



Australian Government
Australian Transport Safety Bureau

Safe Transport

MARINE SAFETY INVESTIGATION
No. 205

Independent investigation into the grounding
of the passenger vessel

True North



in the approach passage to
St. George Basin, Western Australia
7 August 2004



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ISSN 1447-087X
ISBN 1 877071 93 5

April 2005

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Media Release

Report on adventure cruise vessel grounding in the Kimberley region of WA

Over reliance on the accuracy of Global Positioning System (GPS) derived positions by a watchkeeper contributed to the grounding of the 35 m adventure cruise vessel *True North* at about 2300 on 7 August 2004, according to an Australian Transport Safety Bureau (ATSB) investigation report released today.

The ATSB report into the grounding of *True North* in the approach passage to St. George Basin, in Western Australia's Kimberley region, states that the vessel grounded on or near Strong Tide Point after a voyage from Prince Frederick Harbour. On board at the time of the grounding were 26 passengers and 12 crew. No pollution resulted from the grounding.

The report concludes that the vessel grounded while being navigated by an auto helm unit and an Electronic Chart System (ECS) receiving position information from GPS satellites. The GPS derived positions plotted on the ECS differed from the vessel's true position by about 300 m. This error was possibly caused by a combination of factors, including GPS system inaccuracy, geodetic datum ambiguity, and a possible recent change in the ECS operating system's computer or GPS receiver parameters.

The report finds that the vessel's master, who was alone in *True North*'s wheelhouse at the time of the grounding, was probably suffering from some effects of fatigue as a result of his work routine. The master did not adequately cross check the GPS positions on the ECS by other navigational means, nor did he maintain an adequate visual or radar check to ensure the vessel remained in safe water.

The report also concludes that there were deficiencies in the procedures which dealt with the mustering of passengers in the event of an emergency.

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.

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SUMMARY

At 2304 on 7 August 2004, the 34.56 m passenger vessel *True North*, with 38 people on board, ran aground in the entrance passage to St. George Basin in Western Australia's Kimberley region. At the time of the grounding, the master was alone on the bridge. The vessel was in automatic navigation mode with course adjustments initiated by means of a GPS navigation system linked to an Electronic Chart System (ECS), that transmitted course adjustment information to an autopilot. No pollution resulted from the grounding, although several passengers received minor injuries during the initial impact.

True North had draughts of 1.5 m and 2.2 m forward and aft respectively and remained aground for about one hour. It floated clear of the rock on which it had grounded on the incoming tide and moved under its own power to an anchorage south of one of the islands in St. George Basin. The vessel was beached by the master on the morning of 8 August and a full appraisal of the damage made.

On 9 August, a repair team and equipment was flown to the vessel by float plane from Broome, Western Australia. The passengers and non-essential crew were then flown to Broome and repair work commenced. Temporary repairs were carried out while the vessel was beached in between the periods of high water. These repairs were completed by 11 August and *True North* departed St. George Basin for Darwin, where permanent repairs were to be effected.

The vessel arrived at repair facilities in Darwin on 14 August. *True North* was able to depart Darwin for Wyndham on 26 August to resume its cruise schedule.

The report concludes that:

- *True North* grounded on or near Strong Tide Point in unsurveyed waters while being navigated by an auto helm unit and ECS receiving position information from GPS satellites.
- GPS derived positions plotted on the ECS differed from the vessel's true position, possibly caused by:
 - GPS system inaccuracy;
 - Geodetic datum ambiguity;
 - The ECS operating on a common user personal computer which allowed possible corruption of the ECS operating system;
 - A change in the GPS receiver parameters;
 - Loose wiring or connections in the on board systems; or
 - A combination of the above.
- Too much reliance was placed on the accuracy of GPS positions and the GPS positions plotted on the vessel's ECS were not adequately checked by other navigational means.
- A proper lookout was not maintained by visual, radar and other means to ensure the vessel remained in safe water.

- At the time of the grounding, it is probable that the master was suffering from some effects of fatigue as a result of his work routine.
- There were deficiencies in the procedures which dealt with the mustering of passengers in that:
 - The initial safety briefing was not sufficiently comprehensive;
 - company orders in respect of lifejackets and emergency signals were not followed; and
 - company practices in the provision of emergency information and procedures did not meet WA legislative requirements.

The report recommends that:

- Owners and operators of vessels running Electronic Chart Systems should do so on dedicated computers.
- Owners, operators and masters of vessels regularly operating in confined waters should revise procedures governing the use of GPS and auto pilot systems.
- Owners and operators of passenger vessels should ensure information concerning muster areas, emergency signals and instructions and diagrams of how to don lifejackets, are included in any passenger information kits in cabins, and on the inside of all cabin doors, in order to comply with state/territory regulations.
- True North Cruises should review the procedures associated with passenger briefings and the emergency information displayed in the passenger cabins and vessel common rooms.
- Owners, operators and masters of non-SOLAS vessels should consider the introduction of effective fatigue management policies and practices on board vessels.
- AMSA and state/territory marine authorities should carefully consider the type of operation and area of operation when determining the safety manning of vessels of any length.
- Western Australia's Department of Planning and Infrastructure should consider recommending the amendment of WA marine legislation to allow for the option to review and, if necessary, change the safety manning requirements for state registered vessel.

2 SOURCES OF INFORMATION

The owners, management, senior master and master of *True North*

Australian Maritime Safety Authority

Western Australian Department of Planning and Infrastructure – Marine Safety

Passengers on board *True North* at the time of the grounding

Acknowledgements

Electrotech Australia, Darwin

The Australian Hydrographic Service

Dr David Silcock, School of Mathematical and Geospatial Sciences, RMIT University, Melbourne

Navigation Dynamics, Cairns

The Great Escape Charter Company, Broome

InterDynamics' Fatigue Audit InterDyne (FAID)

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The International Management Code for the Safe Operation of Ships and for Pollution Prevention [International Safety Management (ISM) Code] as adopted by the International Maritime Organization (IMO) by Resolution A.741(18).

International Convention on Standards of Training, Certification and Watchkeeping (STCW Convention), 1978 and 1995 amendments, and the STCW Code, the International Maritime Organization.

W. A. Marine (Certificates of Competency and Safety Manning) Regulations 1983.

W. A. Marine (Emergency Procedures and Safety of Navigation) Regulations 1983.

Uniform Shipping Laws (USL) Code, Australian Transport Advisory Council, as amended 1989.

National Marine Guidance Manual 'Guidelines For Onboard Safety Training–Australian Domestic Vessels', National Marine Safety Committee (NMSC).

AMSA Marine Notice 02/2002 (Regulatory Requirements for Vessels on Near–Coastal Voyages Subject to the Navigation Act).

Australia Pilot Volume V, seventh edition 1992.

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FIGURE 1: *True North* undergoing repairs in Darwin



True North

True North is an 'adventure cruise' passenger vessel with an overall length of 34.56 m and a moulded breadth of 8.90 m. The vessel was built in 1999 by Image Marine in Fremantle for North Star Cruises, Australia and operates out of the Western Australian port of Broome. *True North* was built under Lloyds Register of Shipping (LR) design rules as a $\times 100A1$ SSC¹ mono-hull, high speed and low displacement passenger ship. It is surveyed in accordance with section 1B of the Australian Uniform Shipping Laws (USL) Code². The vessel is classed with LR and is registered with the Australian Maritime Safety Authority (AMSA) as an Australian vessel.

True North is of welded aluminium construction and has a gross tonnage of 273. It operates with draughts of 1.5 m forward and 2.2 m aft. Its design features a flat bottomed hull which allows it to operate in areas of shallow water. The vessel's two rudders and propellers are protected from damage by steel skegs which extend 1.4 m below the hull at the vessel's stern. Two Naiad Marine fin stabilisers extend below the hull at the midships position. These are controlled from a panel on the wheelhouse console.

The vessel is powered by two independent MTU 16V 2000 M70 diesel engines, each of 750 kW. Each engine drives a single fixed-pitch propeller, which gives the vessel an operating speed of 12 knots. A bow thruster, mounted aft of the forward collision bulkhead, is used to manoeuvre the vessel during berthing and unberthing operations.

The wheelhouse is located on the upper deck, about ten metres from the stem. A range of navigation equipment is located on the wheelhouse console. This includes a JRC JMA-3254 3 cm rasterscan radar, a JRC FVJ-130 colour echo sounder, a Furuno CH-18 forward scanning sonar colour display, a Raytheon Raystar 398 Global Positioning System (GPS) unit, and two personal computers (with their monitors set into the console). Two independent Electronic Chart Systems (ECS) operate on these computers, the Tsunamis 99 system being the primary ECS used. With the exception of the secondary ECS, this navigation equipment is mounted to port of the vessel's centreline.

A Navicontrol AP3003 Gold autopilot unit is located to port of the wheel, on the wheelhouse centre console. A joystick tiller is located to starboard of the wheel, on the same part of the console. Just forward of the tiller are the two main engine controls. A magnetic compass is mounted in the centre of the wheelhouse control console, directly forward of the wheel. Above the centre console are mounted the vessel's ICOM VHF radio and MF/HF DSC (Digital Selective Calling) unit.

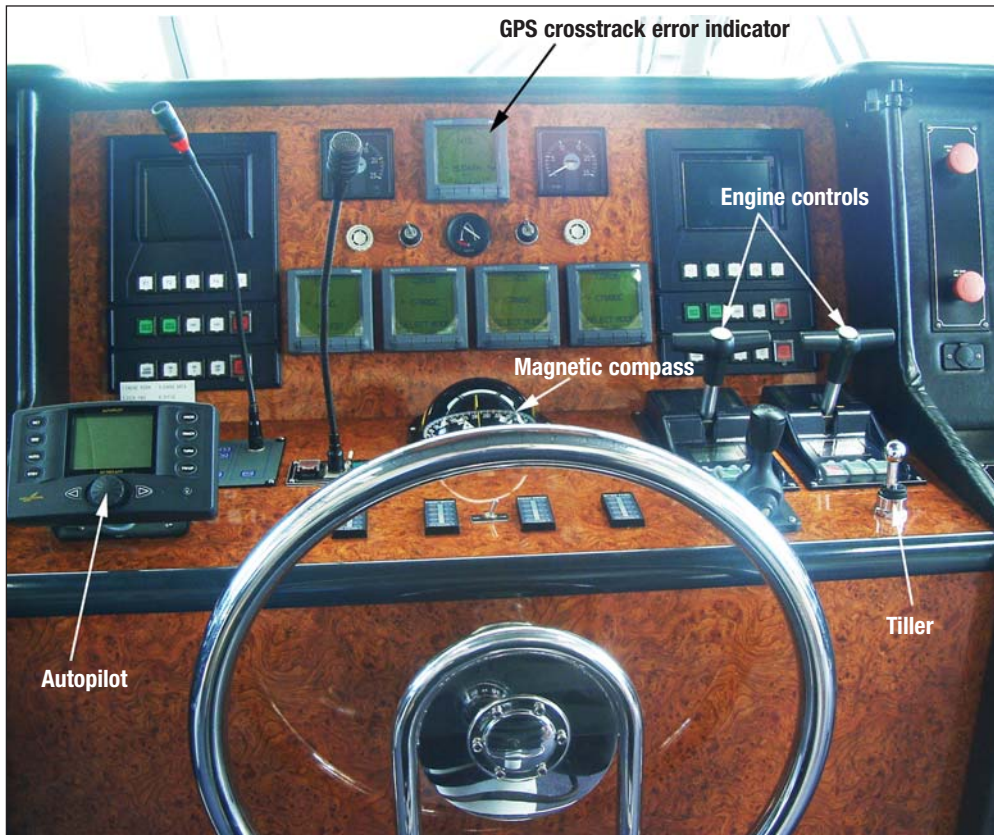
1 Special service craft.

2 A seagoing passenger vessel for use in all operational areas up to and including offshore operations (up to 200 nautical miles to seaward).

FIGURE 2: Portside wheelhouse console



FIGURE 3: Centre wheelhouse console



The vessel is equipped for Global Maritime Distress and Safety System (GMDSS) operations and is certified to operate within sea areas A1, A2 and A3, in accordance with the International Convention for the Safety of Life at Sea, 1974 as amended (SOLAS), regulation IV/2. The INMARSAT-C terminal and another GPS unit are located in a shelf arrangement on the after bulkhead of the wheelhouse.

On board facilities

Up to 26 passengers are accommodated on board *True North* in two staterooms, six double cabins and five twin berth cabins. The two staterooms and two double cabins are located on the middle deck with the remaining cabins located on the lowest deck.

The crew are accommodated in four cabins on the upper deck, behind the wheelhouse, and in two twin cabins on the lowest deck, forward of the passenger cabins. With the exception of the master's cabin, all the crew cabins are twin berth, in a bunk configuration.

Lounge and dining areas are provided for the passengers on the middle deck, just aft of the two staterooms. An under-cover recreational area and bar is provided on the upper deck, aft of the wheelhouse and crew accommodation. The vessel's galley is located on the middle deck, aft of the dining area. An outdoor cooking and fish preparation area is located aft of the galley. Outdoor lounging facilities are provided on the upper deck, forward of the wheelhouse. This area is sheltered by a canopy which extends about six metres forward from the wheelhouse.

