistance from its engines. As the vessel cleared the shoal, the master ordered the engines started and he resumed the voyage to Monkey Mia. Another internal inspection was carried out and the watertight integrity of the hull was confirmed.

No crew member was injured in the grounding and no pollution or damage to the vessel resulted.

4 COMMENT AND ANALYSIS

4.1 Evidence

On 27 August 2005, two investigators from the Australian Transport Safety Bureau (ATSB) attended *Leeuwin II* in Broome to investigate the grounding of the ship in Prince Frederick Harbour on 22 July. They visited the offices of the Leeuwin Ocean Adventure Foundation in Fremantle on 30 August. The foundation's chief executive officer (CEO), the master and directly involved crew members were interviewed, and provided accounts of the incident. Copies of relevant documents were obtained including: log book entries, pilot card, various procedures and statutory certificates.

On 25 September, an investigator from the ATSB attended *Leeuwin II* in Monkey Mia to investigate the grounding of the ship in Shark Bay on 16 September. He visited the offices of the Leeuwin Ocean Adventure Foundation in Fremantle on 27 September. The Foundation's CEO, the master and directly involved crew members were interviewed, and provided accounts of the incident

4.1.1 Time of grounding – Prince Frederick Harbour

The master's entry in the deck log book records the time of grounding as 1530 on 22 July 2005.

The reconstruction of *Leeuwin II*'s track during the voyage from Careening Bay to Hunter River on 22 July (Figure 4) is based on times and GPS positions recorded in the deck log book. Based on analysis of this information, it is considered that the ship actually grounded at about 1600.

4.2 Local knowledge

The evidence in both groundings suggests that the masters and navigating officers on board *Leeuwin II* were aware that Prince Frederick Harbour and Shark Bay were inadequately surveyed. On both occasions the ship grounded on uncharted shoals located in areas that were covered by charts that had been compiled using old or inadequate survey information.

Leeuwin II operates in the northern parts of Western Australia on a seasonal basis, and as such only completes a limited number of voyages in this area in any one year. The ship has a large turnover of crew, essentially because of the reliance on volunteers.

The master on board *Leeuwin II* at the time of the Prince Frederick Harbour grounding was experienced on the vessel but had no experience navigating in Prince Frederick Harbour. The Australian Pilot publication notes that local knowledge is required when navigating in Prince Frederick Harbour[4].

The master on board at the time of the Shark Bay grounding was only new to the vessel and had no experience navigating in Shark Bay. The Australian Pilot publication notes that local knowledge is advisable when navigating in Shark Bay[5].

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4 Australian Pilot, seventh edition, volume V, chapter 4.415, 1992.

5 Australian Pilot, seventh edition, volume V, chapter 7.76, 1992.

Although the masters had no local knowledge, the Foundation did not employ the services of a pilot with local knowledge, nor did the masters elicit advice from local operators.

A commercial vessel passed well to the south of *Leeuwin II* as it floated free of the shoal on which it had grounded in Prince Frederick Harbour. This fact, and the size of the shoal, indicates that this vessel's master and most probably other commercial operators in the area had prior knowledge of the shoal, but the knowledge had not been passed on to either the West Australian authorities or the AHS.

During the past 16 years, there has been a steady flow of hydrographic notes[6] pertaining to navigation matters (on chart AUS730) sent to the AHS. As a result of this information, about five 'Notices to Mariners' have been published each year, updating that chart. Evidence suggests that while there is most probably local knowledge of the shoal, no hydrographic note had been sent to the AHS prior to the grounding of *Leeuwin II* on 22 July 2005.

The master of *Leeuwin II* forwarded a hydrographic note to the AHS following the grounding in Prince Frederick Harbour. Notice to Mariners number 778, edition 18, issued on 2 September 2005, indicates the presence of a shoal in the position where *Leeuwin II* grounded.

4.3 Navigation charts

4.3.1 Zone of confidence and reliability diagrams

Australian navigation charts contain either a zone of confidence (ZOC) or a reliability diagram. This diagram outlines the quality of the survey in the various areas of the chart and is intended to assist the mariner in making an assessment of the quality of hydrographic survey data contained on the chart, and therefore the amount of reliance that should be placed on the survey data presented on the chart.

The ZOC diagram for chart AUS730 (Figure 13) indicates that large areas of the chart are unsurveyed, and that the majority of the chart, including Prince Frederick Harbour is ZOC C.

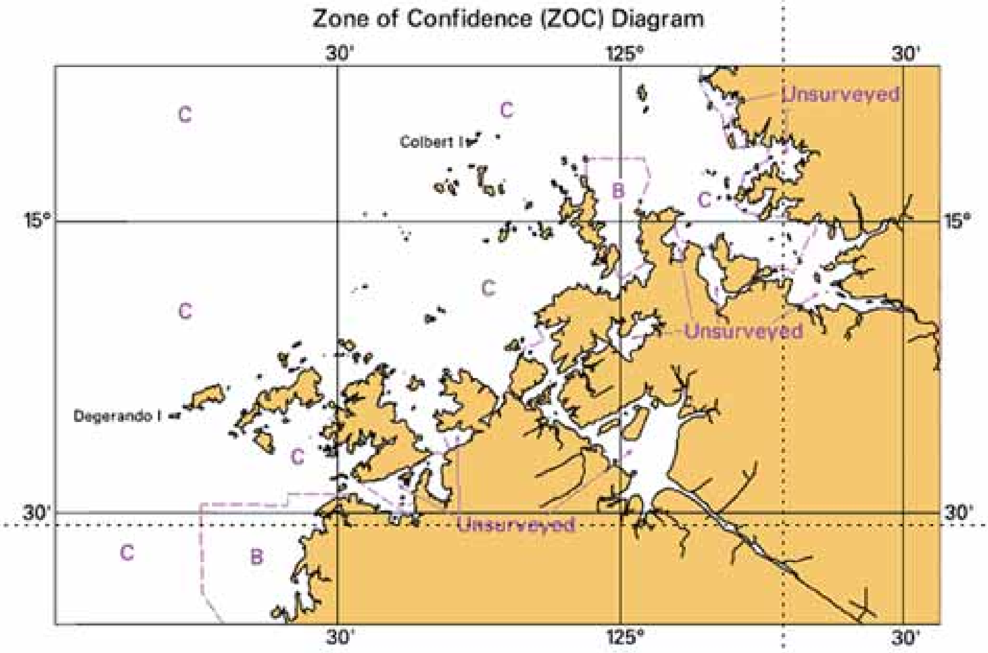
Charts AUS747, AUS748 and AUS749 contain a reliability diagram in place of a ZOC diagram. A reliability diagram does not contain the detail of soundings that are present in a ZOC, and as such reliability diagrams are being replaced with ZOC diagrams on AHS charts when new editions are printed.

