ATSB
Australian Transport Safety Bureau

AUSTRALIAN TRANSPORT SAFETY BUREAU

MARINE SAFETY INVESTIGATION
REPORT 182

Independent investigation into the grounding of the
Greek registered ship

Doric Chariot

at Piper Reef, North Queensland
on 29 July 2002

AUSTRALIAN GOVERNMENT — DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Department of Transport and Regional Services
Australian Transport Safety Bureau

Navigation Act 1912
Navigation (Marine Casualty) Regulations
investigation into the grounding of the Greek registered ship *Doric Chariot* at Piper Reef, North Queensland on 29 July 2002

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***Doric Chariot* aground on Piper Reef**

FIGURE 2:
Photograph across the chart table towards the daybed on the port side

Summary

On 26 July 2002 *Doric Chariot* sailed from Hay Point, Queensland on a voyage to India via the Great Barrier Reef inner passage and Singapore. A pilot was engaged for the Reef passage.

The voyage initially proceeded normally and, on 29 July, as the ship approached Eel Reef light, the pilot requested a slight course alteration to allow more sea room for passing a south-bound ship. After passing this ship the pilot requested another course adjustment to bring the ship back toward the planned track. He then spoke with the OOW (Officer of the Watch) about the time he should next be called and sat on the daybed at the side of the wheelhouse to take a rest before the ship arrived at the next reporting position near Piper Reef.

The ship continued under the direction of the OOW until the pilot was next called. When the pilot stood up and looked at the ship's position with reference to the two beacons ahead at Piper and Inset Reefs, he immediately realised that the ship was to the west of the two-way route and approaching the southern end of Piper Reef. He ordered, 'hard-a-starboard' and, shortly afterwards 'full astern' but it was too late. The ship started to swing to starboard but, within about one and a half minutes, at about 0335, the ship ran aground to the south of Piper Reef light.

The ship was successfully refloated on 6 August 2002. No injuries or pollution resulted from the grounding.

The report concludes that the pilot:

1. sat down intending to rest but fell asleep, in an inappropriate area of the pilotage passage;
2. instructed that he should next be called in a position too close to the approaching dangers for any successful corrective action to be taken should it be required;
3. was likely to have been experiencing a significant level of fatigue, based on the FAID program measurement, that affected his performance. This was predominantly as a result of his personal fatigue strategies before and during the passage and;
4. did not provide the OOW with sufficient clear, unambiguous, instructions regarding the course between Eel Reef and Piper Reef and made assumptions as to the OOW's actions that were not justified.

The report also concludes that the OOW:

1. did not maintain an effective visual watch and allowed *Doric Chariot* to stray from the intended course;
2. did not adjust the ship's course to follow the route drawn on the chart;
3. did not fix the ship's positions at intervals that were consistent with safe navigation and;
4. did not fully understand the pilot's intentions.

Additionally,

1. The bridge resource management exercised by the pilot and the OOW was ineffective.

The report makes three recommendations involving clearer understanding between pilots and officers; a fatigue management policy by pilots; and a paper to the IMO.

Sources of Information

The master and officers of *Doric Chariot*

The pilot and Torres Pilots Pty Ltd

Reefcentre, Hay Point Queensland (Queensland Transport)

Australian Maritime Safety Authority (AMSA)

Chios Navigation (Hellas) Ltd

Acknowledgment

The Inspector is grateful to Interdynamics Pty Ltd (www.interdynamics.com) for the computer program, FAID 330E, which was used during the analysis of the fatigue factors.

Narrative

Doric Chariot

Doric Chariot is a Greek flag, 'panamax' sized, geared bulk carrier. The ship was built by Hyundai Heavy Industries in Ulsan, South Korea in 1994. It is 224.97 m in length overall, has a beam of 32.25 m and a moulded depth of 19.00 m. The ship has seven cargo holds located forward of the accommodation superstructure in a standard bulk carrier design. The holds are serviced by four 25T SWL[1] cranes. The summer deadweight is 73 350 tonnes at a draft of 13.765 m.

The bridge front is 189.12 m from the stem. The bridge is a combined wheelhouse and chartroom with a GMDSS[2] communications centre to the starboard side of the chart table. The bridge is equipped with the required navigational aids including two JRC 8000 series radars (1 'x' band (3cm) and 1 's' band (10cm) with ARPA). The ship also has two GPS receivers (1 x Furuno GP-70 mark2 and 1 x JRC JLR-4110 mark2). The GPS mainly in use (GP-70) has a facility for setting alarms for both cross track and waypoint arrival.

The ship's complement of 20 men consisted mainly of Greek officers and Filipino crew. All the crew were appropriately qualified with STCW95 (Standards of Training, Certification and Watchkeeping, 1995) certificates. The master and OOW had both made a number of transits through the reef on *Doric Chariot* with various pilots. The ship had all the required ISM (International Safety Management) certificates, procedures and checklists.

Great Barrier Reef compulsory pilotage area

The compulsory pilotage area of the Great Barrier Reef lies between its southern extremity at 16°40'S, south of Trinity Opening and north of the port of Cairns, and 10°41'S, near Eborac Island, off the northern extremity of Cape York Peninsular. The compulsory pilotage area is about 430 miles in length which, together with the critical passage through Prince of Wales Channel and Varzin or Gannet passage, extends the pilotage to 480 miles and involves some 14 alterations of course. It consists mainly of relatively narrow fairways and is complicated by tidal effects and cross currents. The seasonal concentration of fishing vessels and reduced visibility in the 'wet' season (November-April) further increase the risks associated with navigation in this area. Conversely, it offers a safe passage, sheltered from the sea conditions experienced outside the reef, and can also offer considerable savings in time and distance for vessels trading between the Australian east coast and bound to or from places west of the Torres Strait.

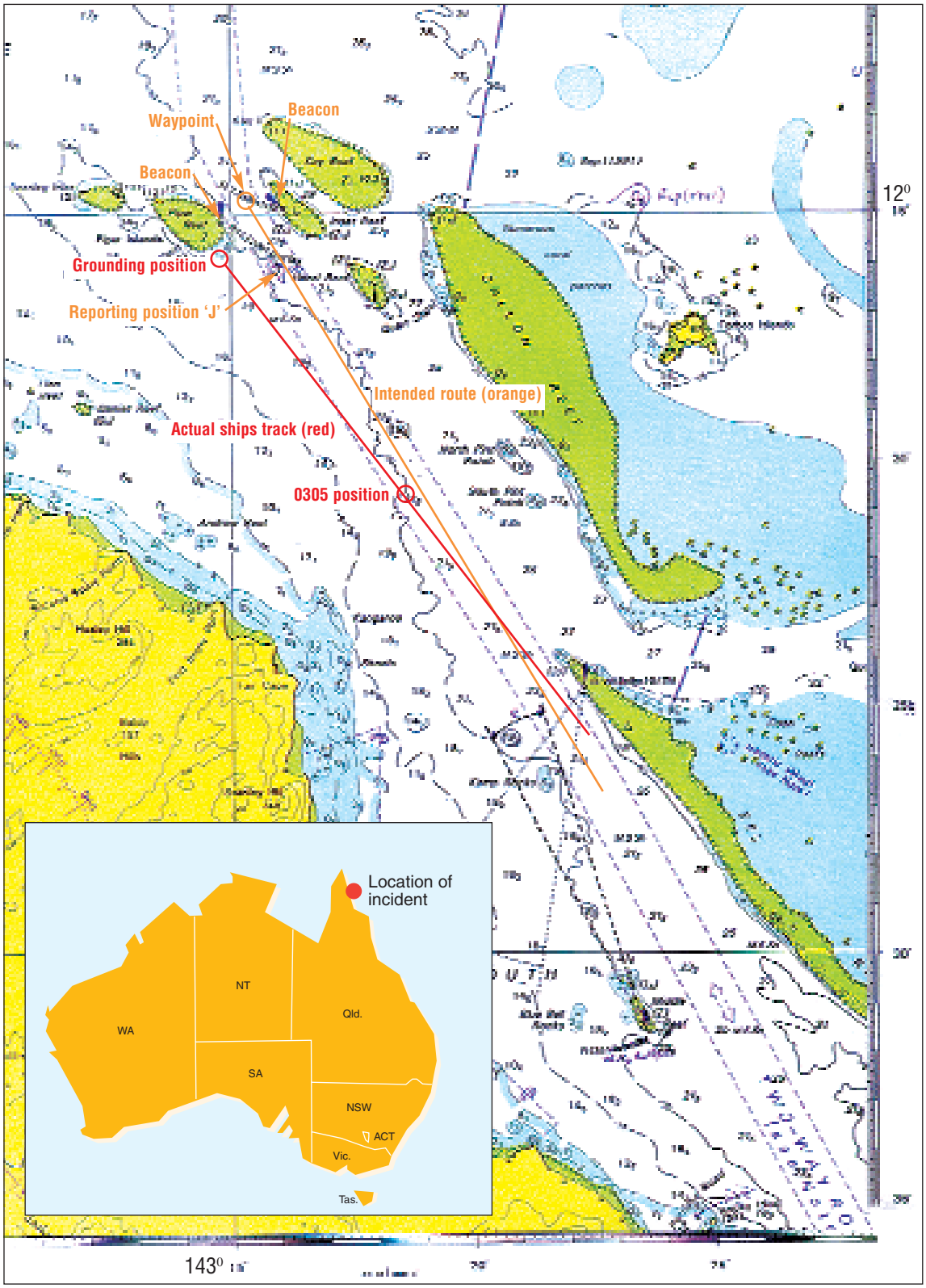
A single pilot has the conduct of the vessel throughout the whole compulsory pilotage area. Recognising that a single pilot cannot be on the bridge for the entire passage and perform to the required level of alertness on a consistent basis, there are recognised areas in which pilots may leave the bridge to rest or refresh themselves. The pilots' ability to use these areas depends upon weather/visibility conditions and the density of other traffic, particularly fishing vessels. The recognised areas are:

- Low Isles to Gubbins Reef;
- Egret Reef to Three Isles;
- Nymph Island to Howick Island;
- Flinders Island to Eden Reef;
- Clerke Island to Hannibal Island;
- Cairncross Island to Wyborn Reef.

1 SWL is Safe Working Load

2 GMDSS is the Global Maritime Distress and Safety System

FIGURE 3:
Portion of chart Aus 835 showing grounding position



Pilotage Services

Before 1 October 1991, pilotage was offered on a voluntary basis. Following recognition of the Great Barrier Reef as a 'Particularly Sensitive Sea area' by the International Maritime Organization, the Australian Government introduced legislation making pilotage through the inner route[3] of the Great Barrier Reef, north of 16° 40'S, compulsory for ships over 70 m in length and for all ships carrying potentially toxic pollutants.

In 1993, responsibility for the regulation and administration of pilotage in the Great Barrier Reef was transferred, by ministerial agreement, from the Queensland Department of Transport to the Australian Maritime Safety Authority. AMSA focused its oversight on pilotage standards, licensing, training, codes of conduct and practice and other safety issues such as fatigue management and safety advisory notices. AMSA also conducts periodic audits of pilots for compliance with the Code of Practice, including the implementation of bridge resource management practices and also conducts regular three monthly meetings with the pilots and pilotage provider companies to discuss on-going safety and operational issues. Recently (July 2002) AMSA has introduced a system of 'check pilots' .

To further enhance safety in the Great Barrier Reef, a mandatory system of ship reporting was introduced, on 1 January 1997, jointly by AMSA and the Queensland Government. A ship transiting the compulsory pilotage area is required to make some ten reports to Reefcentre at Hay Point, at predetermined positions between Cape Townsend and Torres Strait. Ship entry points to the compulsory pilotage area, Torres Strait, Hydrographers passage and in the vicinity of Cairns are also monitored by radar from Reefcentre. The area around Piper Reef does not have radar coverage.

AMSA had earlier researched and planned, and is now in the process of establishing, an alternate route for part of the Inner passage which provides more open water and fewer course changes.

The controls governing service delivery and remuneration for Great Barrier Reef pilots were lifted with the repeal of Queensland legislation governing the pilotage service. Three service providers set up in commercial competition. Two of these provide pilotage services in Torres Strait and the compulsory pilotage area and all three compete for services in Hydrographer's Passage.

Sea pilots operating in the Great Barrier Reef are self-employed. Individual inner route pilots contract to a service provider. The service provider is the direct link to the shipping company and assigns pilots to ships on an 'in turn' basis. The service provider also provides the means of pilot transfer (either boat or helicopter) and the pilots contribute a proportion of the pilotage fee to cover the costs of pilot transfer and administration.

The pilot provider also maintains a record of the ships and hours worked and operates a 'fatigue management system'. One of the aims is to ensure adequate time between assignments to allow a pilot to rest and recuperate in compliance with the AMSA Code of Practice while also equalising income for the various pilots. In the case of the inner route, pilots must have a minimum rest period of 24 hours between ships, which must include uninterrupted rest between 2200 and 0600. After three inner route pilotages the rest period should include two nights rest between the hours of 2200 and 0600.

In addition, the Marine Coast Pilots Code of Conduct requires a pilot to adhere to the rest periods prescribed in the Code of Practice. Other requirements of the code provide that:

> Pilots must be adequately rested and mentally alert in order to provide undivided attention to

[3] The inner route refers to the route to the west of the Great Barrier Reef, between the Reef and the mainland. The compulsory pilotage area is the northern portion of the route, between Trinity Opening and the Northern extremity of Cape York.

pilotage duties for the duration of the passage. It is a requirement that pilots should comply with rest period regulations as defined in the latest revision of the Internal Handbook.

Pilots should prepare a Passage Plan for the intended pilotage passage and should discuss with the Master and Navigating Officer the relevant aspects. If necessary the plan should be updated during the voyage and any significant amendments drawn to the attention of the Master.

Pilots must recognise the importance of Bridge Resource Management in establishing a method of familiarisation for the Master, and navigating officers. The information exchange must include:

- Discussion with bridge personnel on the passage plan.
- Manoeuvring data of the vessel.
- Expectations with regard to draught, squat, tidal calculations and underkeel clearance.
- Procedures for recall when absent from the bridge.
- Encouragement from the Pilot for assistance from the Bridge Personnel.
- MCP Pilots shall include with Voyage Plans an emergency contingency plan to cover:

  1. A vessel incident.

  2. Pilot illness.

- Pilots should recognise the importance of professional development and the need for keeping up to date with changing circumstances and technology. Pilots should therefore ensure that there is regular consultation with bodies such as AMSA, Great Barrier Reef Marine Park Authority and others.

The pilot assigned to *Doric Chariot* on 26 July had joined Reef Pilots in September 1993. He was already an experienced mariner with service as master on the Commonwealth lighthouse ships, based extensively in the Great Barrier Reef. He was issued an Australian Master Class 1 Certificate on 27 February 1991. The pilot qualified for 'open' AMSA pilotage licenses covering all areas (Great North East Channel, the inner route compulsory pilotage area and Hydrographers Passage) by May 1994.

At the time of piloting *Doric Chariot* he was properly qualified with appropriate endorsements. His medical certificate was valid until 10 January 2003.

The incident

Whilst it is not a requirement, it is the policy of Chios Navigation (Hellas) Ltd, the ship management company operating *Doric Chariot*, to engage a reef pilot from the final port of call before the reef passage, in this case Hay Point.

The pilot boarded *Doric Chariot* in the early afternoon of 26 July. He had piloted the ship on four previous occasions in 1998 and 1999. The pilot introduced himself to the master and officers and then familiarised himself again with the ship's bridge layout and equipment. He checked the gyro compass for error and found that it was 1° high. He then discussed the proposed passage to Torres Strait with the navigator and the master. The pilot carried his prepared voyage plan, which included a set of chartlets covering each section of the passage. The navigating officer (the second of the two second mates) had entered the ship's courses in the GPS receiver based on the waypoints from the passage plan of a previous pilot. The pilot and the master agreed to use the plan already adopted by the ship for the coming voyage. The cross track error for all the waypoints was set at two cables (0.2 nautical miles). The navigating officer drew the courses on the chart as far as Cairns, leaving the pilot to draw the courses for the compulsory pilotage area.