FIGURE 4a: Upper deck plan

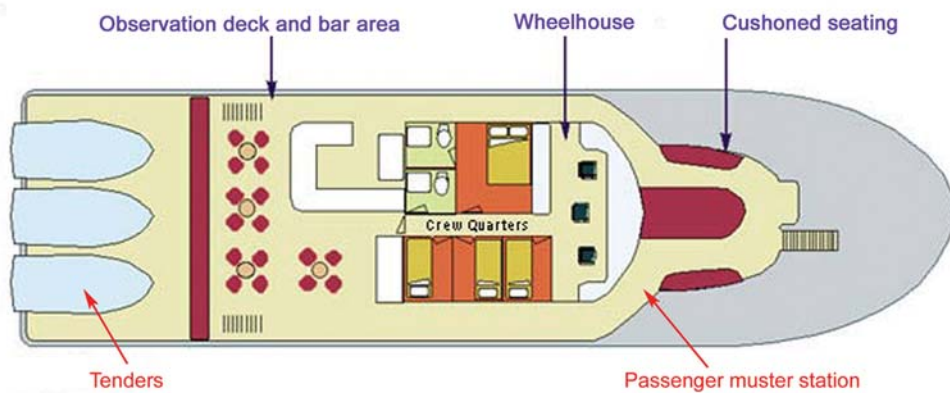


FIGURE 4b: Middle deck plan

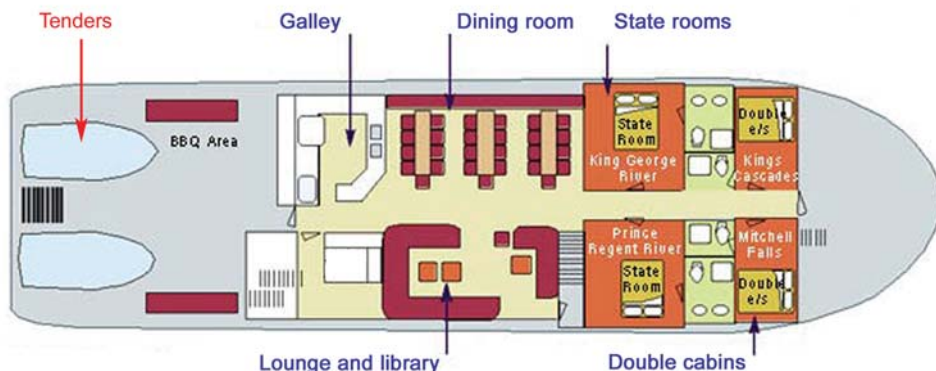
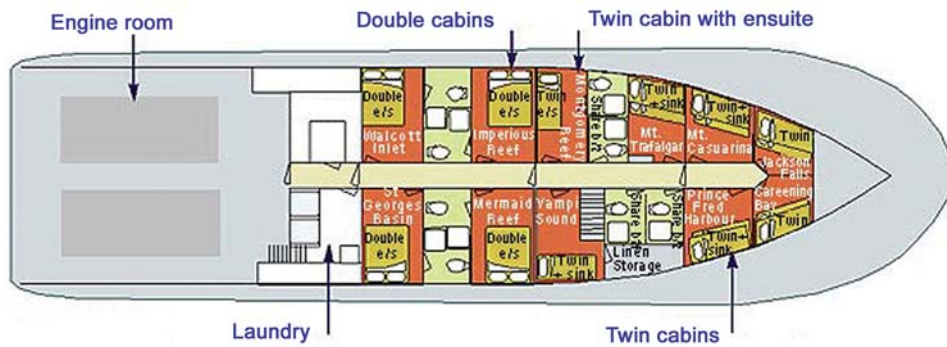


FIGURE 4c: Lower deck plan



Crew

When engaged on Kimberley wilderness cruises, *True North* usually operates with a minimum crew of twelve. This comprises the master and one other navigation watchkeeper (mate), two engineers, a general purpose crew member, a cruise director, two chefs, three cabin attendants/bar staff and a helicopter pilot. The crew of *True North* work a four week on/two week off duty roster. This equates to two Kimberley cruises on board and one cruise off.

The master on board at the time of the incident was 31 years old. In 1989, when he was about 16 years old, he gained his first job on ferries running between Fremantle and Rottnest Island during his school holidays. In about 1991, he became a deckhand on a ketch operating on the Western Australian Coast, including the Kimberley region. In time, he became the skipper of that and other similar sized vessels. In 1997, he gained his Master Class IV certificate of competency. He continued to skipper charter vessels on the Western Australian coast and in Indonesian waters. In addition to the Master Class IV certificate, he held a MED Grade II certificate.

The master joined North Star Cruises at the beginning of 2003 and worked as mate on *True North* until he was promoted to the position of junior master at the beginning of 2004. He had extensive local knowledge of the Kimberley coast, including the entrance to St George Basin, and of small vessel operations and their handling characteristics. At the time of the incident, he had made two successful inward transits of the passage leading into St George Basin as the sole person in charge of the vessel. He had made three transits of the passage under the supervision of the senior master prior to being appointed to his current position. During 2003, he had made seven or eight transits of the passage as mate, again under supervision of the master on board at the time.

The master at the time of the incident joined in Broome on 17 July as mate, after a two week period of leave. He took over as master in Wyndham on 31 July and was due to go on leave again at the completion of that cruise, on 13 August. The mate joined the vessel on 31 July, after two weeks leave. He held a Masters Class V certificate of competency. The vessel had two crew members qualified to work as the vessel's

engineers. One held a Marine Engine Driver (MED) Grade I certificate and the other held a MED Grade II certificate. Another crew member held a coxswains certificate. All these certificates of competency were issued by the Western Australian marine regulatory authority.

Life saving appliances

In accordance with its statutory survey requirements, *True North* is equipped with a range of life saving appliances. This equipment includes:

- two liferafts (for a total of 50 persons)
- six lifebuoys
- 76 lifejackets
- pyrotechnics (stored in a locker in the wheelhouse)
- two radar transponders (in the liferafts)
- three handheld VHF radio transceivers
- a radar transponder (located in the wheelhouse) and
- a 406 MHz satellite Emergency Position Indicating Radio Beacon (EPIRB).

The passengers' muster station is located on the starboard side of the upper deck, just forward of the wheelhouse. All of the passengers' lifejackets are stored in a locker at this muster station. Two liferafts are stowed on the middle deck, on the port and starboard sides, aft of the tenders.

Navigational procedures

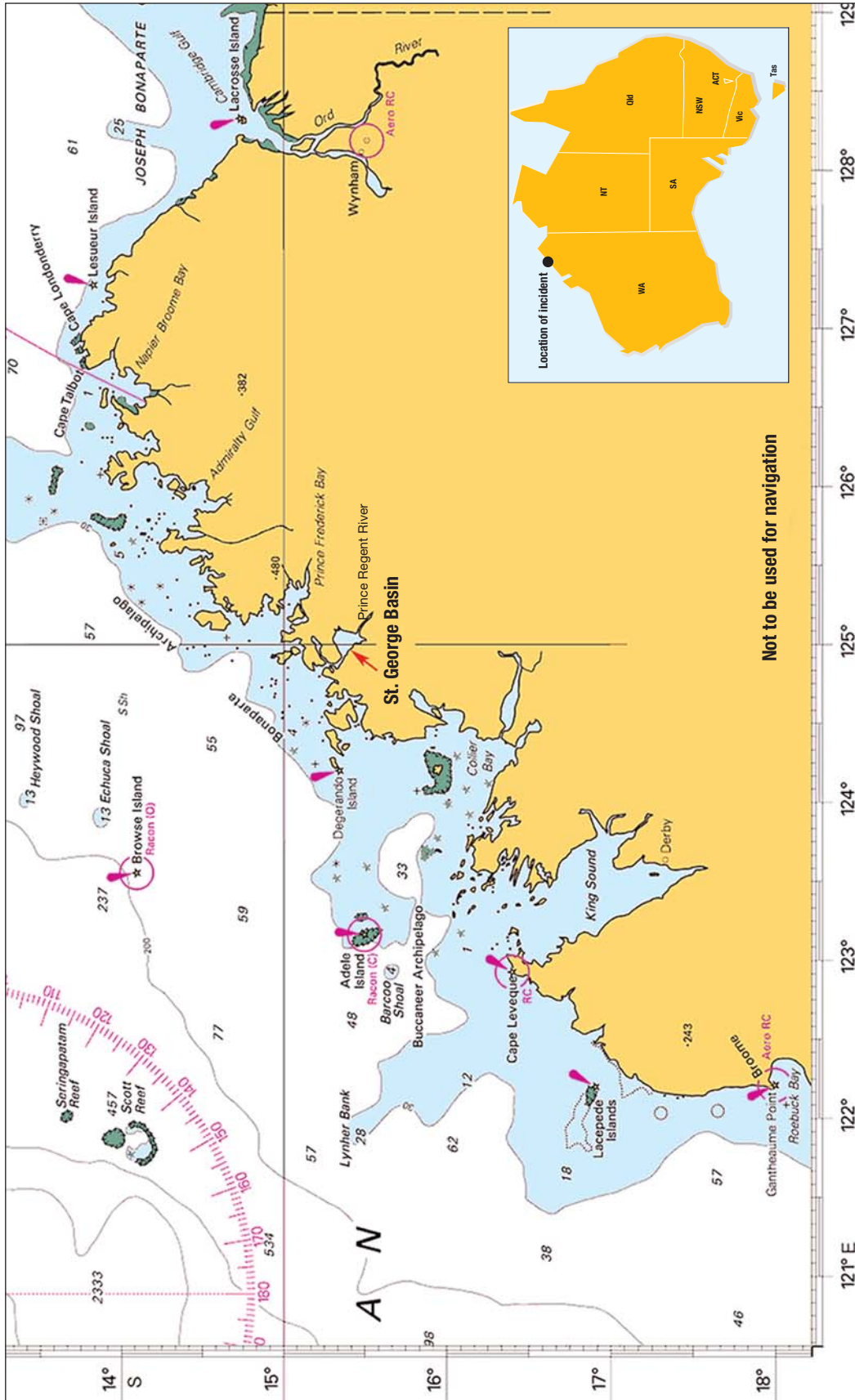
At the time of the incident, it was the usual practice for watchkeepers on *True North* to operate the vessel in a totally automatic navigation mode ('auto-nav' mode). This mode consisted of the GPS smart antenna and GPS wheelhouse unit feeding position information to the ECS. The ECS then fed navigational information into the auto helm unit via NMEA-0183³ standard outputs. The auto-helm unit automatically maintained the vessel on a pre-programmed route. Experience on board had shown that the auto helm maintained a consistent course and it was operated in this mode when underway. Large alterations of course, however, were carried out manually, using the autopilot, after the ECS was disengaged temporarily. Hand steering, using the tiller, was only used for manoeuvring during berthing or unberthing operations.

Cruise operations

For four months each year, starting in March, *True North* operates in the Kimberley coast region of Western Australia. The vessel is engaged in 'adventure tourism', conducting seven and fourteen day wilderness cruises along 2 000 kilometres of the Kimberley coastline. During these cruises, the vessel regularly navigates in rivers and other areas of shallow water and large tidal variations. When not conducting Kimberley wilderness cruises, *True North* is engaged on cruises from Darwin to

³ National Marine Electronics Association (NMEA) – a standard that defines an electrical interface and data protocol for communications between marine instrumentation.

FIGURE 5: Portion of chart Aus 4603 showing Western Australia's Kimberley coastline



Cairns, Rowley Shoal diving expeditions and cruises from Fremantle to Nigaloo Island, in the Monte Bello Island Group to the west of Dampier. A number of other charter vessels operate in the Kimberley coast region, however *True North* is the largest vessel regularly conducting these types of cruises.

Five aluminium tenders, each equipped with outboard motors and VHF radios, are carried on board *True North*. The tenders are used to ferry passengers ashore and to conduct activities during the cruises (fishing, etc). They are stowed on the middle and upper decks aft of the recreational areas. The tenders are operated by the vessel's crew members.

When on Kimberley wilderness cruises, *True North* carries a Bell 407, single turbine engined helicopter. The helicopter is carried on the bridge top. It carries a maximum of seven people (a pilot and six passengers). The helicopter provides access to more remote locations within the wilderness areas.

Prince Regent River and St. George Basin

St. George Basin (Fig. 6) is a body of water that lies about eleven nautical miles upstream from the mouth of the Prince Regent River, a large river at the head of Brunswick Bay in the Kimberley region of Western Australia. Access by water-borne craft to the Prince Regent River, and therefore St. George Basin, is gained through a series of narrow waterways between Cape Wellington and Strong Tide Point. The river between Rothsay Water and Munster Water is disturbed by violent eddies and whirlpools, which are caused by the rapid tidal streams which rush through the confined channels. The rates of the tidal streams in the waterways vary with the widths of the waterways in the river, but may attain between five and seven knots⁴.

About three nautical miles to the southeast of Greville Island, the passage narrows to be about seven cables in width. A further two cables to the southeast, the width of the passage narrows to about five cables. This is the narrowest part of the passage and is bounded by a rocky shoal to the south, and Strong Tide Point on the southern tip of the Marigui Promontory, to the north⁵. This narrow passage divides the Marigui Promontory and the Macdonald Ranges.

St. George Basin is unsurveyed and local knowledge is essential for mariners entering the Prince Regent River. There are no navigation aids within Prince Regent River or St. George Basin.

The incident

At 1720 on 31 July 2004, *True North* departed the Western Australian port of Wyndham for a 14 day/13 night wilderness cruise of the Kimberley coastal region. The final destination was the port of Broome. On board were 26 passengers and 12 crew. At 2110 on 6 August, *True North* anchored in the Roe River, which flows into Prince Frederick Harbour.

At about 0600 on 7 August, the day's routine began for all the crew, who began organising the pre-planned activities. At 1130, the master took the vessel a short distance to Porosous Creek, a tributary of the Hunter River. At 1240 he anchored the

4 One knot equals one nautical mile per hour and 1.852 km/h.

5 Australia Pilot Volume V, seventh edition 1992, page 147.

vessel. After the passengers departed the vessel, the master took a tender to fish for some crabs for a beach barbecue planned for that afternoon.