The reliability diagrams on these three charts (AUS749 shown in Figure 14) clearly indicate that sounding data in the vicinity of Cape Peron North and Cape Peron Flats was obtained using lead line soundings[7] and is inadequate.

6 Information regarding the discovery of a navigational anomaly, sent to the AHS.

7 Sounding taken in shallow water using a marked line attached to a lead weight. The accuracy depends upon the expertise of the operator.

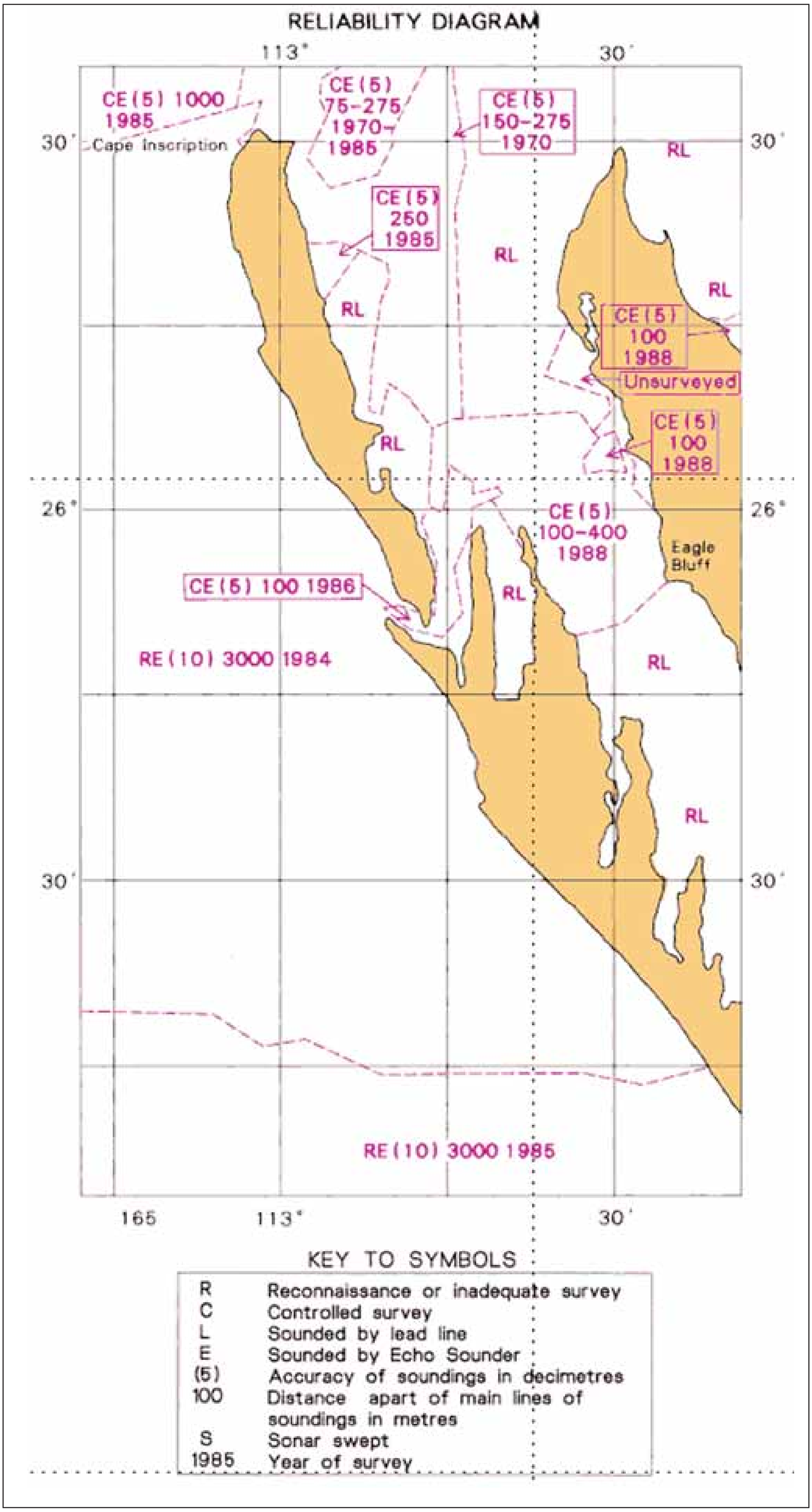
Figure 13: ZOC diagram for navigation chart AUS730



ZOC CATEGORIES
(For details see Australian Notice to Mariners No 25)

ZOC	POSITION ACCURACY	DEPTH ACCURACY	SEAFLOOR COVERAGE
A1	± 5m	= 0.50m + 1%d	All significant seafloor features detected.
A2	± 20m	= 1.00m + 2%d	All significant seafloor features detected.
B	± 50m	= 1.00m + 2%d	Uncharted features hazardous to surface navigation are not expected but may exist.
C	± 500m	= 2.00m + 5%d	Depth anomalies may be expected.
D	Worse than ZOC C	Worse than ZOC C	Large depth anomalies may be expected.
U	Unassessed-The quality of the bathymetric data has yet to be assessed.		
MDSC	Maintained Depth See Chart		

Figure 14: Reliability diagram printed on Chart AUS749



4.3.2 Prince Frederick Harbour – Chart AUS730

The survey used as the basis for chart AUS730 was that carried out by Lieutenant Phillip Parker King in the 1820s.