At 1645 on 26 July 2002 *Doric Chariot* sailed from Hay Point, Queensland, carrying a cargo of 61 951 tonnes of coking coal bound for Visakhapatnam, India. The voyage would take the ship firstly through the Great Barrier Reef compulsory pilotage area, then to Singapore for supplies and then on to India for the cargo discharge. The departure draft was 12.2 m even keel which is the maximum possible to allow the ship to transit the Prince of Wales channel in Torres Strait.

The voyage proceeded without incident, passing Fitzroy Island at 2002 on 27 July and entering the compulsory pilotage area at about 2145.

Based on the ship's normal service speed, the ship would have reached Torres Strait on 29 July before there was sufficient under-keel clearance to transit Prince of Wales Channel. Rather than anchor, and to save fuel, the master and pilot agreed to reduce speed to reach the Prince of Wales Channel at a suitable state of tide.

The pilot had the conduct of the navigation through the compulsory pilotage area. The different OOWs routinely plotted the ship's position on the chart, at about thirty minute intervals, using various methods, including visual bearings, radar and GPS. Both radars were operating at all times with the pilot mainly using the 3cm radar and the OOW using the 10cm radar. In the 40 minutes prior to the grounding, neither the pilot nor the OOW used radar parallel indexing techniques. The master attended the bridge for most of the mornings and evenings and oversaw the actions of the pilot and OOW to ensure that he was confident in the efficiency of the bridge operations.

In the early part of the voyage the pilot assessed the performance of the ship's deck officers to determine his options with regard to rest breaks during the passage. They appeared competent to him and the pilot was confident that, when appropriate, *Doric Chariot* could be left in their charge. Before leaving the bridge at any time, the pilot called the OOW's attention to the course and a position at which he should be next called which he had clearly marked on the chart.

Just after midnight, on 29 July, the ship altered course as planned to 331°(True), 332°(Gyro), off Cape Direction. The master, who was still on the bridge at this time, satisfied himself as to the ship's position and the bridge operations and then went below to rest. The night was fine and clear with a rising moon (81% full). The wind was from the south east at about 20 knots[4]. The bridge was manned by the OOW, the pilot and an AB (seaman) acting as lookout and/or helmsman as required.

After passing Restoration Island at about 0100, the pilot made a mark on the chart about three miles before Eel Reef light and instructed the OOW to call him at that point. The pilot rested on the bridge daybed, sleeping from about 0100 until woken by the OOW at about 0200. At about 0220, as the ship approached the course alteration position off Eel Reef light, the pilot requested a slight course alteration to starboard to 334°(G), to increase the sea room for a southbound ship.

After passing the southbound ship at about 0231, *Doric Chariot*, as anticipated, was about 2 cables (370 m) to the east of the track. The lights on Inset and Piper Reefs were clearly visible ahead, with Inset Reef light fine to starboard. The pilot ordered a course adjustment to port to 326°(G), on a heading between the lights, so as to bring the ship back to the track before the next Reefcentre reporting position. A further adjustment to 325°(G) was then suggested by the OOW and agreed to by the pilot.

Once satisfied that the ship had settled on its new heading the pilot decided to sit down on the bridge daybed and rest. At the ship's current speed of 10.2 knots it was due at the designated SRS[5] position off Piper Reef at about 0330.

According to the pilot, he spoke with the OOW, visually pointing out the lights of Inset Reef and Piper Reef ahead. The pilot pointed out the position of the reefs on the radar and then went to the chartroom where he indicated on the chart to the OOW the position where he wanted to be

4 20 knots=20 nautical miles per hour (about 37km/hr)

5 SRS is ship reporting system

called, which was at the next Reefcentre reporting position. According to the OOW the pilot showed him the islands on the radar but did not point them out visually and pointed to the Reefcentre reporting position (J), before sitting down.

Unlike the earlier periods when the pilot rested, he did not mark the position on the chart where he wanted the OOW to call him. The pilot alleges that he told the OOW to adjust the ship's course as necessary to bring it back to the course line. He then took off his shoes and reclined on the settee on the port side of the wheelhouse.

The OOW maintained his lookout solely by radar. In so doing, he mistakenly identified the echo of Piper Reef light as Inset Reef light. At about 0240, with the pilot's concurrence and very soon after he had sat down the OOW made a one degree course adjustment to port to bring Piper Reef fine on the ship's starboard bow. At 0305 the OOW plotted a position on the chart which indicated the ship was about two cables to port of the track. No course adjustment was made.

At about 0320 the lookout went below to carry out a safety and fire patrol of the engine room and accommodation spaces. This was a routine task that the master required should be conducted every watch. There was no other traffic in the area and the visibility was good. The OOW judged that this was a suitable time for the lookout to conduct his 'rounds'.

At about 0325 the OOW again made a course adjustment to port, a further two degrees this time, still on the basis of his mistaken identification and without plotting the ship's position. The ship was now steering 322°(G) and was about 2.2 miles from the edge of the reef.

A little before 0330 the alarm on the HF/MF DSC (high frequency/medium frequency digital selective calling) receiver was activated and the OOW went to the GMDSS equipment to check and acknowledge it. The alarm was false and he cancelled the alarm and checked the alarm display. He then went to the chart table and checked the chart for details of the next course, before going to the lavatory. When he returned to the bridge he saw the radar echo of the light on Piper Reef (which he still believed was Inset Reef) was still to starboard. The OOW called the pilot saying that the ship was at the reporting position. The pilot replaced his shoes and then got to his feet.

When the pilot stood up and looked at the ship's relative position and heading with reference to the two beacons at Piper and Inset Reefs (both out to starboard), he immediately realised that the ship was to the west of the two-way route and approaching Piper Reef. He ordered 'hard-a-starboard'. The OOW changed to hand steering and applied the helm order. The pilot could now see, in the moonlight, the breaking water on the southern side of Piper Reef close ahead. He realised that the ship would not achieve a rate of turn necessary to clear the shoal water so ordered full astern on the engine. The OOW put the engine to full astern and then called the master. The ship started to swing to starboard. The ship's head swung through an angle of 18° to starboard, due to the action of the rudder and astern engine movement, but within about one and a half minutes the ship took the ground to the south of Piper Reef light.

Doric Chariot grounded at about 0335, 0.52 miles south from Piper Reef light beacon on a heading of 343°(G), in position 12° 15.593'S 143° 15.038' E by the ship's GPS. The high water at Piper Reef was at 0001 at a predicted height of 2.3 m and the next low water was at 0741. The tide at Piper Reef had been ebbing for about 3½ hours.

The master arrived on the bridge just after *Doric Chariot* took the ground. On his arrival on the bridge, the master asked about the situation from the OOW and pilot. He then fixed the ship's position on the chart and ordered the ship's main engine stopped.

Reefcentre was informed and the ship's crew were instructed to start checking the state of the ship's tanks and engine room equipment.

Soundings around the ship's side were taken to establish the grounding situation more accurately.

Salvors arrived on the ship on the morning of 30 July 2002 and began assessing the situation and the possible actions. It was decided that any refloating attempts would be delayed until the next suitable high tide on Sunday 4 August when tug assistance would also be on the scene.

Although the initial attempts to float the ship were not successful, *Doric Chariot* was successfully refloated at 1747 on 6 August. The ship was then anchored about 4 miles north of Piper Reef whilst a full assessment of its condition was made.

A detention order by AMSA was lifted at 1530 on 7 August 2002 after the ship was declared seaworthy and it continued its voyage northward with another pilot.

FIGURE 4:
Photograph taken from starboard bridgewing of *Doric Chariot* with Piper Reef light beacon in the distance

FIGURE 5:
Aerial photograph of *Doric Chariot* aground with Piper Reef beacon in the foreground

Comment and analysis

Evidence

The ATSB safety investigation was significantly complicated by the number of other government agencies seeking to exercise jurisdiction for the purpose of initiating a criminal prosecution or regulatory response. At the date of publication legal proceedings were ongoing.

Interviews were conducted with the master and officers on board *Doric Chariot* on 31 July. The pilot was interviewed in Cairns on 2 August. There were significant differences in the accounts given by the OOW and the pilot in relation to what the OOW was told by the pilot a little after 0230.