At about 1600, the mate weighed anchor and took the vessel back into the Hunter River. Enroute, he picked up the master and his tender. The vessel proceeded to a small island in the middle of Prince Frederick Harbour, where all passengers and crew went ashore for the barbecue. At 1845, *True North* departed the island anchorage and began the five hour voyage, via the Port Nelson channel, to the Prince Regent River. The mate had the conduct⁶ of the vessel but the master was in the wheelhouse with him, overseeing the operation. When clear of Prince Frederick Harbour, the master left the wheelhouse and went to his cabin to shower and prepare for dinner.

Between 1900 and 1930, the master joined the passengers for dinner, a routine he adopted every second or third night. During dinner, he consumed a glass of wine. Sometime between 2030 and 2100, dinner concluded and the master went to his cabin to get a some rest before he took over the watch from the mate, for the passage into St. George Basin.

True North passed Cape Torrens at 2000 and Hardy Point (at the northern entrance to the Port Nelson channel) at 2030, making good a speed over the ground of 11.4 knots. At 2130, *True North* passed Cape Brewster (at the southern entrance to the Port Nelson channel), still making good a speed over the ground of 11.4 knots.

At 2200, the master was woken by the mate, and went to the wheelhouse. The master had more experience in the confined, sometimes turbulent stretch of water into St. George Basin and to the anchorage near Saint Patrick Island. After handing over the watch to the master, the mate left the wheelhouse. When the master took over the watch, *True North* had just rounded Cape Wellington, and was beginning the passage through the narrow waters of the Prince Regent River.

Weather conditions for the transit of these waters was fine and clear, with very little wind. There was no moon above the horizon but the sky was clear and stars were visible. The tide was starting to flood and the vessel's speed over the ground had started to increase.

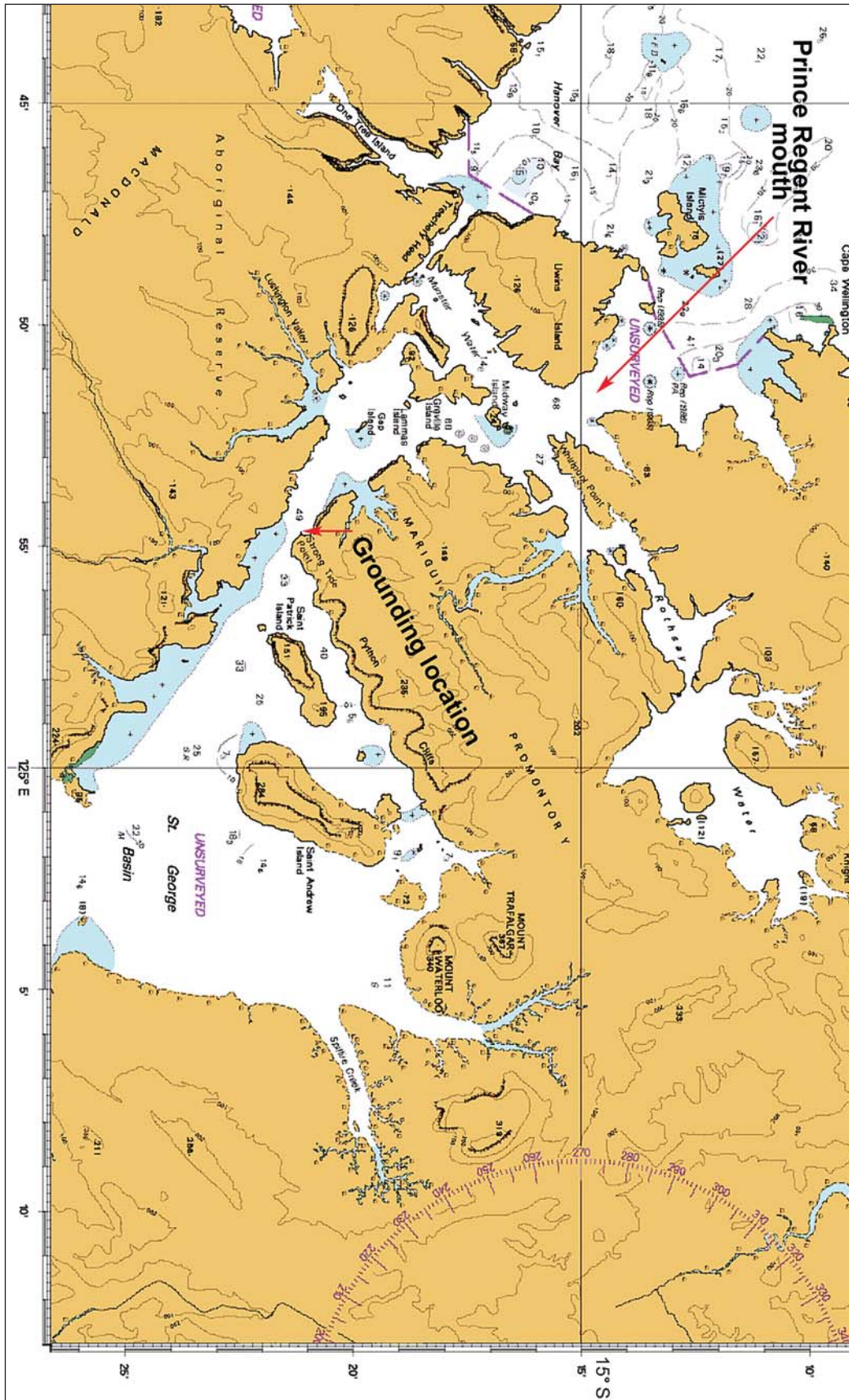
The master stated that, on taking over the watch, he checked all the navigation equipment in the wheelhouse and found that it was functioning normally. During the passage, the master monitored the vessels progress, taking occasional radar ranges. At 2230, *True North* passed to the south of Whirlpool Point (on the northern shore of Rothsay Water) at a distance of 2.55 cables⁷ and with a speed made good of 13.8 knots, as determined by the GPS. According to the master, the autopilot was making slight and subtle course changes to maintain the track programmed in the ECS.

A short time later, *True North* passed to the north of Midway Island and the master took the vessel out of 'auto-nav' mode and made a 73 degree course alteration to starboard. This alteration in course was carried out in 'auto' mode, using the autopilot to turn the vessel by altering the course settings of the autopilot by several degrees at a time. After completing this turn, he returned the vessel to 'auto-nav' mode for the remainder of the passage.

6 To direct the movement or passage of a vessel (commonly referred to as 'having the con').

7 One cable is one tenth of a nautical mile (185.2 m).

FIGURE 6: Portion of chart Aus 730 showing St. George Basin and approach passage



The master claimed he was referencing the cross-track error⁸ information displayed on a repeater situated on the centreline of the vessel, immediately in front of the wheel. He also claimed he was comparing information presented to him by the radar and electronic chart displays. According to the master, he used the clear radar images of the prominent land features to check the vessel's progress, comparing the information displayed on the radar monitor to the vessel's position being displayed on the ECS. There was no apparent discrepancy between the two displays to make him think anything was amiss.

As *True North* approached Strong Tide Point, the master stated he took a radar range off the point, which was 4.5 cables. The vessel appeared to be on the track to pass through the most restricted section of the passage (five cables of navigable water). According to his statement, he moved to the port wheelhouse door, and looked out. He could not clearly see the land features on the port side of the vessel. He then moved out of the wheelhouse to the front of the upper deck, forward of the wheelhouse, for a 'look around'. As he was returning to the port door of the wheelhouse, he could see and feel the vessel turning and sensed that something was not right. He hurried back into the wheelhouse and looked at the radar. As soon as he saw the radar display, he could see a large area of 'green' (being the land) coming at the vessel from port. *True North* was now steering directly for Strong Tide Point at a speed over the ground of about 14 knots. The master quickly made his way to the centre console and was only able to bring the engine controls to stop when, at 2304, *True North* took the ground. The vessel struck with enough force that, according to the master, a 'loud crunching' sound could be heard in the wheelhouse and the entire vessel shuddered on impact.

After the grounding

When it became apparent that *True North* was aground, the master checked that the vessel's engines were out of gear. He then went to the lower deck to check for damage to the inside of the accommodation, and to ensure there was no water ingress into the accommodation space. By this time, passengers and crew were emerging from their cabins to see what had happened. The cruise director and her assistants set about moving the passengers and non-essential crew to the rear of the middle deck. The master, mate and chief engineer together assessed the situation and the master decided to enter the water to see if he could identify the extent of the damage.

On entering the water, with the aid of torchlight, the master could see that a large, sharp rock had penetrated the hull forward of the collision bulkhead. The impact had forced the forward part of the vessel's shell plating up and into the forward void space. The collision bulkhead was also damaged to the extent that water was entering the forward accommodation bilge space, just aft of the void space. He then returned to the vessel. While the master was in the water, the first mate had removed the access hatch in the lower deck, to assess the extent of damage to the collision bulkhead and forward accommodation bilge plating could be assessed. The bilge pumps were started.

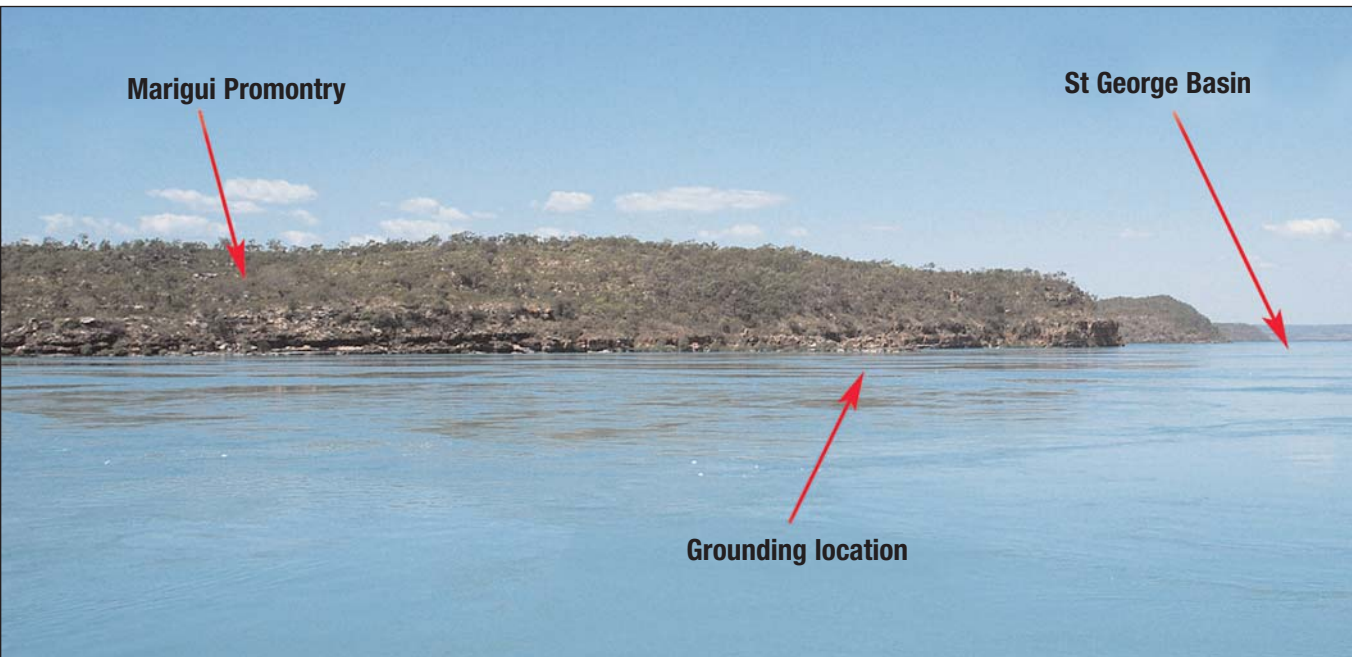
During the time the vessel was aground, the crew established that only two forward compartments were taking water. It was apparent that the vessel was in no danger of sinking. The passengers had been mustered and after establishing the extent of the

⁸ The distance the vessel is off the predetermined course.

damage, the master spoke to them. He ensured that no one was badly injured and that they all knew exactly the situation regarding the grounding and safety of the vessel.

True North remained aground until about 0025 on 8 August when the tide had risen sufficiently to allow the vessel to be refloated. Using the engines, the master moved *True North* to an anchorage position just south of Saint Patrick Island, in St. George Basin, a distance of about 4.2 nautical miles from the grounding position. The anchorage position was near several sandy beaches on Saint Patrick Island where the boat could be beached the following morning and a full assessment of the damage made.

FIGURE 7: Strong Tide Point – location of grounding



(Photo courtesy of The Great Escape Charter Company, Broome, WA)

All equipment was removed from the forward section of the vessel. Any buoyant material on board was moved to the area, including several inflatable fenders.

At 0100 on 8 August, using a satellite telephone, the master advised *True North*'s senior master in Broome of the grounding. The senior master then informed the vessel's owner and managers. Later that morning the vessel's owners and managers held a meeting in Broome to decide how to effect temporary repairs, given its remote location.

Overnight, the vessel remained at anchor and a watch was kept on the level of water in the two damaged compartments.

At about 0700 on 8 August, the master beached *True North* on Saint Patrick Island. The extent of the damage was readily apparent and this was reported back to the owners and managers in Broome. With this knowledge, the decision was made to fly a repair team, equipment and materials to St George Basin and to fly the passengers and non-essential crew to Broome. The master advised AMSA of the incident on the morning of 8 August.

FIGURE 8: Grounding damage



During the day of 8 August, the passengers continued their exploration of the surrounding area, including the Prince Regent River attractions, by helicopter and using *True North's* tenders. The passengers were made comfortable on the beach and that evening, they returned to the vessel.

On the morning of 9 August, a repair team and the senior master departed Broome on a floatplane. During 9 August, the passengers left *True North* and were flown to Broome.