The chart had remained virtually unchanged through till about 1976, when the NATMAP[8] survey of the area was completed. The aim of the NATMAP survey was to survey from the 300 metre depth mark to the 30 metre depth mark. It was not the mandate of NATMAP to report shoals or navigational dangers, and so any that were observed during the survey were not necessarily recorded. The soundings recorded during the NATMAP survey were at approximately one nautical mile intervals and were not intended to be of sufficient density to support unconstrained navigation without the need for additional precautions. As such soundings from these surveys are represented by a combination of upright, hairline figures when they are depicted on the chart, and a suitable reliability diagram or zone of confidence allocation.

The chart has since been updated to World Geodetic System 1984 (WGS84)[9].

Further to the ZOC diagram, there is the following notation, which is located under the chart header:

> Depths are in metres and are reduced to Chart Datum, which is approximately the level of Lowest Astronomical Tide. Depths shown in upright figures are from old or inadequate surveys.

It is important to note that nearly all the depth figures on this chart are in upright figures. This notation and the ZOC diagram clearly indicate that the quality of survey used to compile this chart is of a poor standard.

The AHS also publishes HydrOcscheme[10]. This publication details the results of an evaluation of areas that require survey, and reports on what surveys will be carried out in the near future. Areas are evaluated with regard to their commercial, environmental and defence significance, and a plan for future surveys is developed. Any organisation or individual has the ability to make a submission to the HydrOcscheme, and thus have input into determining the AHS future survey schedule.

Information contained in the 2005–2008 HydrOcscheme publication (printed on 26 August 2005) indicates that the AHS plans to start surveying the Bonaparte Archipelago (Figure 14) in late 2006. Chart AUS730 covers just a small part of this survey. It is estimated that it will take several years to complete the entire survey. When the survey is completed it is expected that zone of confidence for the chart AUS730 will be A2 or B (Figure 13).

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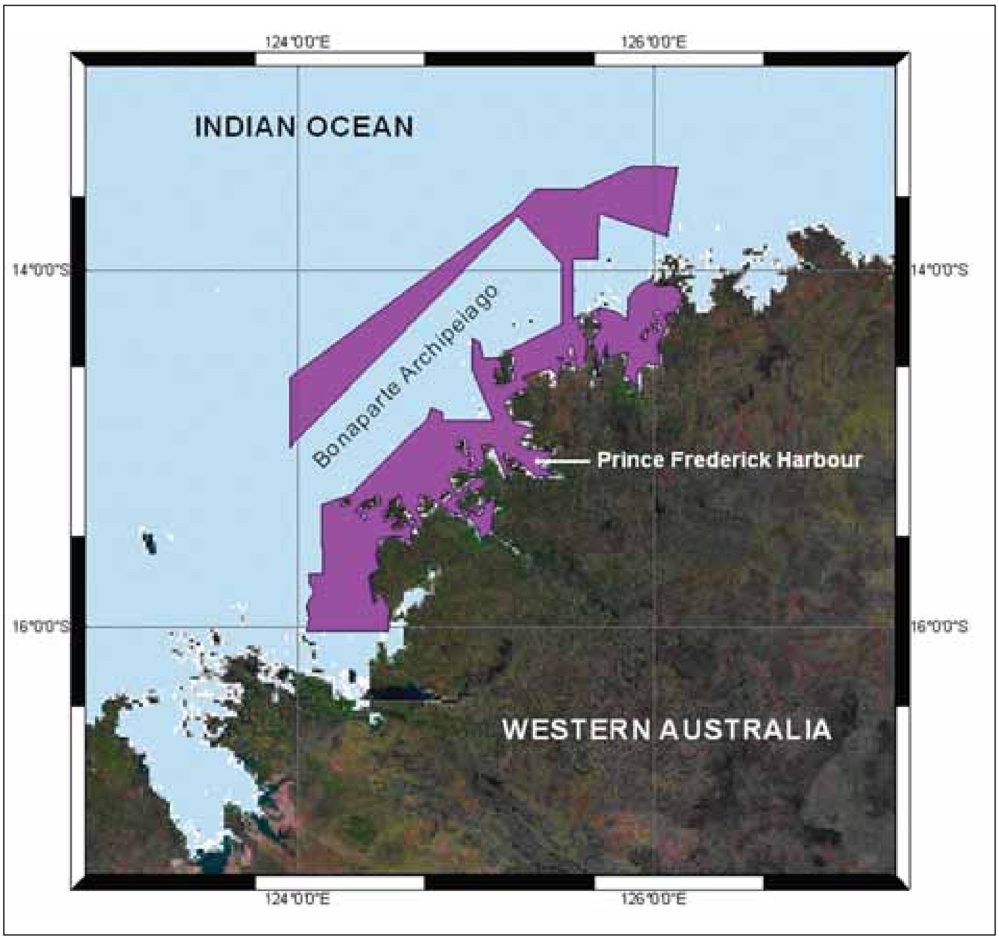
8 Now Geoscience Australia.