Records of the working hours, as provided, of the master, OOW and pilot were assessed against the Fatigue Audit InterDyne (FAID) fatigue modelling program, developed by Interdynamics in collaborative partnership with the Centre for Sleep Research at the University of South Australia. The pilot's work history since September 1993 was supplied by AMSA and the pilotage provider company. The fatigue management plan supplied by the pilot provider company was also reviewed. Audio tapes from Reefcentre were checked to verify radio communication information.

The night was fine and clear with a 'pleasant' temperature. The wind was from the southeast, force 4-5 (11-21 knots). There was no swell.

No machinery or equipment failure on board contributed to the grounding. The lights marking Piper Reef and Inset Reef were also operating with the correct characteristics.

The log book and other ship's documentation were examined. There is no accurate contemporaneous record of the time that the engine was put from full ahead to full astern, at about 0334.

Copies of the charts in use and the course recorder chart were analysed. The course recorder was assessed as indicating 1° high (same as the gyro) and 5 minutes fast of UTC (Coordinated Universal Time). The evidence from the course recorder shows a one degree adjustment of course from 325°(G) to 324°(G) at 0240 and a two degree alteration at 0325 to 322°(G). The course recorder trace suggests that full starboard rudder was applied at about 0335:12, but no appreciable heading movement occurred for about 30 seconds. Thereafter the ship turned to starboard at a rate of 20°/min.

The master

The master left the bridge after *Doric Chariot* had passed Wye Reef and Cape Direction. He left the bridge in the charge of the pilot, OOW and helmsman/lookout.

In addition to the Company Standing Orders, the master had issued his own supplementary standing orders. These were consistent with the company's orders and the requirements of Chapter VIII of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (as amended in 1995).

As the ship was not passing through a recognised rest area the master had no reason to suspect that the pilot would not be exercising direct control over the conduct of the vessel. The visibility was clear, the weather fine and the bridge watch was properly constituted. The courses were drawn on the chart and had been agreed between the pilot and the master. The courses and waypoints had been programmed into the GPS and the requirement to report to Reefcentre at Piper Reef had been noted on the passage plan. The weather was fine and clear and the situation appeared well under control when the master went below just after midnight.

There was no apparent reason for the master to remain on the bridge.

Actions of the OOW – 0235 to 0335

According to the OOW, at about 0235 the pilot went to the radar and pointed out the reefs ahead. Then, on the chart, the pilot pointed to the Reefcentre reporting position (position J) and instructed the OOW to call him at that point.

The OOW spoke English well and the possibility that he was unable to understand instructions, or was unable to articulate a request for clarity, is unlikely.

A short time before the OOW called the pilot, he was distracted by the alarm on the digital selective calling component of the Global Maritime Distress Safety System (GMDSS). The alarm was spurious. He then went to the lavatory at the rear of the bridge, the door of which is directly behind the chart table, adjacent to the internal bridge entry door. These distractions detracted from his watchkeeping. However, it appears that this neither delayed the OOW in calling the pilot, nor influenced his performance in general.

The OOW roused the pilot at about 0330 by shaking his knee. *Doric Chariot* was in a position roughly abeam of the reporting position 'J', but displaced nearly one mile to the west. At this time *Doric Chariot*'s bow was about 1160 m or 3 minutes 40 seconds in time from the shoal water at the southern extremity of Piper Reef. The OOW was quite unaware of their situation.

About 55 minutes earlier, at about 0235, after the pilot went to sit down on the bridge settee, the OOW had been left with a simple, routine task of maintaining the ship on track. At 0240, without fixing the ship's position, he adjusted course one degree to port to a heading of 324°(G), assessing the alteration relative to the ship's head and (he thought) Piper Reef. He had to call the pilot at the next Reefcentre reporting position, 1.2 miles before Piper Reef. In the hour and five minutes between Eel Reef and the grounding, the OOW fixed the ship's position only once, at 0305, using a radar range and bearing from First Stoney Point, 4.5 miles on the port beam.

The 0305 position is about 0.2 miles south and west of the track programmed in the *Doric Chariot*'s GPS set. The cross track error (XTE) alarm had been set at 0.2 miles and should have activated at about this time, whilst the ship was still 5.6 miles from grounding on the reef. It is a strong possibility that the alarm prompted the OOW to fix the ship's position at 0305. The XTE alarm can only be silenced by pressing the 'clear' button (or removing the alarm inducing condition). After the audible alarm was silenced the display still indicated the continuing alarm condition by a small 'XTE' light in the top corner. The GPS XTE audible alarm did not have a time-dependent recycle function, that is it would not 'sound' again unless it was reset and reactivated.

The OOW had adequate time to adjust the course, had he had a proper appreciation of the ship's position relative to the intended track and the passage between Inset and Piper Reefs. From the time of fixing the ship's position he had about 30 minutes to react, had he realised the significance of the alarm. In fact at 0325, again without plotting the ship's position, he altered a further 2 degrees to port to a heading of 322°(G).

Chios Navigation (Hellas) provide standing orders and check lists for 'Safety of Navigation'. In the OPERATIONAL GUIDANCE FOR OFFICERS IN CHARGE OF NAVIGATIONAL WATCH (form No. D07-003), the following guidance is provided:

2. During the watch the course steered, position and speed shall be checked at sufficiently frequent intervals, using any available navigational aids necessary, to ensure the ship follows the planned course.

Form No. D07-005, a "CHECK LIST FOR NAVIGATION IN NARROW WATERS", asks:

6. 'Is the ship's position being fixed at regular intervals?'

These guidelines mirror the International Chamber of Shipping's Bridge Procedures Guide and the requirements of Chapter VIII of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (as amended in 1995). No mention is made in any guide as to what frequency of fixing would qualify as 'regular intervals'. It is reasonable that the decision of what constitutes 'regular' should be left to the professional judgement of the master and the officer of the watch. In the Inspector's opinion, however, in the compulsory pilotage area of the Great Barrier Reef, fixes every 30 to 35 minutes do not meet the test of reasonable frequency, particularly in the absence of the pilot.

Although the night was fine and clear and the temperature 'pleasant', the OOW maintained his monitoring of the ship's progress only by looking at the radar display. On the radar he saw, amongst other target returns, a return from Piper Reef light and returns from the islands on the west side of Piper Reef, Farmer Island (12 m above datum) and Fisher Island (14 m above datum). The OOW misinterpreted the target return from Piper Reef as being that of Inset Reef and Fisher and Farmer Islands as being the return from Piper Reef. His adjustment of course at 0240, and indeed 0325, was on the basis of passing between the return from Piper Reef and Fisher Island.

It is likely that the OOW spent some time at, or in the vicinity of, the chart table. There is a strong possibility that the GPS alarm at 0305 stimulated him to fix the ship's position. The GMDSS equipment is adjacent to the chart table and the bridge lavatory is immediately behind the chart table. There is also a strong possibility that the OOW spent a significant amount of time either at the radar, the GMDSS equipment, or at the chart table. What is clear is that he did not study the course laid down on the chart or give thought to the ship's intended course and the course made good.

Had the OOW fixed the ship's position at more frequent intervals and kept a proper lookout ahead it should have been obvious that his interpretation of the radar picture was wrong. Any visual lookout from the bridge front and any examination of the chart must have been, at best, cursory.

Actions of the pilot – 0235 to 0335

The pilot stated that, after passing the south bound ship off Eel Reef, as *Doric Chariot* was to the east of the intended track he set a course of 325° to bring the ship back to the track. Before sitting down on the wheelhouse settee he showed the OOW the lights of Inset and Piper Reefs and pointed out that the ship was heading between the two lights. The pilot assumed that, once the track drawn on the chart was regained, the OOW would make the 3° course alteration to bring *Doric Chariot* on a heading between Inset and Piper Reefs. While the instructions he gave the OOW are the subject of some dispute, the OOW had made such adjustments previously under the pilot's supervision.

From a position just west of Eel Reef light the pilot was seated in the wheelhouse. Although he did not intend to sleep he made himself very comfortable and, at some time in the hour before the grounding, he had done so. This is the third grounding in the Great Barrier Reef, when a pilot had been on the bridge but asleep, to be woken minutes before, or as, the ship grounded. (Peacock, Report No. 95 – New Reach, Report 147) In the cases of *Peacock* and *New Reach* the pilots were in the pilot chair asleep. In the case of *Doric Chariot* the pilot was reclining on a settee fixed fore and aft against the port side bulkhead of the wheelhouse, just aft of the bridgewing door.