Temporary repairs

Between 9 and 11 August, aluminium plates were welded over the area of damage in the fore part of the vessel. This was done while the vessel was beached in between the periods of high water. Internal bracing was welded in place and cement was poured into the temporary structure to provide additional rigidity. The temporary repair work was completed by mid afternoon of 11 August. At 1510 that afternoon, the floatplane departed St. George Basin with the repair team and four non-essential crew members on board.

At 1840 on 11 August, *True North* departed St. George Basin for Darwin, where the vessel was to be dry docked for permanent repairs. During the 430 nautical mile trip to Darwin, two people maintained navigation watches, with regular ½ hourly visual checks made on the damaged areas. Only a very small amount of water was seen to enter the area and this was removed using the bilge pump. *True North* maintained contact with the Rescue Coordination Centre (RCC) in Canberra through regular AUSREP⁹ position reports. The vessel also maintained contact with pearling vessels operating in the area, in the event of assistance being required.

⁹ Australian Ship Reporting System

The weather was fair and when it was evident that the repairs would hold, the decision to dispense with the helicopter was made by the senior master. At 1500 on 12 August, the helicopter pilot and one other non-essential crew member left *True North*. This left seven crew members on board, the senior master, the master, the first mate, the deck hand, both engineers and the chef.

The weather for the trip to Darwin remained fine with zero to ten knot, northwest to northeast winds and seas between calm to slight. Speed during the trip ranged between seven and ten knots.

At about 2030 on 13 August, *True North* anchored in Darwin's quarantine anchorage. At 0645 on 14 August, a Darwin harbour pilot boarded the vessel and it proceeded to the ship repair wharf. By 0715, the vessel was secure alongside and the pilot departed.

Repairs were completed by 25 August and at 0545 the following morning, *True North* departed Darwin for Wyndham, to resume its cruise schedule on the Kimberley coast.

4 COMMENT AND ANALYSIS

Evidence

On 15 August 2004, two marine investigators from the Australian Transport Safety Bureau (ATSB) attended *True North* in Darwin. The master, senior master and vessel's co-owner, who also serves as master on occasions, were interviewed and provided accounts of the incident and subsequent repair operations. Copies of relevant documents were obtained including: log book entries, operations manuals, passenger safety information; various procedures and statutory certificates.

Data from the vessel's ECS for the relevant days was downloaded and used in the analysis of the incident.

Assistance and advice regarding the integrity and accuracy of the GPS system was obtained from the School of Mathematical and Geospatial Sciences, RMIT University, Melbourne. Electrotech Australia (Darwin) tested the vessel's GPS antenna and, together with Navigation Dynamics (Cairns), provided advice regarding the use of ECS.

The incident

True North grounded while transiting the Prince Regent River, in the entrance passage to St. George Basin, at about 2304 on 7 August 2004. The weather was fine and clear, and the tide was flooding at a rate of about 2.5 knots. At the time of the grounding, the vessel was being steered by the auto navigation system ('auto-nav' mode). At no time in the passage from Prince Frederick Harbour that day, did the watchkeepers observe the ECS giving an indication of any positional errors, or cause them to have any concern regarding the navigational accuracy of the system. The vessel was following established routes, previously entered into the ECS, and had not encountered any problems during past transits of the passage using the 'auto-nav' mode.

At the time of the grounding, *True North's* ECS indicated that the vessel was on course and in safe water when it ran aground. There are a number of possible causes for the GPS/ECS errors which lead to this incorrect information being presented to the watchkeeper. There are:

- GPS system inaccuracy
- Geodetic datum ambiguity
- A change in operating system
- A change in the GPS receiver parameters
- Loose wiring or connections in the on board systems or
- A combination of the above.

The grounding

Evidence indicates that the vessel grounded on or near Strong Tide Point, after a period of time when the actual position of the vessel differed significantly from that displayed on the ECS. The ECS data at the time of the grounding was apparently in error by about 1.6 cables¹⁰. The ECS shows *True North* in clear water on or close to the intended track at the time the vessel took the ground, which was anything up to 300 m north of the ECS position (Fig. 9).

During the transit, the master claimed he was using printouts of the vessel's courses, as entered in the ECS, with radar ranges of land features pencilled in on them. These printouts were used to check radar ranges taken as the vessel progressed on the transit of the passage. These printouts, combined with the route information in the ECS, formed a very basic passage plan for the master to follow.

The positions being displayed on the ECS had the potential to lull the master into a false sense of security and contributed to his relying on GPS as the primary positioning tool for the passage.

Using the track data downloaded from *True North's* ECS, an analysis of positions, courses and speeds made good on 7 August was made.

At 2257:38, *True North* altered course off Marigui Promontory for the passage into St. George Basin. The course for this leg of the voyage was 127°(T). The ECS replay shows that the course made good (CMG) was 121°(T) after that turn took place. A CMG of 121°(T) would have taken the vessel to within about 0.7 cables (129.6 m) of Strong Tide Point. This is in contrast to the 1.46 cables (270.4 m) off the point, which has proved in the past to be a safe passing distance following a CMG of 127°(T).

There are no soundings in the area around Strong Tide Point, so very little is known of the underwater topography and contours. It is not known how close the vessel has to be to the point to run aground. Therefore, by maintaining a CMG of 121°(T), passing 0.7 cables off Strong Tide Point may have been close enough to cause the vessel to ground on an unknown underwater obstruction.

As the vessel approached Strong Tide Point, the master claims to have taken a radar range of Marigui Promontory and he states that this range corresponded to the GPS position on the ECS. This range, according to the replay of the ECS data, would have been about 2.5 cables. On a CMG of 121°(T), this range would have been reduced to 1.8 cables. Any reduction in clearing range may not have seemed significant to the master at the time, but should have prompted further investigation.

True North's radar had the capability of being used for parallel indexing¹¹, to a limited degree. Parallel indexing had been used by navigation watchkeepers in the past. Parallel indexing by radar was not used in the time leading up to the grounding. Parallel indexing provides a much more accurate way of ensuring that a vessel is on track than radar ranges off conspicuous land features alone. Had it been employed in the time leading up to the grounding, the master would have been aware that the vessel was not on track, as displayed on the ECS. However, parallel indexing is not contained in the master class V or IV training package. Therefore the master was possibly unaware that he could use the vessel's radar in this way.

¹⁰ 1.6 cables equals 296 m.

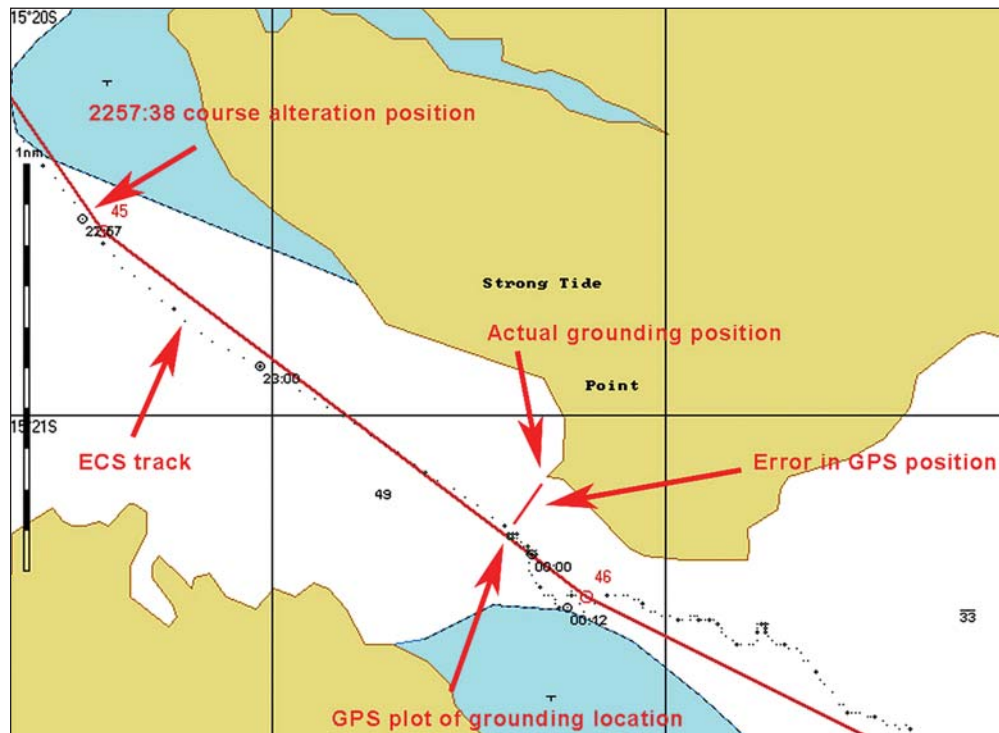
¹¹ A technique that allows the operator of the radar to instantaneously and continuously verify at the vessel is maintaining its course and will therefore pass a radar mark at a predetermined range.

The master stated that he left the wheelhouse after taking the radar range of Marigui Promontory and went onto the deck in front of the wheelhouse. As he returned to the wheelhouse, he could see and feel the vessel turning to port (towards the northern shore) and hastened his return to the helm.

True North was travelling at a speed over the ground of approximately 14.5 knots when it grounded at 2304. This equates to 7.459 m/s. The 127°(T) course laid off on the ECS passes about 270 m from Strong Tide Point. The vessel had to move about 270 m from the charted course to being aground off the point. At the speed it was travelling, the vessel would take 36 seconds to travel that 270 m. The ECS replay plots the vessel's position every 10 seconds. A definite change to port in course over the ground for that period of time would easily be seen on the ECS replay and plot (Fig. 9).

There is no evidence of a substantial course or heading alteration to port prior to the grounding.

FIGURE 9: ECS plot of vessel track leading up to grounding



Echo sounder and forward scanning sonar

Neither the echo sounder nor the forward scanning sonar were operating at the time of the grounding.

While echo sounders give the watchkeeper an indication of shoaling water under the vessel, the equipment provides very little assistance in the case of a vessel encountering a 'point obstruction' in its path, such as a rock. It is not known if *True North's* echo sounder would have alerted the master to a possible danger because the nature of the underwater contours was not known.

True North's forward scanning sonar's transducer had to be lowered beneath the hull of the vessel to allow the sonar to operate. The unit had been damaged on several occasions in the past and it was the practice on board not to use it when the vessel was

travelling on courses or routes in known safe water. In the time leading up to the grounding, it was believed that *True North* was operating in water previously traversed which was clear of obstructions and underwater dangers, and the master had not deployed the transducer.

However, had the forward scanning sonar been operating, it may well have provided a warning of possible underwater dangers forward of the vessel, and allowed the master to take avoiding action.

Standing orders

At the time of the grounding, the company standing orders covering navigational procedures on board the vessel were brief and reportedly supplemented by verbal orders from the senior master. The orders, as posted in the wheelhouse and in the company procedures consisted of half a page of dot points, all general in their directions to the watchkeepers.

Standing orders, like all operating procedures, are to assist people to perform tasks. Good standing orders and procedures are a defence against mistakes or lapses that may manifest themselves in times of emergency or during periods of high stress on board ships.

While there was no legal or company requirement for *True North* to have more than one watchkeeper on watch during navigation in restricted or unsurveyed areas, it **may** have been prudent to 'double up' on watch during these transits. Having two persons on navigational watch would have reduced the level of operational risk (caused by 'single person errors') during navigation in these types of waterways.

At the time of the grounding, standing orders governing the appropriate use of GPS and the 'auto-nav' mode for navigating in close confined waters were non-existent. The decision to use this mode of navigation was left to the master on the vessel at the time. The master on watch at the time of the grounding had taken the vessel through the passage on two other occasions, in his capacity as master. He had, however, completed several transits under instruction from the master when he was serving as mate in the vessel. He stated that he had not experienced any problems with the reliability of the GPS positions displayed on the ECS. He relied on the GPS and the autopilot to steer the vessel when he was on watch.

The navigational standing orders stated that regular checks must be made on the GPS cross track error to ensure that the vessel stayed as close to track as possible and that the cross track error alarm must be turned on. The cross track limits were set to half a cable (92.6 m). The master stated that at no time preceding the grounding did he see the vessel exceed the cross track limits on the ECS nor did he hear the cross track alarm sound. This is consistent with the GPS positions being almost on the track in the ECS.

The standing orders also stated that the vessel's position was to be monitored using radar, ECS plotters and visual means to ensure that the vessel maintained its track and remained in safe water. While not written in documentation, the senior master had issued advice to watchkeepers which required radar to be the primary navigation

means for position fixing. The radar and ECS displays are adjacent to each other on the wheelhouse console and easily compared at a single glance. In addition, the GPS unit displayed CMG information and this was readily available to the watchkeeper during his monitoring of the navigation of the vessel.

The evidence indicates that an adequate and proper check was not kept on the radar and visual situation in the short period of time the vessel was in the approach passage to St. George Basin. Too much reliance was placed on the accuracy of the GPS positional data. Irrespective of whether the vessel appeared on the track as displayed by the ECS, had a careful check been maintained on the radar display, it would have been readily apparent that the vessel was steering into danger.

Since the grounding, the owners have revised the standing orders. The new standing orders formalise and improve some existing long standing practices in place at the time of the grounding. They also expand the duties and responsibilities of the watchkeeper and include ensuring that the vessel shall not be navigated 'by the autopilot in navigation mode i.e. the interface between the autopilot and the plotter must not be used'.

Use of tide

True North was entering St. George Basin on a flood tide. This is the usual practice for the vessel and saves both time and fuel by using the flow of the following tide. The opposite is the case when departing the basin, i.e. use of the ebb tide. There is no governing rate of tide on which *True North* will not transit the passage. However, during maximum spring tidal flows, the time of transit will usually be adjusted so that the vessel is not in the passage at the maximum rate of flood or ebb.

Large vessels would normally stem the tide, to maximise the speed of water flow over the rudder to enable the ship to maintain effective steerage at a lower speed. *True North* is a vessel with a shallow draught and relatively powerful engines that allow the vessel to maintain steerage even in a relatively rapid flowing tide.