9 Updated to allow satellite derived positions to be plotted directly onto the chart.

10 Hydrographic and Oceanographic Scheme.

Figure 15: Area of Bonaparte Archipelago to be surveyed



4.3.3 Shark Bay – Charts AUS747, AUS748 and AUS749

As with chart AUS730, charts AUS747, AUS748 and AUS749 contain hydrographic survey data which was compiled without the aid of modern survey equipment. The charts have been corrected for the WGS84 datum, allowing GPS positions to be plotted directly onto the charts.

These three charts are the largest scale charts (1:150,000) which cover Shark Bay and they were on board *Leeuwin II*, and available for use, during it passages throughout the bay. All three charts contain notes to mariners regarding the inadequacy and quality of the hydrographic survey data which was used to make the chart. The chart being used at the time of the grounding was AUS749.

The charts are clearly marked with the notation 'Inadequately Surveyed'. The note on the chart regarding the inadequate survey states:

> Mariners are warned to exercise care within the areas indicated. These areas are not based on adequate hydrographic surveys and uncharted navigational dangers may exist.

Additionally, there is a printed warning on AUS747 and AUS748 (Figure 16) in the inshore route used by the master on 16 September which states that shoaling was reported in this area in 1994. This warning was not present on either AUS749 (Figure 17) or the ECS chart (Figure 12), both of which were in use at the time of the grounding. The master stated, however, that he was aware of the warning of the reported shoaling as printed on AUS747 and AUS748 prior to his deciding to transit the inshore route.

Figure 16: Western portion of navigation chart AUS748

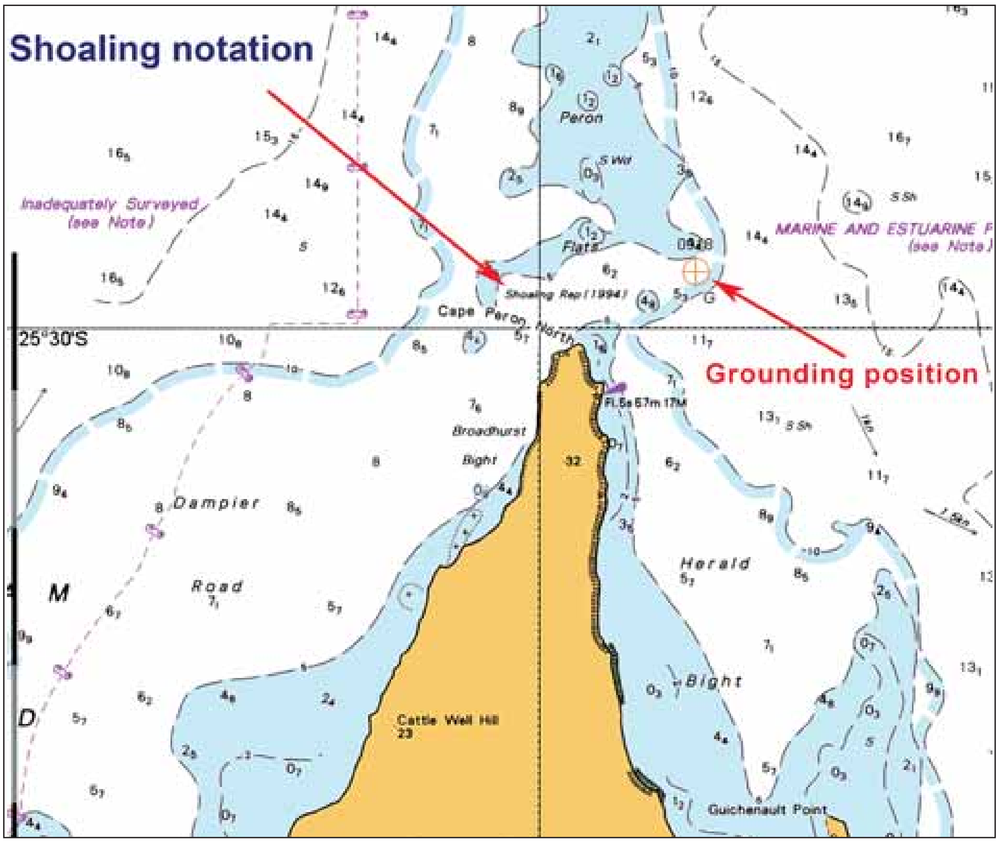
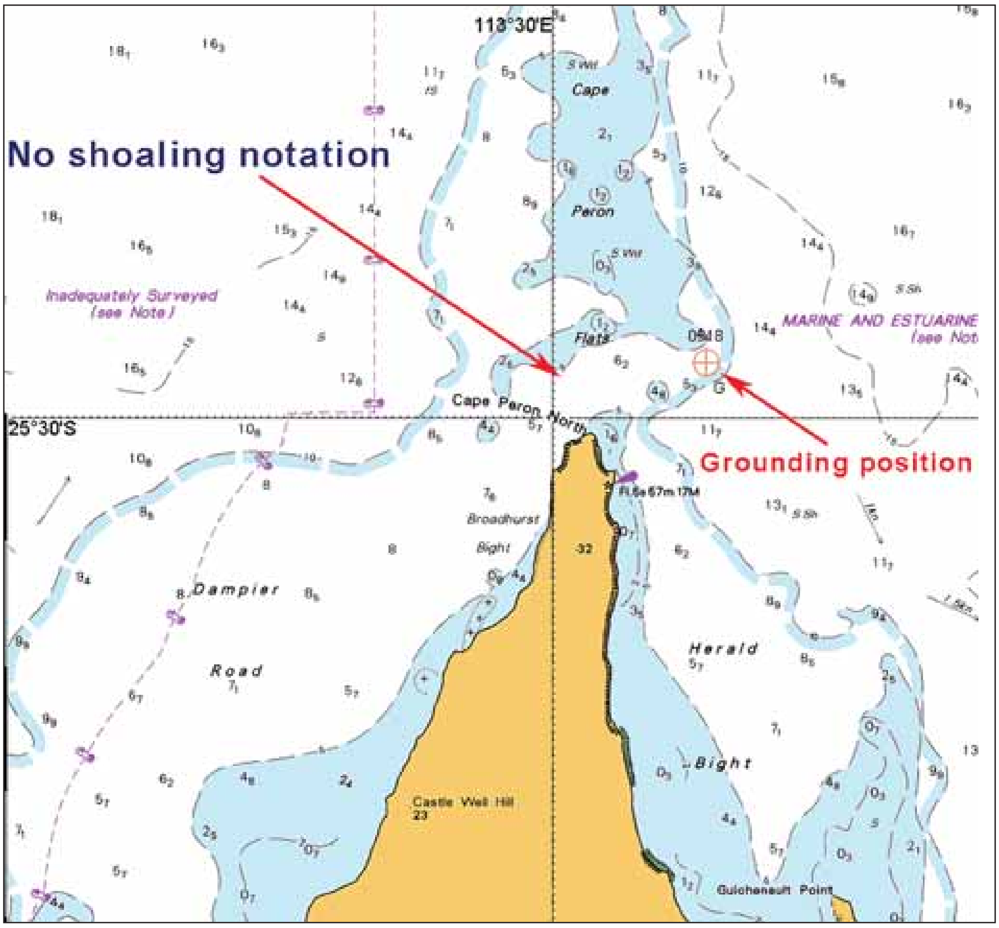