The presence of the pilot on the bridge would normally indicate that the pilot has direct control of the conduct of the ship, and the role of the OOW is one of monitoring the pilot's actions. A pilot resting on the bridge introduces a degree of ambiguity in the role of the pilot. Who has charge of the navigation? Is the pilot awake or asleep? Will he be irritated if disturbed if he is asleep? Sitting on the settee the pilot

could not see ahead, but neither was he obviously detached from the conduct of the passage and the bridge activity.

In submission the pilot stated that he had handed the conduct of the vessel to the OOW. Provided the OOW maintained the ship on course there was no reason for the pilot not to rest or even have a short sleep. However, in the inspector's opinion, the pilot was engaged to conduct the ship through the whole of the inner route. However he managed this task he retained the conduct of the vessel as contracted to the master.

What is apparent is that the instructions given by the pilot were inadequate, or deficient, in that he did not tell the OOW why he had selected the 325° heading or to return the ship to the planned heading once back on track. He did not say whether he was intending to sleep or not. Although he did not intend to sleep, the risk of falling asleep was significant and, if he did not intend to sleep, the pilot should have been aware of the risk and made attempts to mitigate it.

The pilot had instructed the OOW that he be called at position J. By choosing this position, the pilot had not allowed for any possible errors or miscalculations. This position is so close to all the surrounding dangers that it would not be possible to correct for any but the most minor and insignificant discrepancy in his plan.

Alertness

Both the pilot and the OOW were operating at the time of day associated with the low point of the circadian rhythm. Both men would have been prone to tiredness due to this time-of-day effect.

The pilot, by sitting down, removing his shoes and putting his feet up and then reclining on the settee, without specific orders to the OOW to ensure he stayed awake, was inviting sleep. He had been on the bridge since Eden Reef, a period 10½ hours. The temperature was comfortable, and there was a quiet background noise. It was 0230 in the morning, a time when the diurnal human being has a natural propensity to sleep. All the factors were weighted heavily against the pilot staying awake without some external stimulus.

The International Maritime Organisation, together with the International Labour Organisation, defines fatigue as:

> 'A reduction in physical and/or mental capability as a result of physical or emotional exertion which may impair nearly all physical abilities including strength, speed, reaction time, coordination, decision making and balance.'

The Seafarers International Research Centre defines fatigue as:

> 'Acute or chronic and encompassing tiredness, depression, sleepiness, stress, sleep quality and disturbed circadian rhythms and boredom.
>
> Acute fatigue can occur in a matter of hours and is usually the result of excessive or physical activity.
>
> Chronic fatigue is reached when the 'normal' period of sleep proves insufficient to restore the individual's working performance to its usual level. It is insidious and usually happens over a period of time. Persons suffering from chronic fatigue always perform below their personal best.'

There are acknowledged to be four stages of sleep[6]:

- Stage 1 - a transition between wakefulness and sleep, during which time the amplitude of the brain waves decreases and the rate of brain wave activity slows. A well rested person is easily roused and may not realise that he/she has, in fact, slept.
- Stage 2 - is a deeper, intermediate sleep associated with slower metabolic and heart rates. A person is usually easily woken by sound.
- Stage 3 – a deeper sleep from which a person is more difficult to wake.

6 De Landre, J. Boag, C., & Fletcher, A., *Asleep at the Controls*, Flight Safety Australia, Vol 6 No.5, p.24, September-October 2002.

- Stage 4 – the 'deepest' sleep associated with large delta brain waves.

Waking somebody from stages 3 and 4 sleep is quite difficult. A person woken from these deep sleep stages will probably be groggy, disorientated and confused and experience 'sleep inertia'.[7] The period of sleep inertia tends to be increased by being woken suddenly. Also, people who are already sleep-deprived may enter a state of deep sleep within 20 to 30 minutes of the first sleep episode. In the first three minutes of wakening, decision making performance can be as low as 51 per cent of the person's best decision making ability.[8]

The stage of sleep that the pilot experienced when awoken cannot be known with certainty. The stage of sleep would depend on when he actually entered stage one sleep and the degree of fatigue that he was experiencing at the time. When he was aroused he first put on his shoes before standing to look forward out of the bridge front windows. It was only then that he realised that *Doric Chariot* was standing into danger. Although this report cannot quantify any delay that occurred between the pilot being aroused and the order for full starboard rudder, there was almost certainly some delay, to a greater or lesser degree, due to a degree of sleep inertia.

The pilot's work schedule and level of alertness

The pilot had taken annual leave from the end of May until 9 July 2002. His first duty when back from this leave was to conduct one ship north through the compulsory pilotage area, a passage of 37.25 hours. He flew south to Cairns then, at his own request, was not included in the pilotage roster again until 19 July.

On 19 and 20 July he conducted a bulk carrier, at 11.9 m draught, from Cairns to Varzin Passage, a duty time of 36.5 hours. He remained at the Torres Pilot accommodation on Thursday Island until 1930 on 22 July, a period of just over two days, when he boarded the bulk carrier *Doric Pride* for the southbound, ballast passage, to Dalrymple Bay. He was on board for 62.5 hours. After disembarking, he booked into a motel in Mackay for about 31 hours before boarding *Doric Chariot* at about 1500 on the afternoon of 26 July 2002. During this time ashore he visited some friends. He did not have any daytime naps but that night did have a normal full night's sleep.

The pilot remained on the bridge of *Doric Chariot* from about 1500, throughout the departure from the port, until 1900. In all, between Hay Point and a point south of Fitzroy Island he had spent seven hours on the bridge observing the ship's officers' watchkeeping practices and 21 hours resting. Thereafter, until the time of the grounding, the pilot spent 25 hours on the bridge (two of these sitting on the settee) and 7½ hours off the bridge (rest hours).

The periods spent off the bridge coincided with recognised areas of reduced risk in the compulsory pilotage area where, providing the weather conditions and traffic allow, the pilot is able to leave the bridge.

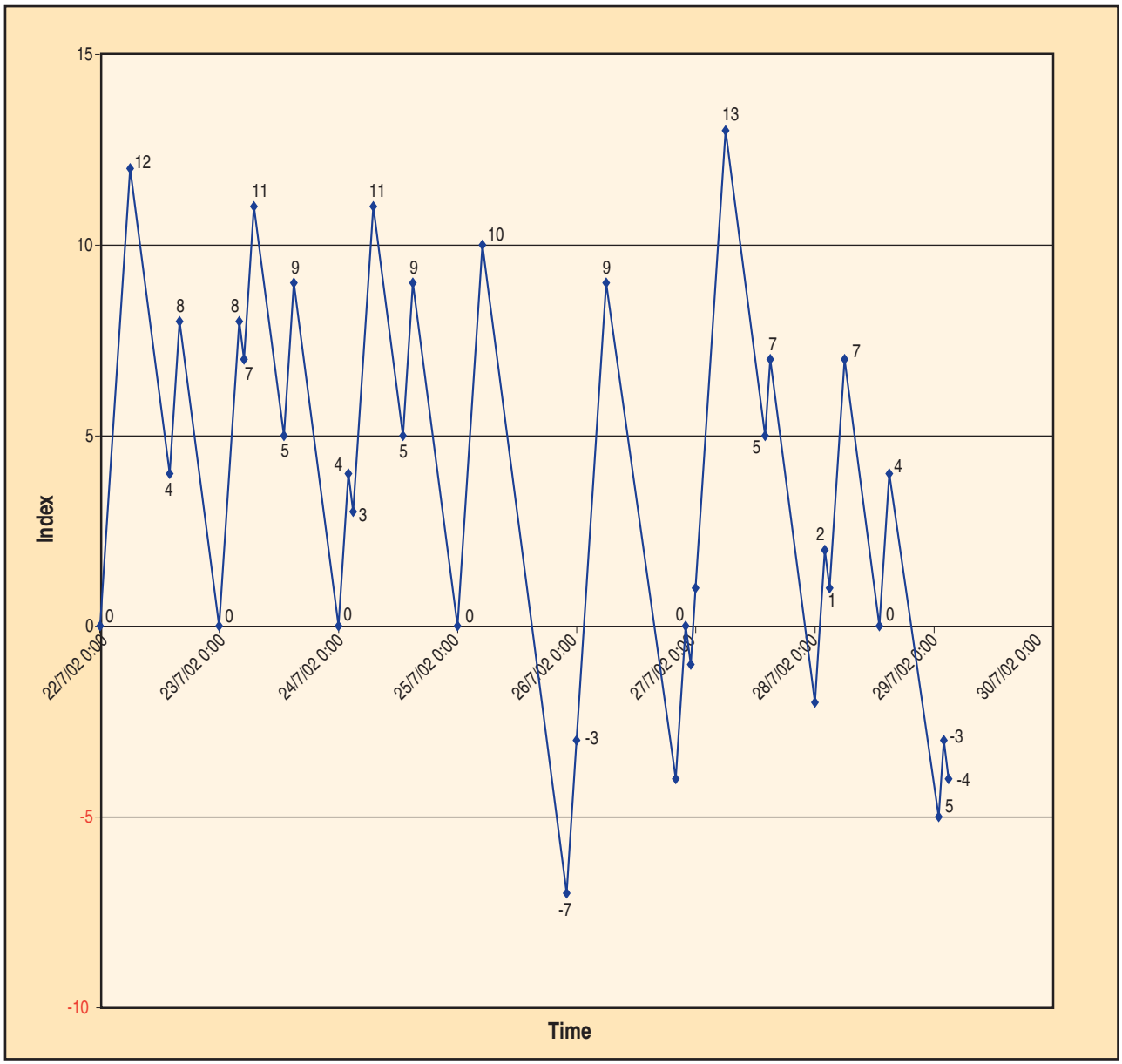
The on-board decision to reduce speed rather than anchoring near Prince of Wales Channel had the effect of lengthening the periods that the pilot was on the bridge but it also lengthened his rest periods. These factors should be taken into account by the pilot in his personal fatigue management strategy.