GPS positioning

GPS is a satellite-based radionavigation system developed by the United States Department of Defense. Using 24 orbiting satellites, GPS provides instantaneous position, speed and accurate time information 24 hours a day anywhere on or near the Earth's surface. The system is not 100 per cent accurate in its position calculation. Since the removal of 'Selective Availability'¹², civilian users of the GPS system (for absolute positioning) can theoretically achieve 10 m horizontal and 15 m vertical accuracy at a 95 per cent confidence level. This level of accuracy can be improved by the use of Differential GPS (DGPS), which can achieve 2 m horizontal and 10 m vertical accuracy at a 95 per cent confidence level.

Satellite geometry is critical for good position fixing. This is reflected in the Horizontal Dilution of Position (HDOP)¹³ value. The lower a HDOP value, the better the satellite geometry relative to a GPS receiver's location, and the higher the expected position accuracy.

¹² The intentional degradation of the GPS signals by a time varying bias. Removed by the United States Department of Defense in May 2000.

¹³ Measurement of horizontal positional accuracy.

The GPS unit on board *True North* was a standard absolute positioning unit, and does not have DGPS capability. In addition, the area in which the vessel operates does not have DGPS coverage.

The use of GPS has inherent errors associated with it and these errors must be taken into account when positions are determined. They must also be taken into account by users of GPS when relying on GPS for accurate position fixing in confined or unsurveyed waters. GPS, like all aids to navigation, has to be used in conjunction with other methods of navigation so that any errors in position fixing can be minimised. Too much reliance on one navigation aid, like GPS, is inherently dangerous.

GPS errors can be generally categorised as ‘noise’/‘bias’ errors and ‘blunders’. Noise/bias errors may result in typical ranging errors of around 15 m for each satellite used in the position solution. This would be negligible for navigation purposes. Blunders, however, can result in errors ranging from a few hundred metres to hundred of kilometres. A list of some of the more common GPS errors can be found in Annex 1.

Expert advice requested by the ATSB on the integrity of the GPS system indicates that there were no satellite outages at the time of the grounding. The close proximity of the land, combined with the low elevation of *True North*’s GPS antenna, means that possibly 31% (worse case scenario) of the sky to the north east of the vessel was not visible to the GPS antenna (Fig. 10c). This is a large portion of sky and it contained a number of GPS satellites. However, there were still seven satellites, with a sufficient HDOP, visible to the GPS antenna in the remainder of the sky able to provide a reliable position fix (Fig. 10a) (Data sourced from Trimble Navigation, USA).

FIGURE 10a: GPS satellite visibility at time of grounding

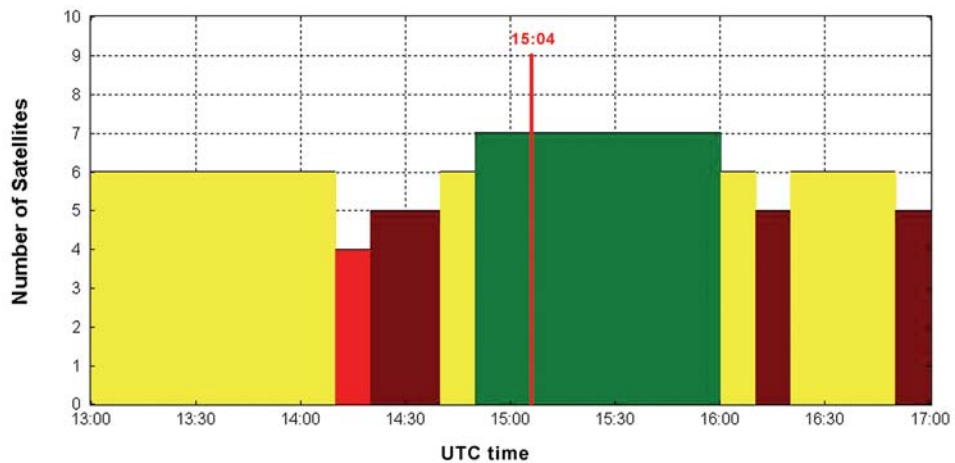


FIGURE 10b: GPS HDOP at time of grounding

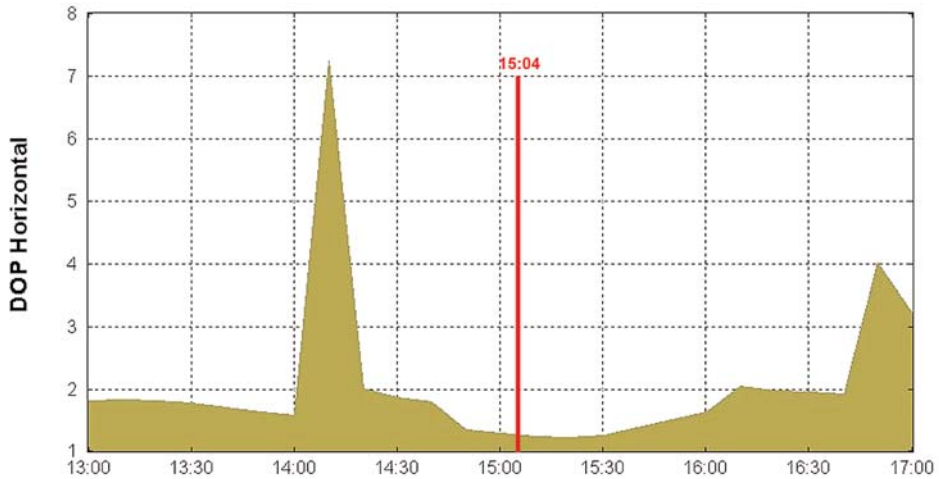
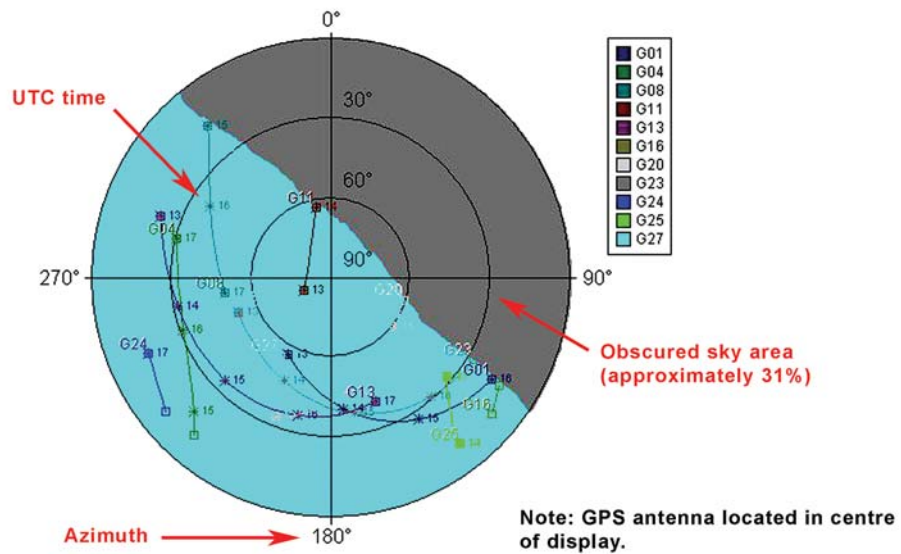


FIGURE 10c: GPS satellite plot at time of grounding



GPS position discrepancy

Why a discrepancy in the ECS position and the actual geographical position existed can not be stated with surety. However, there are several scenarios which might go some way to explaining why the charted and actual track of *True North* differed by such a large amount.

True North was up to 300 m off the charted track when it ran aground. While there were definitely some errors present in the GPS position at the time of the grounding, these alone would not add up to an error in the magnitude of 300 m. If any large error existed, it would be 'blunder' based.

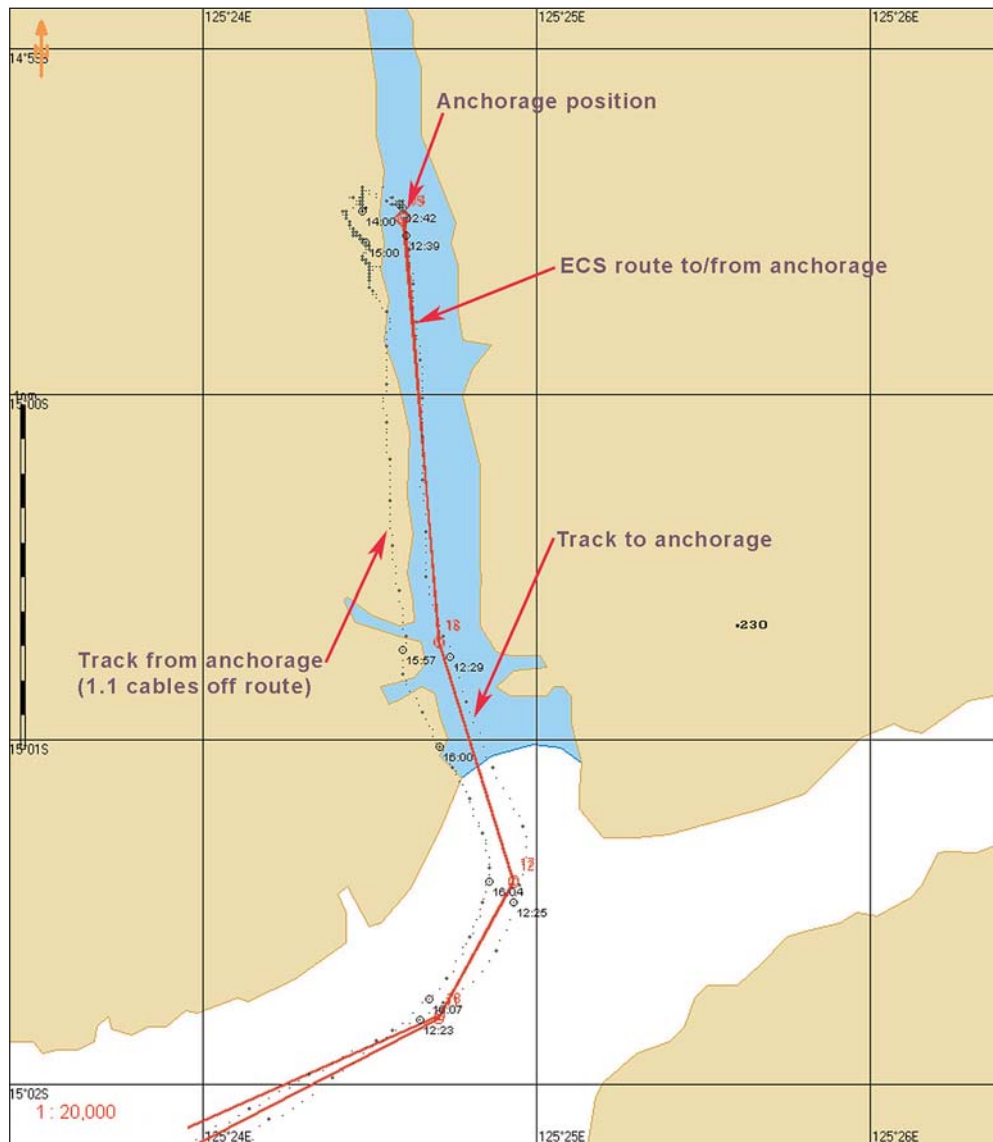
True North uses the same routes in the ECS each voyage. Each route used is named after the area of operation. However, the various routes cannot be combined to form a single voyage. The route for the next leg of the voyage can only be entered into the ECS at the arrival point on the preceding route.

The data from the ECS for 7 August indicates that an anomaly occurred while the vessel was anchored in Porosous Creek on the afternoon of 7 August (Fig. 11).

The vessel proceeded to and from the anchorage in the creek during hours of daylight, when the watchkeeper was able to visually reference the banks of the creek, to ensure the vessel remained in safe water. As such, he did not have to rely on GPS positions. The 'auto-nav' system was operating but not used.

As the plotted positions in figure 11 show, the track up to the anchorage was in the creek, on the route programmed in the ECS. However the track from the anchorage to the river was displaced over the western bank, a distance of 1.1 cables (203 m) off the route to be followed.

FIGURE 11: Plot of vessel's track into and out of Porosous Creek on 7 August



The ECS route from Porosous Creek to St. George Basin was entered while the vessel was at anchor in the creek. According to the crew, they neither made any changes to the GPS receiver nor the programs running on the personal computer on which the ECS operates. They also did not notice any problem with the computer when the route within the ECS was changed at anchor, between 1242 and 1400 on 7 August.

The location of the grounding was the closest point that the vessel passed land on the passage from Porosous Creek to St. George Basin. If the position error apparent leaving Porosous Creek is applied to the approach to St. George Basin, then *True North* would have been 1.1 cables to the north of the pre-programmed track, which could explain the grounding.

It is possible a change in the ECS operating system's computer or GPS receiver parameters may have caused a problem with the GPS position data being plotted.

Dedicated computers for use with ECS

True North was equipped with two personal computers mounted on the wheelhouse console, both of which ran ECS programs. These computers were not dedicated to the use of the ECS alone and had other programs installed on them, related to the vessel's operations – catering and the like.

ECS are susceptible to changes in computer operating system files which occur when other programs are installed or deleted from the personal computer's hard drive. Changes in these files may alter the operation of the electronic charting program, leading to errors and its incorrect operation. The most common problems come from computers that are used for more than one task and have many programs loaded on their hard drives. This results in conflicts when the user attempts to multitask between programs while running the ECS in the background.

It is most important that personal computers used for navigation be dedicated units. Expert advice sought on this problem indicates that ECS on dedicated personal computers seldom give any trouble.

It is possible that a change in the operational set up of *True North*'s ECS occurred at some time before the grounding. This may have contributed to the inaccurate representation of the vessels positions on the ECS. There is no direct evidence to support this theory. However, there were no safeguards in place to prevent such a possibility from happening.