Figure 17: Eastern portion of navigation chart AUS749



Leeuwin II transited the inshore route at almost low tide. By doing so and not waiting for the tide height to increase, almost no room for error existed if the vessel was to encounter uncharted dangers or inaccurately surveyed depths. The master reduced the speed of the engines, in the hope of reducing any squat effect during the transit. However, taking into account the vessel's speed (under motor) and its relatively fine lines, the effect of any squat would have been negligible.

While being aware of the inaccuracy of the charts, which led to the possibility that uncharted shoals might have existed in the inshore route, and knowing the state of the tide, the navigation team still decided to deviate from the intended safe route planned to clear the area of shoaling (Cape Peron Flats).

4.3.4 Summary

The evidence suggests that because of the masters' lack of local knowledge of the areas in which they were navigating the vessel, they placed an over reliance on the survey information presented to them on the charts.

4.4 Risk management

Each year, during the months of April to October, *Leeuwin II* is engaged in tours of north and north-western Western Australia. The ship completes two return voyages between Broome and Darwin, and then divides the return trip from Broome to Fremantle into a number of smaller voyages. There is a large passenger demand for these voyages and the income they generate helps the Leeuwin Ocean Adventure Foundation meet its annual goals and subsidises the cost of running the Foundation's youth leadership training voyages.

The responsibility for operating the ship in these areas rests entirely with the masters. There is no evidence to suggest that the Foundation or the ship's masters have carried out a full analysis of the risks involved in operating the ship in these poorly charted areas.

In the Prince Frederick Harbour grounding, the ship successfully refloated on the flood tide and was not damaged. The evacuation of passengers and non-essential crew was managed well by the master. However, the Foundation did not have any emergency management procedures in place, in the event of the vessel becoming stranded in a remote location. Had the grounding been more serious, and the vessel holed or foundered, there were no contingency arrangements in place to evacuate the passengers and crew in an efficient and timely manner.

An overall risk management strategy should include the implementation of effective passage planning and bridge resource management (BRM) principles.

4.4.1 Passage planning

An important element in undertaking any voyage is proper berth-to-berth passage planning.

The Seafarer's Training, Certification and Watchkeeping (STCW) Code outlines several principles which should be incorporated in a vessel's voyage plan.

Section A-VIII/2 the code[11] states that:

> The intended voyage must be planned in advance taking into consideration all pertinent information and any course laid down must be checked before the voyage commences.

> Prior to each voyage the master of every ship must ensure that the intended route from the port of departure to the first port of call is planned using adequate and appropriate charts and other nautical publications necessary for the intended voyage, containing accurate, complete and up-to-date information regarding those navigational limitations and hazards which are of a permanent or predictable nature, and which are relevant to the safe navigation of the ship.
>
> When the route planning is verified taking into consideration all pertinent information, the planned route must be clearly displayed on appropriate charts, and must be continuously available to the officer in charge of the watch who must verify each course to be followed prior to using it during the voyage.
>
> If a decision is made, during a voyage, to change the next port of call of the planned route, or if it is necessary for the ship to deviate substantially from the planned route for other reasons, then an amended route must be planned prior to deviating substantially from the route originally planned.

The guide to passage planning makes it clear that a proper passage plan is more than merely drawing courses on charts or entering waypoints into an ECS.

While the STCW Code applies to the training of watchkeepers serving on large vessels, the principles of passage planning contained within the Code can be applied to commercial vessels of any size.

The safety management system (SMS) on board *Leeuwin II* gives little guidance to the ship's officers with regard to the organisation's requirements for passage planning. It simply states the following:

> The Master and Chief Officer should prepare a passage plan prior to each voyage. Use of the Australian Pilot, port information file and any other material pertinent to the voyage is encouraged. Tracks must be drawn on each chart using the largest scale available. This planning is fundamental to putting the voyage program together.