To assess the pilot's possible exposure to fatigue the simple test of 'sleep credit/deficit' was applied to the pilot's waking and sleeping hours as provided by him. This system credits each sleep hour with two index points and debits one index point for each hour awake. This system makes no allowance for physical or mental

7 ATSB aviation safety advisory notice SAN 20010244, 'Sleep Inertia' is a period of poorer task performance that results immediately after awakening

8 Ibid *Asleep at the Controls*

FIGURE 6:
Sleep credit/deficit analysis graph



effort or for circadian rhythms. A negative score only indicates that the work hours warrant further examination.

Given the negative score, the pilot's routine was then subjected to further examination using the FAID fatigue computer program.

FAID is a tool designed to help roster and manage work hours so as to reduce the potential for excessive on-the-job fatigue levels. The algorithms within the program allow for both the fatigue effect of the current shift's hours of work and the cumulative effect of the work hours over the previous seven days. They also include an allowance for the 'time-of-day' effect (circadian rhythms). Fatigue programs are useful tools and demonstrate a responsible and professional approach to safety management. However they can only be used as a guide. They do not make allowance for mode-specific environmental factors such as noise, light, vibration, or the proximity to the workplace for pilots and ship's crews.

FIGURE 7:
The best case

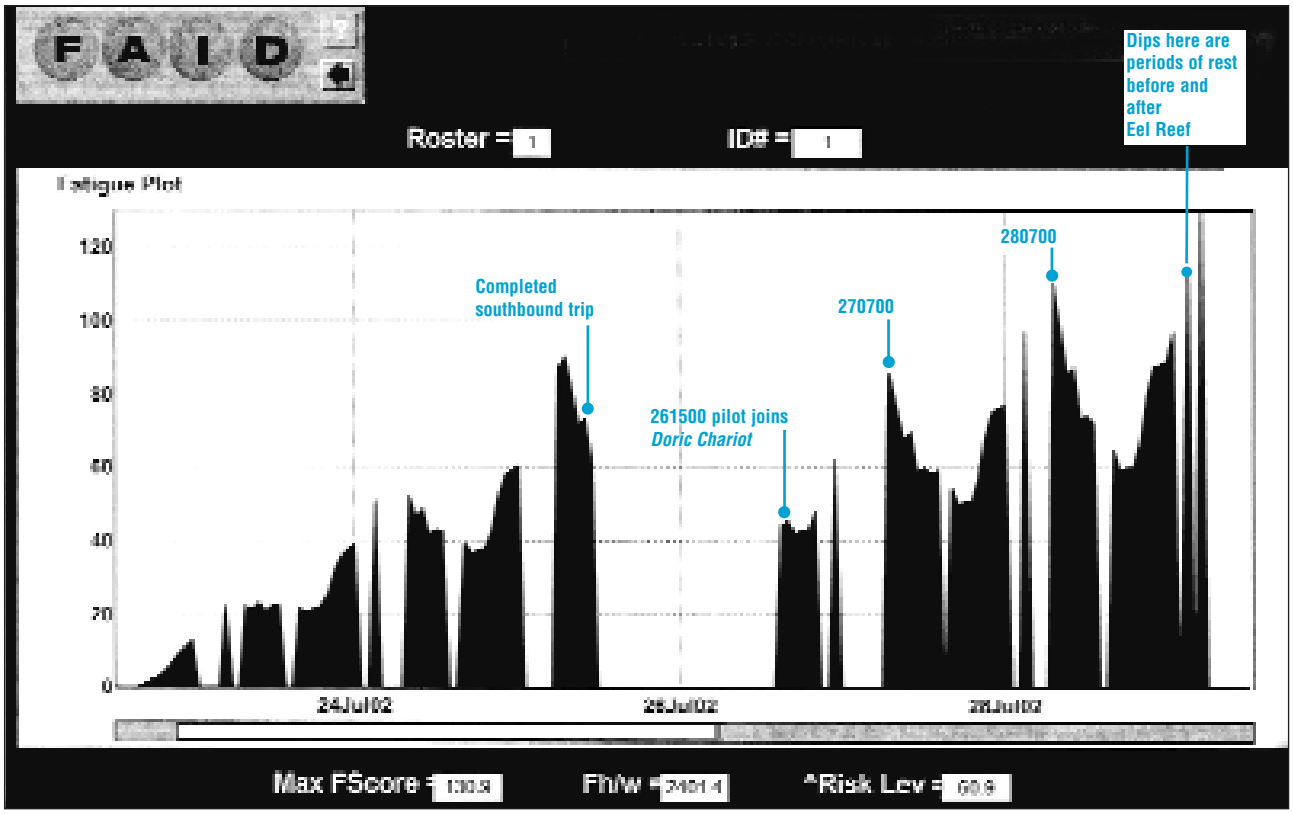
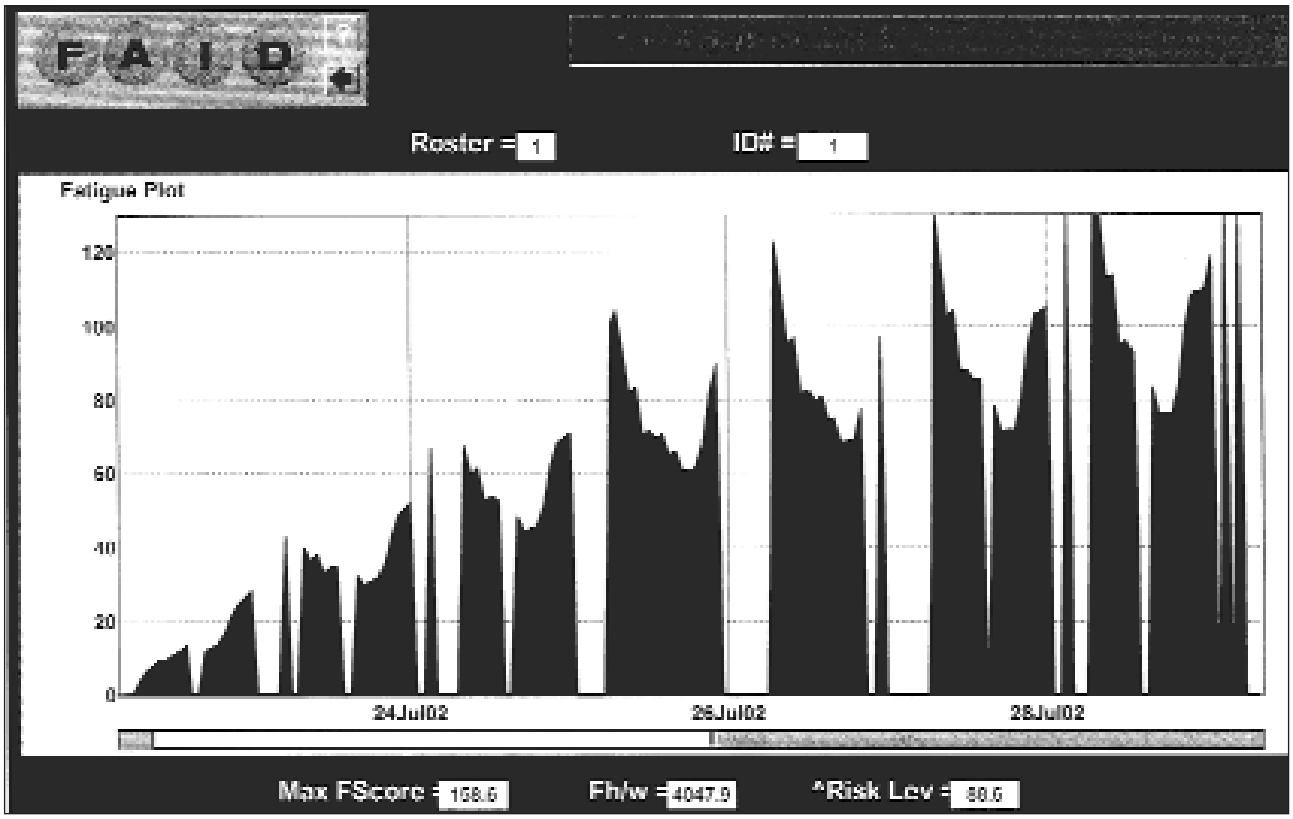