Geodetic datum

Geodetic datums are used to define the size and shape of the earth. Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of metres. The diversity of datums in use today requires careful datum selection and careful conversion between coordinates in different datums¹⁴.

GPS used the World Geodetic Survey 1984 (WGS84)¹⁵ datum to determine positions. If GPS equipment is incorrectly set up and not all positioning components set to the same geodetic datum, then large positional errors can occur.

14 Peter H. Dana, Department of Geography, University of Texas at Austin, 1995.

15 Defined and maintained by the U.S. National Mapping & Imaging Agency (NMIA) as a global geodetic datum. It is the datum to which all GPS positioning information is referred by virtue of being the reference system of the Broadcast Ephemeris.

Some of the geodetic datums currently in use around Australia include:

- WGS84,
- Geocentric Datum of Australia 1994 (GDA94),
- Australian Geodetic Datum 1984 (AGD84), and
- Australian Geodetic Datum 1966 (AGD66)¹⁶.

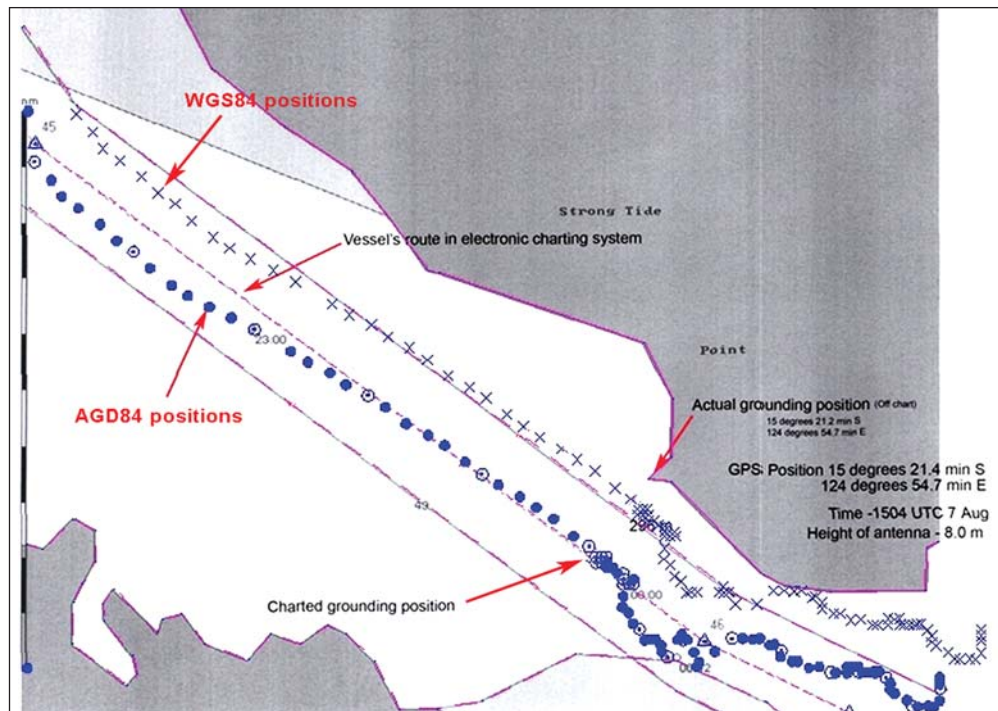
In the Prince Regent River region of Western Australia, the difference in positions between WGS84 and the three listed datums are:

- GDA94 – coordinates read from GDA94 will be the same as those of WGS84,
- AGD84 to WGS84 – 161 m to the north and 137 m to the east
- AGD66 to WGS84 – 159 m to the north and 134 m to the east.

Practically, in most marine applications, AGD66 and AGD84 present the same error in position. The error between AGD66/AGD84 and GDA94 (hence WGS84) positions is about 200 m, in a direct line¹⁶.

To apply the theory that incorrect datum information was being used on board *True North*, its track information was provided to the School of Mathematical and Geospatial Sciences, RMIT University, Melbourne. The data was imported into a surveying software package (LISCAD) and then registered with the nautical mile scale bar, as seen below in figure 12.

FIGURE 12: Comparison of datum position plots



16 Geoscience Australia.

The plot compares the ECS display using two datums, AGD84 and WGS84. The effect of this is that if *True North* was running its 'auto-nav' system on WGS84, with the GPS receiver inadvertently logging ADG84, the plotted position would have been in error by 1.1 cables (203 m) south of the true position relative to land. This happens to be the distance the track was displaced when *True North* departed its anchorage in Porosous Creek.

If the northerly and easterly errors resulting in plotting AGD84 or AGD66 positions on a WGS84 chart are applied to the charted positions when the vessel left the anchorage, the vessel's positions would be placed in the centre of the creek, on the pre-programmed route.

It could also explain the grounding on, or close to, Strong Tide Point.

The evidence that the wrong geodetic datum was being used is circumstantial, supported by the fact that the position of grounding closely coincides with the WGS84 datum position.

Accuracy of the electronic chart

The accuracy of the position of the charted land in electronic charts needs to be taken into account when relying on GPS for accurate position fixing. The Australian Hydrographic Service (AHS) Seafarer chart produced for this area is Aus 730. Advice from the AHS is that this chart was first published in 1989 and that the topography information used in its production was the best the AHS had at the time. A new edition of Aus 730 was produced in February 2003. Part of the reason for the publication of a new edition was to shift the geodetic datum from AGD66 to WGS84.

True North was not navigating using official AHS Seafarer charts. The vessels ECS was using Transas electronic raster charts of the same area. These raster charts are digitised reproductions of paper charts published by the AHS. While these charts are correct for WGS84 plotting, the accuracy of the position of the land depicted on the Transas AU730 chart can not be determined as the unsurveyed boundary may not be properly presented.

GPS smart antenna

While docked in Darwin for repairs, a technician attended *True North* and carried out a check of the GPS associated equipment. These checks found that several of the GPS/antenna connections on terminal blocks in the wheelhouse console were loose. The extent, if any, that these loose connections contributed to the GPS position discrepancy is unknown.

The technician tested the antenna in order to establish whether there was any large error in the position information it passed to the GPS unit. The smart antenna, a Raytheon Raystar 112, did not show any extraneous error during the testing, maintaining a position within 10 m to 15 m from its exact location. This error in position is within the 95 per cent confidence level expected for non-DGPS units.

If the particular GPS unit that *True North* had connected to its ECS loses a GPS signal, it does not default to dead reckoning (DR) navigation. Had there been inaccurate positions derived from an interrupted signal, inconsistent positions would have been

evident. The ECS replay indicated a series of consistent positions in the minutes immediately prior to the grounding, and no erroneous plots.

It was apparent from the observations of the antenna that it took between three and four minutes for an accurate position to be derived after the unit was powered up. It is not known if the power to the antenna was interrupted at any time prior to the grounding.

The replay of the vessels tracks on the ECS does not indicate that there was any loss in GPS signal in the time leading up to the grounding. The ECS plotted track of the vessel is a regular track that does not depict loss of satellite or unacceptable positioning. Were satellites dropped or extreme HDOP values present, variations in the positions on the ECS would be apparent, being up to 500 m or 600 m in value.

Evidence indicates that there was no large position error that could be attributed to the smart antenna in use at the time of the grounding.

At the request of the owners, the technician replaced the GPS smart antenna.

Master's work schedule and level of alertness

Because of the nature of the vessel's operations and the requirement to carry only two qualified watchkeepers, the master inevitably spent long periods directly supervising the navigation on passage. When at anchor, his duties extended to direct involvement in passenger activities.

The master had charge of the watch at the time of the grounding. He had been working almost continuously since 0600 that morning. He had taken over the watch from the mate at about 2200, after a short period of rest in his cabin. He had been following a similar daily work routine since taking over as master in Wyndham on 31 July, and had been on the vessel since 17 July, in his previous capacity as mate. During the four days immediately before the grounding, he was awake in excess of 16 hours each day.

The master stated that he did not feel tired when he took over the watch from the mate, even though he had been awake and busy all day, with the exception of the 45 minutes immediately prior to coming on watch. In the House of Representatives Standing Committee on Communications, Transport and the Arts report on fatigue in the Australian transport industry, 'Beyond the Midnight Oil', released in 2000, it is stated that:

A common perception equates fatigue with feeling sleepy or tired. In many cases, the research uses the terms fatigue and sleepiness interchangeably. However, many researchers differentiate fatigue from 'sleepiness' or 'tiredness'. Tiredness may refer to the ability to initiate sleep while fatigue refers to the ability to maintain job sufficient alertness. By these definitions, it is possible to be fatigued but not feel tired. For example, the time of day may make it difficult to fall asleep even though a person is fatigued. Further, sleepiness is a subjective state while fatigue involves a loss of objectively measurable performance capability over time.

The master provided his hours of work and recreation since the vessel departed Wyndham on 31 July. This data was analysed using InterDynamics' Fatigue Audit InterDyne (FAID) (software developed in conjunction with the Centre for Sleep Research at the University of South Australia) to assess his level of fatigue at the time of the grounding.

FAID is primarily a rostering tool which calculates a 'score' for an individual's level of fatigue at a given time, based on their rostered tasks. These calculations take into consideration four factors that have emerged from research into shiftwork and fatigue over several decades. The specific determinates of work-related fatigue which FAID takes into account are:

1. the time of day of work and breaks;
2. the duration of work and breaks;
3. work history in the preceding seven days; and
4. the biological limits on recovery of sleep.

FAID does not make allowance for mode-specific environmental factors such as noise, age, medical condition, light, vibration or the proximity to the workplace of ship's crews. No allowance is made for any activity outside work hours such as domestic tasks or, as in this case, socialising with passengers.

FAID results are given as an index score, which is plotted on the left of the graph. What the scores indicate is that a figure of:

- < 80 work related fatigue is unlikely,
- >80 to <100 some people will show signs of fatigue impairment on some tasks,
- >100 all people are likely to be impaired by any task.¹⁷

Research by the Centre for Sleep Research suggests that a fatigue score of 40 to 80 as being moderate, 80 to 100 as being high, with scores of 100 to 120 being very high.

A study conducted by the Centre for Sleep Research at the University of South Australia, following the development of the FAID program, states that:

the impairment observed in an individual working with a fatigue score between 80 and 100 is comparable to the impairment of an individual intoxicated with alcohol to a blood alcohol content of 0.05% or greater.

Such a level of alcohol related impairment would not be acceptable at work.

Fatigue affects an individual's performance in the following ways: forgetfulness; fixated on one task; apathetic; slowed reaction time; poor decision making; reduced vigilance; poor communications; bad mood; and being lethargic.

To examine the master's fatigue level at the time of the incident, two FAID scenarios were considered. The first scenario (Fig. 13) uses only his hours of actual work on the vessel as the input, whereas the second scenario (Fig. 14) uses all of his waking hours as the input parameters. The actual score probably lies somewhere between these two scenarios.

¹⁷ Professor Drew Dawson - Centre for Sleep Research, University of South Australia.

FIGURE 13: FAID scenario number one – working hours

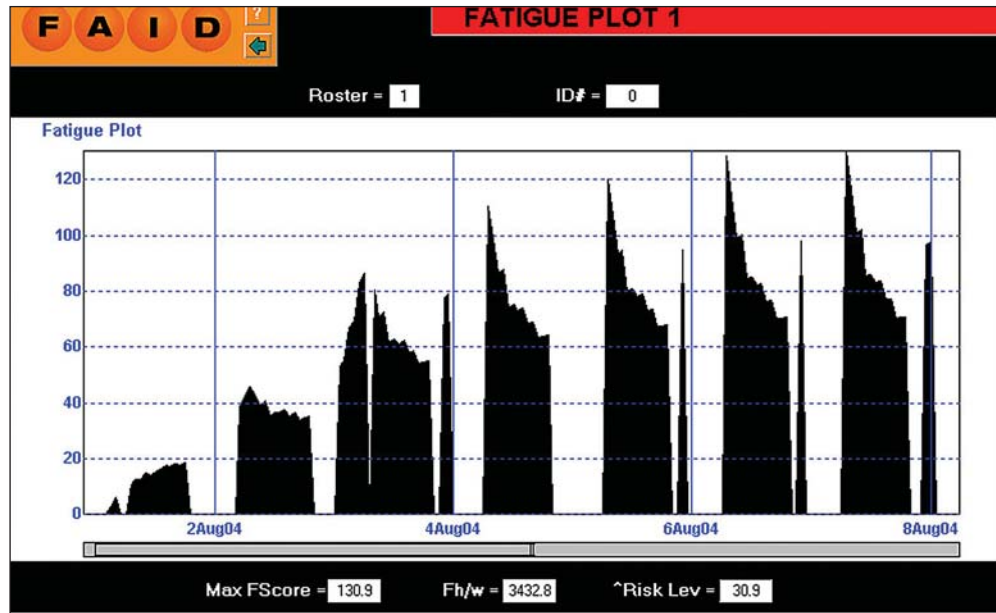
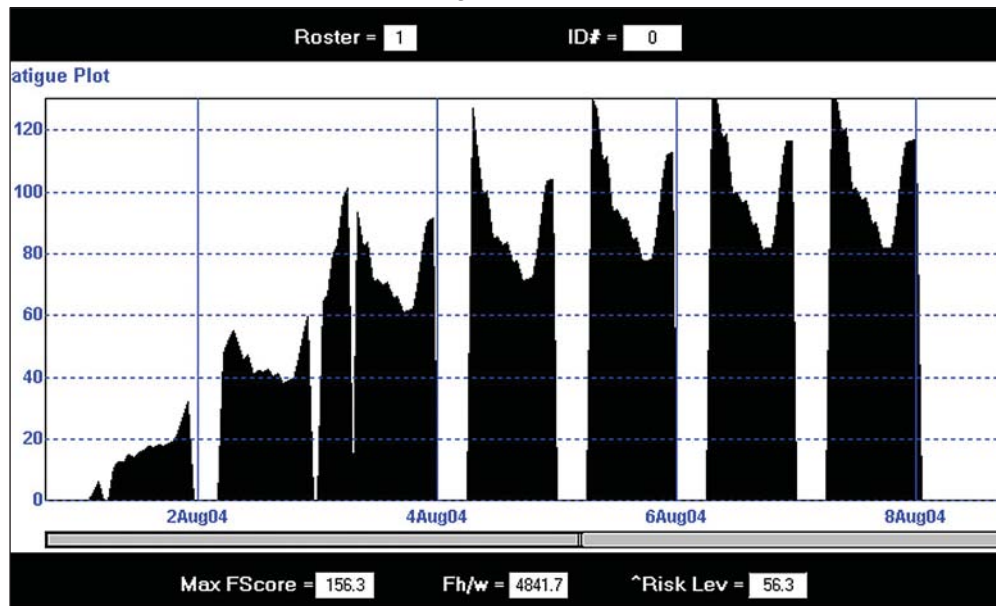


FIGURE 14: FAID scenario number two – waking hours



The first FAID scenario shows an index score of 97, immediately prior to the grounding. The second scenario score was 117. These fatigue scores are considered to be in the high to very high range.