Prince Frederick Harbour

The courses for the scheduled voyage from Broome to Darwin were laid off on the charts prior to the master joining the vessel in Broome. Prior to the voyage from Careening Bay to Hunter River, he reviewed the intended route laid off on the paper charts and considered it appropriate.

The ship's officers indicated that *Leeuwin II* had in the past followed the same route through Prince Frederick Harbour. There were records containing past voyage information maintained on board *Leeuwin II*. These records included written descriptions of past tracks, ECS route records and anchorage 'mud maps'. While there was evidence that the ship had operated within Prince Frederick Harbour in the past, there was no evidence that the ship had followed the route used on 22 July.

While the route from Careening Bay through Prince Frederick Harbour to Hunter River was laid out on the paper chart, evidence indicates that it was not entered in the ECS.

11 Section A-VIII/2.

It is evident that there was no formal passage plan in place for the voyage from Careening Bay to Hunter River and that by not entering the intended track into the ECS, the master and ships officers did not use all the navigational equipment they had at their disposal.

Shark Bay

Formal passage planning, as described in the preceding paragraphs was not fully practiced on 16 September for the voyage to Monkey Mia. The master prepared a simple route plan on the ECS and was aware of the tides in the area. He had drawn the route and notated danger areas on the paper chart (AUS749) so that the watch officers were aware of the charted shoal patches. However, he deviated from the plan without fully considering and appreciating the risks associated with the change.

Had he referred to the warnings on the charts and the information contained in the Australian Pilot publication regarding the conditions in Shark Bay, the master may have chosen to remain on his originally intended route.

4.4.2 Bridge Resource Management (BRM)

Nijjer (2000) defines BRM as:

> The use and coordination of all the skills and resources available to the bridge team to achieve the established goal of optimum safety and efficiency.[12]

The Australian Maritime Safety Authority, Marine Notice No. 34/2002, states the following:

> BRM should begin at the initial pre-passage planning stage to identify the dangers to be met and the necessary precautions and contingency arrangements, and continue until the end of the passage. A debriefing should be held shortly after the passage to analyse the events and to identify improvements that can be made in the BRM arrangements for subsequent passages. BRM should include a clear identification of all the bridge team members at all stages of the voyage, their relative duties and responsibilities, and the line of command including the levels of authority in making, challenging or responding to decisions and instructions.[13]

BRM provides a method of organising the best use of human and other resources on the bridge to reduce the level of operational risk. A key safety aspect of BRM is that it builds a 'shared mental model' and puts in place defences against 'single person errors', which can result in a serious casualty.

Prince Frederick Harbour

According to the watch officer, who had the con of the vessel until ten minutes before the grounding, he had no clear understanding as to where the master intended to take the ship.

He was aware that after coming around Cape Torrens he was to follow the courses laid off on the paper charts. He knew there would be a number of course alterations around some islets in the centre of the harbour and that the ship would ultimately be anchoring in Hunter River. He did not understand where in Hunter River the ship was heading.

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12 Nijjer, R. (2000) *Bridge Resource Management: The Missing Link*, Sea Australia 2000, Sydney.

13 AMSA Marine Notice No. 34/2002 (superseding 7/1994).

There is no evidence to suggest that the master and navigating officers had identified all the dangers that could be encountered in the upcoming voyage, and they did not put strategies in place to mitigate them. There was no briefing prior to the voyage and the discrepancies in the statements made by the master and the watch officer indicate they had not communicated properly. They did not have a shared mental model of the passage ahead.

Shark Bay

The master of the vessel in this incident was following good BRM practices when he consulted all the navigation officers about his wish to use the inshore route. However, he did not fully identify the dangers he may encounter by altering his intended route.

4.4.3 Summary

Passage planning and BRM are used extensively in the operations of large ships world-wide. Their application and advantages, however, are yet to be appreciated in the operation of smaller vessels in Australia.

The masters of *Leeuwin II* at the times of the groundings were both experienced master mariners with extensive command time on large vessels. They should have been aware of the principles of passage planning and BRM and their application. As such, these principles should have been in use on board *Leeuwin II*.

4.5 Depth indication and recording

Leeuwin II is fitted with a digital graphic display echo sounder (Figure 18). It indicates the depth below the transducer at any given time, and the display shows a history of water depth over a short period of time.

Figure 18: Echo sounder on board *Leeuwin II*

The echo sounder transducer is fitted in the midship section of the vessel, only recording the depth under this part of the vessel and not at the bow. The echo sounder does not look forward or to either side.

When operating in shoal water with minimum under keel clearance, an echo sounder is not effective in showing that a vessel is about to ground. Had *Leeuwin II* been fitted with a unit such as a forward scanning sonar, the shoaling ahead of the vessel may have been detected, and the groundings avoided.