FIGURE 8:
The worst case



To examine the pilot's fatigue using FAID a 'best' and 'worst' case scenario was adopted. The best case uses only the hours of actual work on the bridge as the input whereas the worst case uses all the waking hours as the input parameters. The 'true' score probably lies somewhere between these two extremes.

The 'best' case

Both of these FAID outputs were based on the detailed information provided by the pilot at the ATSB interview given a few days after the incident. The 'best' case shows a maximum of about 113 prior to the grounding.

The 'worst' case

In this extreme example the fatigue score was over 150.

In submission, both AMSA and the pilot provider expressed doubt as to the validity of the data used by the Inspector. The pilot had provided them with a copy of his 'pilotage hours log', a form the pilot is required to complete contemporaneously with his passage and return to the provider after each voyage. This form showed different hours of work and resulted in them computing an index score of about 80.

Though there is some subjectivity about what hours are entered into the program, the results were such that, in combination with all the other factors available for examination, the Inspector is satisfied that the pilot was suffering from the effects of fatigue and also, immediately prior to the incident, a sleep inertia effect (see page 15). In addition to the time-of-day effect, this was in part due to his own management of his hours up to the time *Doric Chariot* entered the compulsory pilotage area. For instance, after leaving his previous vessel he elected to visit a friend rather than try to sleep. However, few people can sleep at will even when aware of future demands on their time.

The hours of work of the master and OOW, as supplied, were also examined using the FAID fatigue program, but in neither of these cases did it positively identify fatigue as an issue.

Bridge resource management

Fully utilising all the assets, particularly the human assets on a ship's bridge, reduces the risk of a 'one person' accident. The basis of BRM is to maximise the involvement and contribution of all persons on the bridge, utilising the skills and experience of the ship's staff and a pilot, if embarked, together with the ship's equipment to their best effect. BRM is now an accepted system for reducing risk factors and increasing the safety and efficiency of navigation. The key to effective BRM is communication between all the parties involved.

In the Advisory Note to Coastal Pilots (3/99), 'The Use of Passage Plans', AMSA drew the attention of pilots to the requirement of the STCW Convention for ships to plan passages. The Advisory Note opined that a ship's passage plan would not have the details required to ensure safe passage in the compulsory pilotage area in all circumstances. The Note reminded pilots of the need to maintain their own passage plans.

BRM depends on a two-way exchange of information covering any limitations on the operational status of the ship and the role that the individuals play. The pilot had his own extensive passage plan, including chartlets. The plan already adopted by the ship was very similar to the pilot's own and any variation was not significant. However, in adopting the previous pilot's plan, and not using his own, the exchange of information was abbreviated. The pilot did not specifically refer the master or the officers to the areas of the route that were, in his view, the areas of greatest risk.

The issue of pilots briefing ships' bridge crews on their (the pilot's) passage plan is one that elicits a variety of opinions. It is argued that expecting to brief the master and all officers in one meeting is impracticable, given the differing

duties that officers have when sailing or arriving in port. In long passages the officers may forget critical instructions. Some pilots favour progressive briefing as the voyage progresses. What is important is that those on the bridge have a shared concept of the ship's route over the hours to come and the actions that must be taken to achieve the aim. None of this is difficult or particularly complex, but it is very important.

The evidence indicates that, on the morning of 29 July, the OOW did not properly understand the pilot's intentions (though he did not express any doubt). That he should have done, and that a qualified and competent officer should have recognised the intention from the chart, cannot be disputed. However, people do make mistakes and their performance can be affected by distractions, misunderstandings and attitude, all of which may be compounded by time-of-day effects and hours on duty.

Previous accidents

Since 1985 there have been 18 incidents[9] involving trading ships over 70 m in length within the current compulsory pilotage area. There were 10 groundings and eight collisions, seven of the collisions involved fishing vessels and one a patrol boat.

Between 1 January 1985 and the introduction of compulsory pilotage on 1 October 1991 there were 10 reported incidents within the area. In the eleven years since the introduction of compulsory pilotage there have been eight incidents, four collisions and four groundings. This accident rate of 0.727 per year in the Great Barrier Reef since the introduction of compulsory pilotage is comparable with the similar Chilean pilot service which has a rate of about 0.771 serious groundings per year[10].

Of the eighteen incidents recorded since 1985 all but one have occurred north of Barrow Island. Eleven of the incidents have occurred in the area between Eden Reef and Clarke Island. Since 1 October 1991, six of the eight incidents occurred between Eden Reef and Clarke Island, five between the hours of 2230 and 0400.

It is self-evident that individuals could not maintain an effective presence on the bridge for the full extent of the compulsory pilotage area and the critical passage through the Prince of Wales Channel and Varzin or Gannet Passage. The six recognised rest areas are designed to help manage the pilots' performance and reduce the effects of fatigue. The extent of the rest areas is about 27 per cent of the total length of the pilotage. The problem is that the rest area that gives the longest rest opportunity is at the southern extremity of the pilotage area. Other rest areas, depending on the ship's speed, allow breaks in the order of one hour to 1½ hours. The inner route between Eden Reef and Clerke Island (Cape Grenville) is 141 miles in length and is the longest part of the passage without a rest area.

The presence of an alert pilot does not remove all risk of a marine accident. The experience of past groundings and collisions in the Great Barrier Reef could support an argument that to reasonably guarantee a fully alert pilot at all times, ships should carry two pilots working alternating watches. Although such an arrangement would possibly reduce some risk factors during the passage, it would not remove all risk as evidenced by the Chilean experience. And such a regime could possibly introduce

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9 This figure does not include the grounding of a navigational aids ship engaged in work in and around Mid Reef in 1993.

10 In the Chilean Pilotage Service, two pilots, alternating time on the bridge, pilot ships over 1060 miles. The passage experiences very strong cross currents and two areas where a 'tidal window' is necessary for the passage. The service experiences an average of 2.41 groundings per year of which 70 per cent are minor'touching bottom' incidents which do not result in damage. The weather conditions tend to be more extreme than in the Great Barrier Reef.

different risks such as greater levels of boredom and issues of pilot recruitment and remuneration. The case for two pilots is not clear cut and would require careful and detailed assessment.

Safety actions

The Australian Maritime Safety Authority erected a radar transponder beacon (RACON) at Piper Reef in response to this incident.