Based on the master's working routine and his time awake, it is reasonable to conclude that the master was, to some degree, affected by fatigue. As such, it is likely that he was operating below a level of awareness necessary to properly carry out his duties as a sole watchkeeper in charge of the vessel.

Safety Management System

True North has a gross tonnage of less than 500, so the provisions of the SOLAS Convention or the International Safety Management (ISM) Code do not apply to it. Under current Western Australian and Australian Commonwealth legislation, there is

no requirement for a vessel of True North's size to have a Safety Management System (SMS) in place. However, at the request of AMSA, North Star Cruises has introduced several operating manuals for True North. These include an emergency response manual and an operations management manual. In addition to these management manuals, the vessel also carries a harm minimisation management plan (guidelines as to how the company will fulfil its obligations with respect to Section 5(1)(b) of the *W.A. Liquor Licensing Act 1988*).

Fatigue management

Section 2.3 of *True North's* Operations Manual states:

True North (the company) is committed to the implementation of management systems that will ensure the protection of the environment and the health and safety of all involved with *True North* operations and workplace practices. True North aims to reduce all legal liabilities associated with the management of our operation and believe we can achieve this with sound communication, training, monitoring and auditing of our performance. Through consultation with all involved in *True North* operations, continuous HSE improvement will be possible.

Fatigue, fatigue minimisation or its management is not specified in this or any of the company procedures or documents relating to the operations of *True North*. Under current legislation covering non-SOLAS vessels, there is no need for fatigue to be specifically targeted as a safety issue on board.

There is no reference to fatigue management or minimisation in USL Code. However, the soon to be released Part E of the National Standard for Commercial Vessels (NSCV), which is intended to replace the USL Code, states the following for all vessels:

2.8.4 Fatigue

Action should be taken to ensure that fatigue, and the risk from fatigue is minimised.

NOTE: The IMO's Guidelines on Fatigue provides practical guidance on measures to avoid and minimise fatigue. In particular crew rosters should be designed so that they do not cause undue fatigue.

There are other references to fatigue in Part E, within the requirements to have an approved SMS in place on board.

Legislation and manning requirements

True North was registered as an Australian ship under the *Shipping Registration Act 1981* in 1999. Until 2004, the vessel came under the survey requirements of the Western Australian Department of Planning and Infrastructure and its predecessor, the Department of Transport. In early 2004, *True North* came under full AMSA survey, with LR carrying out the surveys on AMSA's behalf.

The vessel currently operates under Western Australian marine legislative requirements, including the *W.A. Marine Act 1982*, when trading within the state. When proceeding on interstate voyages, the vessel is subject to the provisions of the

Navigation Act 1912, and some of its subordinate legislation, including Marine Notice 02/2002. *True North* is not a 'Declared Vessel'¹⁸ under Section 8AA of the *Navigation Act 1912*.

The number of certificated crew members on *True North* was determined by the Western Australian Department of Planning and Infrastructure, in accordance with the manning levels set down in Part IV of the *W. A. Marine (Certificates of Competency and Safety Manning) Regulations 1983*. The total safety manning levels for a vessel surveyed to USL Class 1B with a measured length¹⁹ of less than 35 m are given in Schedule 5 of the Regulations (Fig. 15). These manning levels are the same as those levels contained in the USL Code (Section 3, Schedule II) for a similar sized vessel. *True North* has a measured length of 33.20 m and was manned in accordance with the Regulations.

FIGURE 15: Extract from W. A. Marine (Certificates of Competency and Safety Manning) Regulations 1983 stating the safety manning levels

Measured length	Total Safety manning	Deck manning			Engine room manning			
		Certificated personnel (see Note 1)		Other personnel (see Note 4)	Qualifying tugboat (see Note 2)	Certificated personnel (see Note 1)		Other personnel
		Duty	Qualification			Duty	Qualification (see Note 3)	
Over 80 metres	As determined by Manning Committee				Over 80	As determined by Manning Committee		
35 metres and over but less than 80 metres	5	Master 2nd Mate 3rd Mate Mate } if carried	Master Class III Mate Class IV Mate Class IV	1 GP	50 and over but less than 80	Chief Engineer 2nd Engineer	Engineer Class III Marine Engine Driver Grade I	
25 metres and over but less than 35 metres	5	Master Mate	Master Class IV Master Class V	2 GP	35 and over but less than 50	Chief Engineer 2nd Engineer	Marine Engine Driver Grade I Marine Engine Driver Grade II	
20 metres and over but less than 25 metres	4	Master Mate	Master Class IV Master Class V	1 GP	25 and over but less than 35	Engineer	Marine Engine Driver Grade II	
Less than 20 metres	3	Master	Master Class V endorse to go beyond 100 miles to seaward	1 GP	20 and over but less than 25	Engineer	Marine Engine Driver Grade II (see note 5)	
					Less than 20	Engineer	Marine Engine Driver Grade II (see Note 5)	

Part IV, regulation 28 (2) of the *W. A. Marine (Certificates of Competency and Safety Manning) Regulations 1983* state:

Where a party with an interest in a vessel disputes a decision of the chief executive officer, made in accordance with subregulation (1), the safety manning of a trading ship shall be determined by the Manning Committee, which shall be guided (but not bound) by Schedule 5.

Advice received from the W. A. Department of Planning and Infrastructure – Marine Safety indicates that:

under the West Australian Marine Act 1982, there is no real power providing a regulator to enforce manning greater than the minimum safety standard set out in schedule 5 of the *W.A. Marine Certificates of Competency and Safety Manning Regs 1983*.

18 Section 8AA of the Navigation Act empowers AMSA to declare, in writing, that the Act applies to a trading vessel even when that vessel is proceeding on a voyage other than an overseas or interstate voyage.

19 Distance from the fore part of the hull to the after part of the hull, taken at the upper side of the uppermost watertight deck and measured in accordance with Annex A to Section 1 of the USL Code (*W.A. Marine (Certificates of Competency and Safety Manning) Regulations 1983*).

Had the WA marine authorities reviewed, or wanted to review, the certificated manning of *True North*, the state marine legislation therefore could not compel the company to employ additional certificated navigation or engineering personnel for the vessel's safety manning.

AMSA Marine Notice 02/2002 (Regulatory Requirements for Vessels on Near-Coastal Voyages Subject to the Navigation Act) applied to the vessel when its engaged on interstate voyages. This Marine Notice states:

Operators of vessels engaged in, or wishing to undertake, inter-state voyages or others voyages to which the navigation Act applies, are required to provide the nearest AMSA office with detailed information on the current or proposed vessel operations as soon as possible. Based on this information, AMSA will assess or reassess its requirements for the vessel and inform the vessel operator accordingly. Assessment will comprise of:

- Vessel size, type and area of operation;
- Proposed manning levels;
- Competency levels/qualifications held;
- Communications equipment requirements; and
- State and Territory survey certificates held.

This legislation gives AMSA the right to modify the manning requirements of *True North* when it is engaged on inter-state voyages only, should AMSA consider it necessary to do so, given the circumstances of the operations of the vessel.

Passenger emergency procedures

As part of the investigation into *True North's* grounding, passengers were asked to complete a questionnaire (Annex 2). The aim of the questionnaire was to:

- ensure persons directly involved in the grounding were give an opportunity to provide information that they felt may be relevant;
- provide a passenger perspective on the emergency response; and
- assess whether any improvements in emergency procedures are necessary.

The questionnaire focused on:

- the safety information available to passengers before the incident;
- the passengers' reaction to the emergency; and
- any suggestions by the passengers to improve the effectiveness of emergency procedures.

Twenty one of 26 passengers responded. Five of those who responded were in the age bracket 31–45 years; eight in the 46–60 year age bracket; and eight were over 60 years of age. Twelve of the passengers had travelled on a commercial vessel more than four times prior to their trip on *True North*. One of the passengers had a physical disability that affected mobility.

According to the passengers, they were provided with a safety briefing at a 'welcome aboard' party held on the evening of 31 July in the bar, after the vessel had left Wyndham. At the briefing, the information passed to the passengers was purely verbal

and there was no visual, written or 'hands on' element to it – the passengers were not asked to put on a lifejacket.

In submission, True North Cruises stated that:

The master of the vessel strongly disputes this statement – a visual demonstration of donning a life jacket is always included in *True North's* safety demonstration and [True North Cruises] is assured that such a demonstration was included in the briefing provided to this passenger group.

and

It is standard practice to brief the passengers in the vessel's bar area – this area is immediately aft of the upper deck accommodation area and, the muster point is immediately forward of the upper deck accommodation area. The briefing is conducted in the bar because passengers are more comfortable in this position and, therefore more likely to pay attention to the briefing. The location of the actual muster point and the location of the life jackets are clearly indicated from this location.

Sixteen passengers rated the briefing at the time it was given as adequate and easy to understand. In contrast, five passengers disagreed. However, after the grounding, six of those sixteen passengers changed their views and considered that the briefing should have been more comprehensive. Seventeen passengers considered that, as a result of the briefing, they knew what to do when the vessel grounded.

True North did not carry safety information in the passenger cabins, but safety notices were posted in the public rooms. To test the effectiveness of these notices, passengers were asked, 'do you recall seeing any safety information posted around the vessel?'. Fifteen of the 21 passengers responding to the questionnaire could not recall seeing or remembering information contained in these notices.

Section 15, paragraphs 6.5 and 6.6 of the USL Code, as legislated by regulation five of the *W.A. Marine (Emergency Procedures and Safety of Navigation) Regulations 1983*, state that:

Passenger Emergency Procedures Notice shall include the following information:

- (a) Cabin number and berth letter where applicable;
- (b) Emergency signal;
- (c) Action to take on hearing emergency signal in or near your own cabin;
- (d) Action to take when not in or near own cabin;
- (e) Location of lifejackets;
- (f) Location of Emergency Station;
- (g) Survival Craft allocation; and
- (h) Abandon ship signal.

and

Notices showing how to don and secure lifejackets shall be displayed in every passenger cabin and in conspicuous places throughout the passenger spaces and these notices shall include information on how to adjust the lifejackets of children.

An examination of passenger cabins, and the information kits in those cabins, by the ATSB revealed that the above information was not provided for the passengers.

The vessel's owners should have provided the above information to comply with the provisions of the *W.A. Marine (Emergency Procedures and Safety of Navigation) Regulations 1983*. Despite the evident deficiencies, the vessel had been issued the necessary State and Commonwealth certificates to enable it to operate.

When *True North* grounded, all passengers were in their cabins, either in bed or preparing to go to bed. It is apparent that most of the passengers felt the grounding and realised that something potentially serious had happened, although the general alarm or emergency signal had not been sounded and no announcement had been made on the public address system. Three of the passengers were alerted to the incident by the crew.

In submission, True North Cruises stated that:

At the time of the incident, the crew used reasonable common sense with regard to the issue of jackets and the sounding of signals. With specific regard to the actual circumstance, the issue of life jackets and the sounding of signals were deemed to be unnecessary as the vessel was assessed to be in no danger of sinking and, passengers had been mustered and accounted for.

All but one of the passengers found their way or were guided to the improvised muster point on the after upper deck within three minutes of the grounding. Fifteen of the passengers took no personal possessions, though six took wallets, phones, laptop computers and other valuables. One passenger, subject to a strict medication regime, did not take her medication to the muster station and was concerned that she did not have her medication if they should be ordered to abandon the vessel.

One passenger reported that he did not reach the muster position for at least ten minutes, having been thrown out of bed and stunned by the fall when *True North* took the ground. This would suggest that a roll call was not conducted until some time after the muster of passengers. Given the size of the vessel and the limited number of passengers on board, the delay in detecting a missing passenger requires a review of procedures aboard.

According to the majority of the passengers questioned, the crew remained calm, professional and reassuring throughout the incident.

In general the passengers reflected a range of views. The most relevant being:

- the muster station being changed without explanation;
- lifejackets were not distributed and worn as a precaution;
- the tenders were not put in the water as a precaution;
- the passengers were allowed back to their cabins to sleep before the damage was properly assessed and the position properly explained; and
- passengers on medication should be encouraged to carry their prescription to any emergency muster.