Figure 19: Prince Frederick Harbour events and causal factor chart

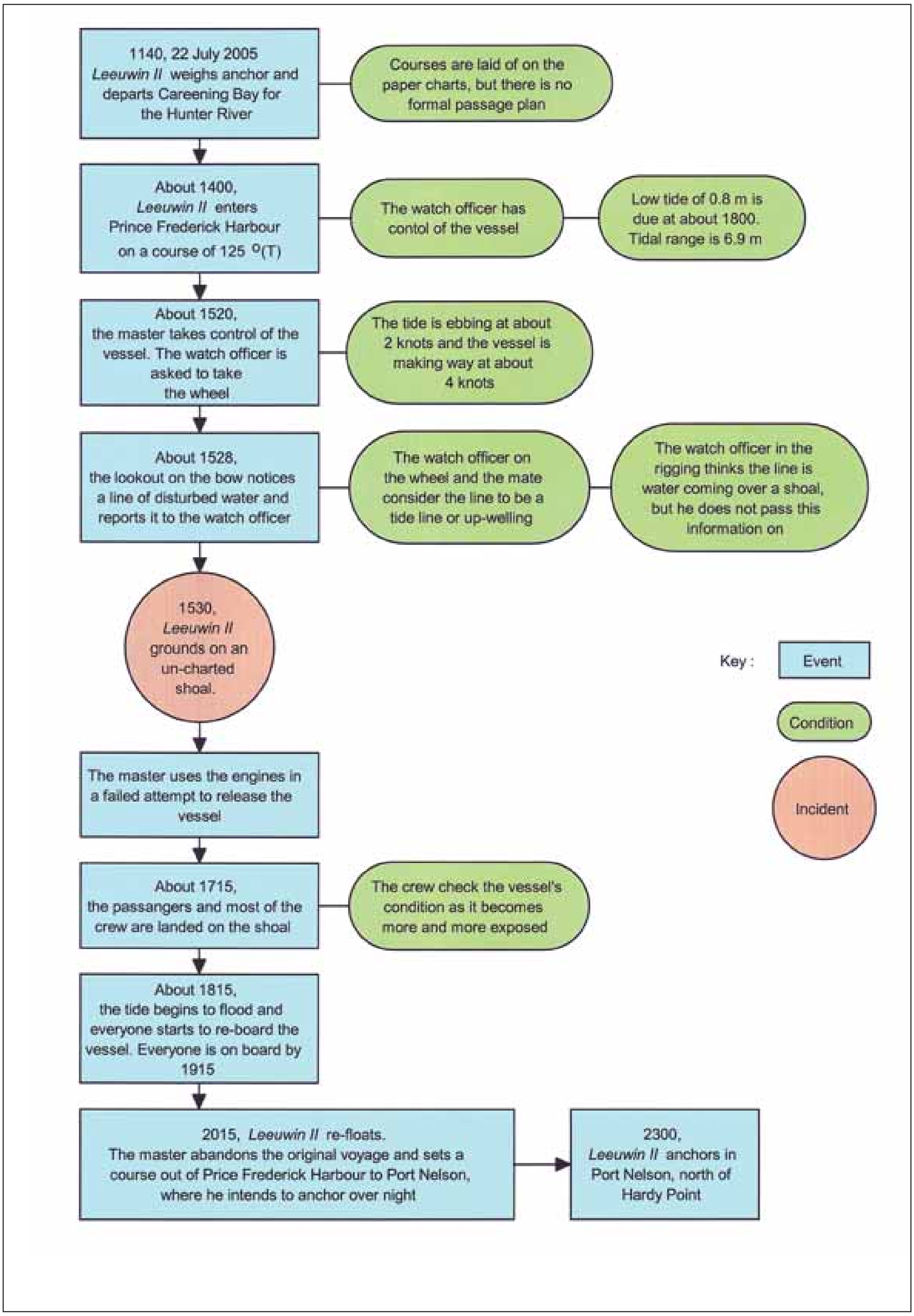
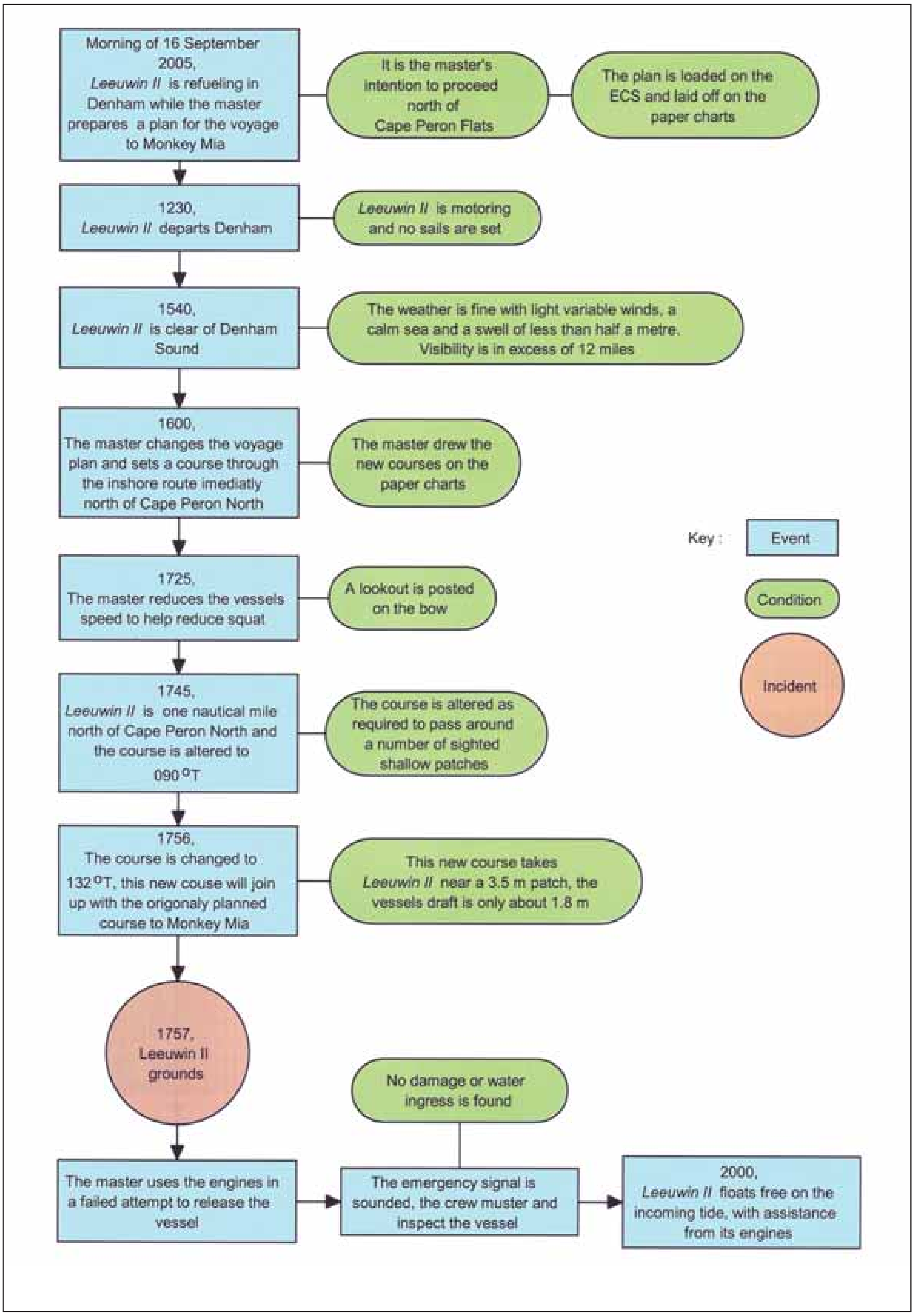


Figure 20: Shark Bay events and causal factor chart



5 CONCLUSIONS

These conclusions identify the different factors that contributed to the accident and should not be read as apportioning blame or liability to any particular individual or organisation.

Based on the available evidence, the following factors are considered to have contributed to the groundings of *Leeuwin II* in Western Australia on 22 July and 16 September 2005:

1. On both occasions the vessel grounded on uncharted shoals in poorly or inadequately surveyed areas.
2. The masters' lack of local knowledge of the areas in which they were navigating may have led to an over reliance on the survey information presented on the navigation charts, without taking note of the quality indicators embedded within the chart.
3. Proper passage planning was not used in the preparation of the voyages and there was a lack of effective communication and understanding of the objectives.

It is also considered that:

4. An effective risk management strategy could have led to the development of procedures and practices which may have reduced the risk of these groundings occurring.
5. The echo sounder was not effective in warning that the vessel was about to ground.
6. Had the existence of the shoal in Prince Frederick Harbour been reported to the Australian Hydrographic Service prior to *Leeuwin II*'s grounding, the navigation chart would have reflected its position. The master could then have planned the voyage accordingly.

6 RECOMMENDATIONS

MR20060013

The Australian Hydrographic Service, in consultation with local commercial vessel operators, should consider implementing a schedule for the complete survey of the Bonaparte Archipelago to ensure that priority is given to those areas most highly trafficked.

MR20060014

Masters of vessels navigating in areas which are inadequately surveyed should ensure that they are aware of the limitations of the information displayed on the navigation charts.

MR20060015

The Leeuwin Ocean Adventure Foundation, in consultation with *Leeuwin II*'s masters, should undertake an analysis of the risks involved in operating the vessel in areas that are unsurveyed or inadequately surveyed, with the intention of developing effective risk management strategies and local knowledge.

MR20060016

The Leeuwin Ocean Adventure Foundation should consider the practicalities of installing a forward scanning depth indicating device on board *Leeuwin II*.

MR20060017

Masters and skippers of vessels of all sizes are encouraged to forward hydrographic notes to the Australian Hydrographic Service when they discover any navigational anomalies that are not displayed on the chart.

7 SUBMISSIONS

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

The final draft of this report was sent to AMSA, AHS, Leeuwin Foundation and the masters and officers of the watch, at the times of the incidents.

Submissions were included and/or the text of the report was amended where appropriate.

8 LEEUWIN II

IMO Number	852373
Call sign	VNWB
Flag	Australian
Port of Registry	Fremantle, Western Australia
Ship Type	Steel hulled barquentine
Builder	Australian Shipbuilding Industries
Year built	1986
Owners and managers	Leeuwin Ocean Adventure Foundation, Fremantle
Displacement	344 tonnes
Design draft	3.4 metres
Length overall	55.0 metres
Beam	9.01 metres
Moulded depth	5.01 metres
Engine	2 x Volvo Penta diesel
Total power	400 Kilowatts
Permanent crew	Six
Volunteer crew	Seven
Passenger berths	40

9 MEDIA RELEASE

Sail training ship groundings

An Australian Transport Safety Bureau (ATSB) investigation report released today states that on two occasions the Australian registered sail training ship *Leeuwin II* grounded on uncharted shoals in poorly or inadequately surveyed areas.

On 22 July 2005 *Leeuwin II* grounded on an uncharted shoal during a voyage under motor from Careening Bay to the Hunter River in the Kimberly region of Western Australia. Just under two months later, on 16 September 2005, *Leeuwin II* grounded on an uncharted shoal in Shark Bay, Western Australia, during a passage from Denham to Monkey Mia.

Both groundings were investigated by the ATSB, and because of the similarities in the key factors which led to both incidents, the reports have been combined.

The ATSB investigation report concludes that the masters' lack of local knowledge of the areas may have led to an over reliance on the survey information presented on the navigation charts.

The report also concludes that proper passage planning was not used in the preparation of the voyages and that an effective risk management strategy could have led to the development of procedures and practices which may have reduced the risk of the groundings occurring.

Copies of the report can be downloaded from the ATSB's internet site at www.atsb.gov.au, or obtained from the ATSB by telephoning (02) 6274 6478 or 1800 020 616.

Independent investigation into the grounding of the sail training ship *Leeuwin II* in Prince Frederick Harbour, Western Australia 22 July 2005 and in Shark Bay, Western Australia 16 September 2005