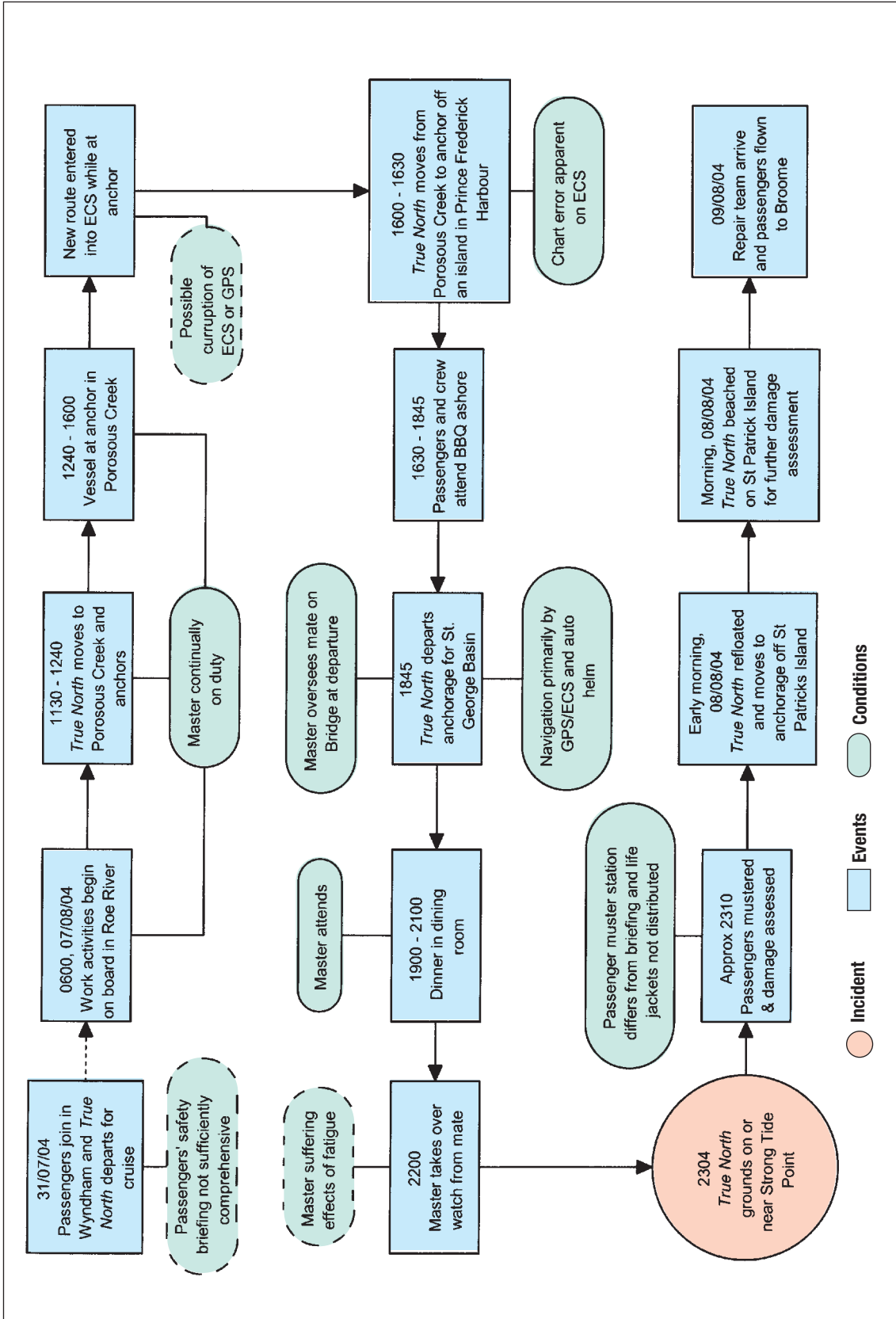
In submission, True North Cruises stated that:

Passengers do not necessarily have any expertise or knowledge that would allow them to make qualified comment regarding this or any other marine incident.

and

Passengers that have endured severe disruption to holiday arrangements should not be relied on with regard to the making of objective statement.

FIGURE 16: Events and causal factor chart



5 CONCLUSIONS

These conclusions identify the different factors that contributed to the incident 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 grounding of *True North* in the entrance to St. George Basin on 7 August 2004:

1. *True North* grounded on or near Strong Tide Point in unsurveyed waters while being navigated by an auto helm unit and ECS receiving position information from GPS satellites.
2. GPS derived positions plotted on the ECS differed from the vessel's true position, possibly caused by:
 - a. GPS system inaccuracy;
 - b. Geodetic datum ambiguity;
 - c. The ECS operating on a common user personal computer which allowed possible corruption of the ECS operating system;
 - d. A change in the GPS receiver parameters;
 - e. Loose wiring or connections in the on board systems; or
 - f. A combination of the above.
3. Too much reliance was placed on the accuracy of GPS positions and the GPS positions plotted on the vessel's ECS were not adequately checked by other navigational means.
4. A proper lookout was not maintained by visual, radar and other means to ensure the vessel remained in safe water.
5. At the time of the grounding, it is probable that the master was suffering from some effects of fatigue as a result of his work routine.
6. There were deficiencies in the procedures which dealt with the mustering of passengers in that:
 - a. The initial safety briefing was not sufficiently comprehensive;
 - b. company orders in respect of lifejackets and emergency signals were not followed; and
 - c. company practices in the provision of emergency information and procedures did not meet WA legislative requirements.

6 RECOMMENDATIONS

MR20050006

Owners and operators of vessels running Electronic Chart Systems should do so on dedicated computers.

MR20050007

Owners, operators and masters of vessels regularly operating in confined waters should revise procedures governing the use of GPS and auto pilot systems.

MR20050008

Owners and operators of passenger vessels should ensure information concerning muster areas, emergency signals and instructions and diagrams of how to don lifejackets, are included in any passenger information kits in cabins, and on the inside of all cabin doors, in order to comply with state/territory regulations.

MR20050009

True North Cruises should review the procedures associated with passenger briefings and the emergency information displayed in the passenger cabins and vessel common rooms.

MR20050010

Owners, operators and masters of non-SOLAS vessels should consider the introduction of effective fatigue management policies and practices on board vessels.

MR20050011

AMSA and state/territory marine authorities should carefully consider the type of operation and area of operation when determining the safety manning of vessels of any length.

MR20050012

Western Australia's Department of Planning and Infrastructure should consider recommending the amendment of WA marine legislation to allow for the option to review and, if necessary, change the safety manning requirements for state registered vessel.

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 the owners, senior master and master of *True North*, the Western Australian Department of Planning and Infrastructure – Marine Safety, AMSA and the School of Mathematical and Geospatial Sciences, RMIT University, Melbourne.

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

8 TRUE NORTH

IMO number	9192105
Call sign	VM3994
Flag	Australia
Home port	Broome
Classification society	Lloyds Register of Shipping (LR)
Ship type	Passenger (USL Class 1B ship)
Builder	Image Marine, Fremantle
Year built	1999
Owners and managers	North Star Cruises, Broome
Gross tonnage	273
Net tonnage	107
Deadweight (summer)	44 tonnes
Maximum draught	2.20 m
Length overall	34.56 m
Measured length	33.20 m
Length between perpendiculars	29.25 m
Moulded breadth	8.90 m
Moulded depth	3.37 m
Engines	2 x MTU 16V 2000 M70 diesel engines
Total power	1 500 kW
Number of propellers	Two
Service speed	12 knots
Crew	12 (Australia)
Passengers	26 (Australia, New Zealand)

9 ABBREVIATIONS, TERMS AND DEFINITIONS

Definition

Deadweight	The weight of cargo, fuel, fresh water and stores that a vessel can carry at a relevant draught.
Gross tonnage	Measurement of total internal volume of a vessel, including all underdeck tonnage and all enclosed spaces above tonnage deck. (One gross tonne = 40 m ³)
Net tonnage	Measurement derived from gross tonnage by deducting certain spaces allowed for crew and propelling power.
Length overall (LOA)	The length of a vessel, measured from the extremities at the stem and stern.
Length between perpendiculars (LBP)	The distance, at the summer waterline, from the forward side of the stem to the after side of the rudder post.

Sources of GPS signal errors

Factors that can degrade the GPS signal and thus affect accuracy include the following:

Noise and bias errors

- **Satellite clock error** – Any inaccuracy of the atomic clock on the satellites can impact directly on position calculation.
- **Receiver clock errors** – Since it is not practical for a GPS receiver to have an atomic clock installed, the built-in clock can have very slight timing errors.
- **Ephemeris (orbital) error** – Inaccuracies in the satellites reported location in space.
- **Ionosphere errors** –
 - elevation angle of satellites – satellites near the horizon most affected,
 - time of day – 2pm local time is generally the minimum,
 - location – equatorial and polar regions are the most affected,
 - solar activity – Solar storms and sun spots (especially in equatorial and polar regions),
 - scintillation²⁰ causes a rapid change in the amplitude and phase of the incoming GPS signal and the potential loss of signal tracking,
 - scintillation is most likely to occur in equatorial regions between November and March and 9am to 2pm local time.
- **Troposphere errors** –
 - elevation angle of the satellite (minimised by using an elevation mask to reject low elevation satellites),
 - temperature, pressure and relative humidity of the atmosphere,
 - weather patterns.
- Interference and jamming errors – GPS signals are below the ambient RF noise levels (i.e. they are extremely weak) so nearby microwave sources, such as the following ship-based transmitters can overwhelm the GPS receiver:
 - RADAR,
 - satellite communications devices,
 - mobile phones, and to some extent

²⁰ A radio wave traversing the upper and lower atmosphere of the Earth suffers a distortion of phase and amplitude. When it traverses drifting ionospheric irregularities, the radio wave experiences fading and phase fluctuation, varying widely as a function of frequency, magnetic and solar activity, time of day, season, and observer latitude. Collectively the effect is known as 'ionospheric scintillation'.

- active television antennas,
 - air-conditioning units, and
 - general electric motors.
- **Signal Multipath errors** – Reflection of the GPS signal by nearby objects before it reaches the GPS antenna, such as cliffs and the vessels own structures. This increases the travel time of the signal.
 - **Masking errors** – Blocking of the GPS signal by nearby ships, structures, mountains, cliffs etc leads to weaker satellite geometry.

Blunders

- Control segment mistakes due to computer or human error can cause errors from one metre to hundreds of kilometres.
- User mistakes, including incorrect geodetic datum selection, can cause errors from one to hundreds of metres.
- Receiver errors from software or hardware failures can cause blunder errors of any size.

ANNEX 2

True North passenger questionnaire

<i>Name</i>	<i>Cabin name</i>
1. Age and gender of those covered by this response as of 8 August 2004	Age Male Female
	<6
	6–11
	12–18
	19–30
	31–45
	46–60
	61–75
	76 or over
2. At the time of the incident, did you have a physical disability?	No Yes If yes, please specify: Vision Hearing Mobility Other (please specify)
3. How many times have you traveled on a commercial ship or vessel, including <i>True North</i> ?	0 1–2 2–4 More than 4
4. Did you find the safety briefing to you given by the master on joining <i>True North</i> : (a) adequate and (b) easy to understand?	(a) Yes or No (b) Yes or No
5. Were you provided with any additional safety information when you boarded, or during the voyage?	No Yes If yes, did it help you?
6. Do you recall seeing any safety information posted around the vessel?	Yes No If yes, did it help you?

7. As a result of the safety briefing and other safety information, do you feel you knew what to do in the event of an emergency?	No Yes
8. Where were you on the vessel when you became aware of the incident on 7 August?	
9. How were you first alerted to the incident? (Please tick appropriate box.)	Alarm/announcement Saw the ship ground Heard something unusual Felt an unusual movement Unusual behavior of other passengers Unusual behavior of ship's crew Warning from other passengers Warning from ship's crew Other, please describe:
10. Did you believe that there was a serious incident when first alerted?	No Yes If no, describe the clues that were required to convince you that there was a serious incident:
11. Describe your very first actions when you were alerted to the incident.	
12. Estimate how long it took you to start to move to the muster station after first being alerted to the incident.	mins seconds
13. Did a ship's crew member instruct you on what to do on leaving your cabin to proceed to the muster station?	No Yes If yes, please describe the instructions:
14. Did you take any personal effects with you when you went to the muster station?	No Yes If yes, please describe:

15. Were there enough crew members to assist the passengers during the incident?	No Yes
16. Please describe how the crew behaved while assisting the passengers.	
17. Were there any specific examples of passenger behaviour you would like to comment on?	No Yes If yes, please describe:
18. On your way to the muster station, did you see any passengers going back to their cabins?	No Yes If yes, did this cause congestion or slow the mustering process?
19. At the muster station, were you told what the incident was?	No Yes By whom? Crew Other passenger
20. While at the muster station, were you system kept informed of what was going on?	By the crew Public address No No Yes Yes
21. Were you aware of a roll call or head count at the muster station?	No Yes Comment:
22. Were life jackets passed out at the muster station?	No Yes If yes, what did you do with it?
23. If you put a life jacket on, how did you put it on?	Put it on without help Shown by crew member Assisted by crew member Other, please specify:
24. Was the vessel's public address system used during the incident?	No Yes Comment:

25. Were the announcements made on the public address system easy to understand?	No Yes If no, please explain:										
26. Were you at any time confused about what you were asked to do?	No Yes If yes, please explain:										
27. Was there a member of the crew with you at the muster station at all times?	Yes No Comment:										
28. How do you rate the overall performance of the crew during the incident?	<table border="0" style="width: 100%; text-align: center;"> <tr> <td>Poor</td> <td></td> <td>Satisfactory</td> <td></td> <td>Excellent</td> </tr> <tr> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> </table>	Poor		Satisfactory		Excellent	1	2	3	4	5
Poor		Satisfactory		Excellent							
1	2	3	4	5							
29. On reflection, do you think the safety briefing you received on boarding True North was adequate?	No Yes If no, please specify what you think should be improved on:										
Any other comments:											

**Independent investigation into the grounding of the Australian registered passenger vessel
True North in the approach passage to St. George Basin, Western Australia, 7 August 2004**

ISSN 1447-087X

ISBN 1 877071 93 5

743 179 0081

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