The issue of pilot fatigue and options to address the lengthy passage between Heath Reef and Eborac Island is under active consideration by the Great Barrier Reef and Torres Strait Shipping Management Group, as part of its broad ranging analysis of all factors involved in shipping incidents in the Great Barrier Reef. This includes assessment of a wide range of measures to reduce the risk of incidents occurring, including pilotage levels, new technologies, education and awareness programs and vessel traffic systems.

Although AMSA has previously reviewed the particular factors applying to this part of the passage, this matter will be revisited and will be addressed at the next scheduled meeting between AMSA and pilots in September 2003. The meeting will consider if there is a need for a common safety and fatigue reduction strategy for the area. However, AMSA is of the view that each passage is uniquely affected by weather, nature of ship and cargo, time of day, density of shipping and other factors. It is therefore the primary responsibility of the pilot, in consultation with the master, to determine the best fatigue reduction strategies in light of these factors when formulating the agreed passage plan for the particular voyage.

Drugs and alcohol

The Inspector is satisfied that neither alcohol nor drugs, prescribed or illicit, were taken by any of those involved in the grounding.

Conclusions

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

All shore-based and shipborne navigational aids, the ship's engine and the steering functioned as designed. On the evidence available, the following factors are considered to have contributed to the incident:

The pilot:

1. sat down intending to rest but fell asleep, in an inappropriate area of the pilotage passage;
2. instructed that he should next be called in a position too close to the approaching dangers for any successful corrective action to be taken, should it be required;
3. was likely to have been experiencing a significant level of fatigue, based on the FAID program measurement, that affected his performance. This was predominantly as a result of his personal fatigue strategies before, and during, the passage and;
4. did not provide the OOW with sufficient clear, unambiguous instructions regarding the course between Eel Reef and Piper Reef, making assumptions as to the OOW's actions that were not justified.

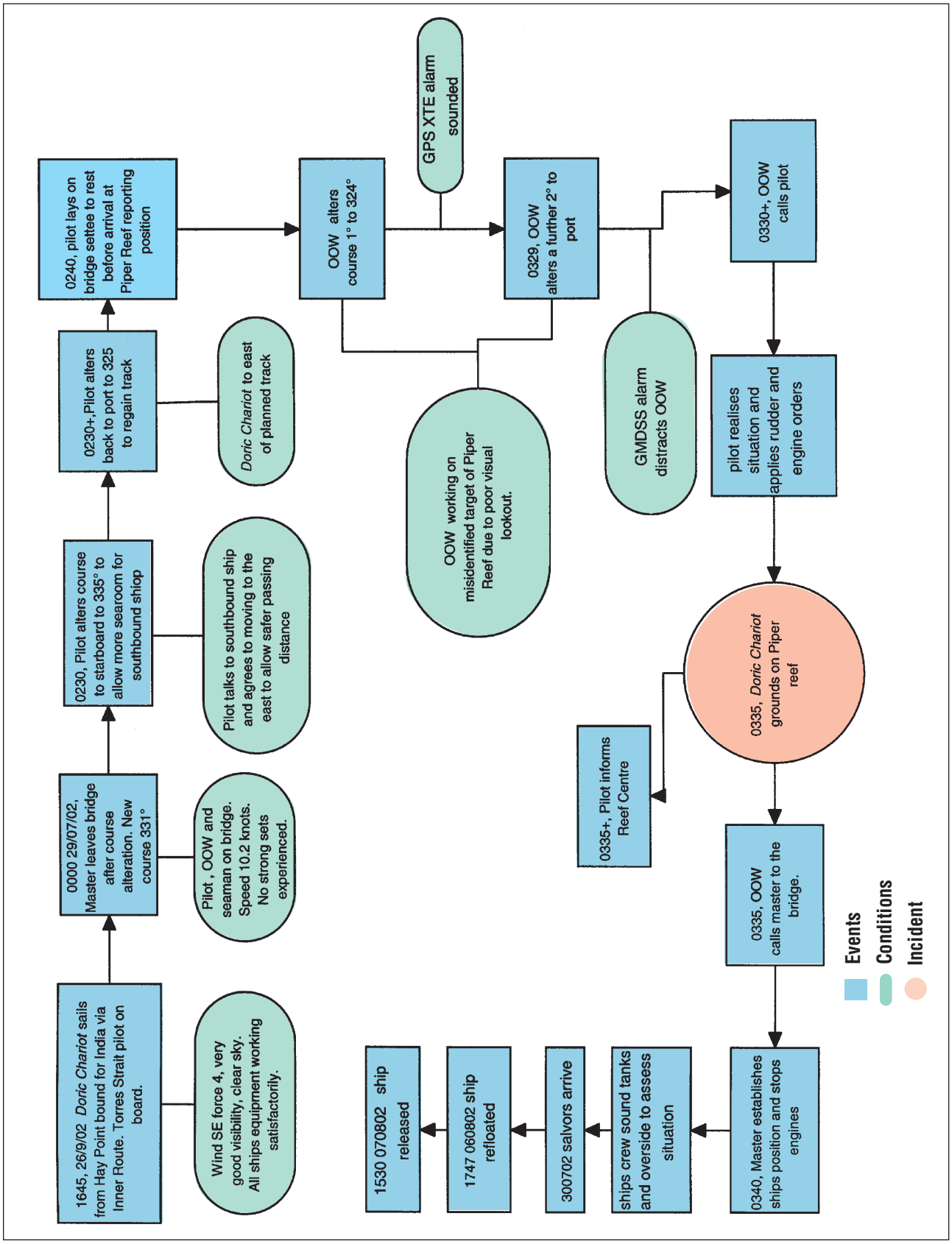
The OOW:

1. did not maintain an effective visual watch and allowed *Doric Chariot* to stray from the intended course;
2. did not fix the ship's positions at intervals that were consistent with safe navigation;
3. did not adjust the ship's course to follow the route drawn on the chart and;
4. did not fully comprehend the pilot's intentions with regard to both his sleep/rest and his navigational requirements.

Additionally:

1. The bridge resource management exercised by the pilot and the OOW was ineffective.

FIGURE 7:
***Doric Chariot*: Events and causal factors chart**



Recommendations

MR20030032

Ships' officers should ensure that they fully understand any intentions and instructions that they are given by a pilot prior to accepting 'active' conduct from them. Pilots must ensure that they are satisfied that ship's officers fully understand the pilot's intentions. Pilots and ships' officers should both ensure that any handover of responsibility is unambiguous and complete.

MR20030033

The Great Barrier Reef pilotage services should consider adopting a fatigue management policy that predicts potential fatigue levels at key positions in the pilotage task. Rather than only examining a pilots fatigue level after a passage, the pilotage provider should, prior to allocating the job, use the FAID program to ensure that a reasonable projection of the pilot's fatigue score would not exceed a predetermined value at any point during the pilotage.

MR20030034

Australia should submit a paper to the IMO seeking to amend the performance criteria of GPS sets to include distinctive alarms and indicators. Such alarms, when silenced, should automatically annunciate again after a specific time period, unless the GPS is reprogrammed or the alarm condition ceases.

Submissions

Under sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or the relevant part of the report. Sub-regulation 16(4) provides that such a person may provide written comments or information relating to the report.

The final draft of the report, or relevant parts thereof, was sent to

The Great Barrier Reef pilot

Second mate *Doric Chariot*

Master *Doric Chariot*

The pilotage provider

The Australian Maritime Safety Authority (AMSA)

The ship owner *Doric Chariot*

The ship manager *Doric Chariot*

The following is an extract from the submission received from AMSA.

> …we believe the accuracy of the FAID score quoted in the report must be questioned. To quote from the introduction to the FAID program "A recent study indicated that scores between 80 and 100 (that is, high fatigue) are equivalent to the predicted level of work-related fatigue achieved after 23-24 hours of continuous sleep deprivation (starting at 0800)."
>
> The draft report states at page 16, in respect of the pilot's duties on this occasion, that "In all, between Hay Point …the pilot spent 25 hours on the bridge (two of these sitting on the setee) and 7½hours off the bridge (rest Hours)."
>
> Our previous comments also identified the other opportunities available for rest before and during the voyage by the pilot. Taken with the above, AMSA considers that the assessment that the pilot has a score between 130 and 150 is erroneous.
>
> Regarding recommendation 2, again primary responsibility for managing fatigue rests with the individual pilot. Regulation and policy can only provide guidance and it is up to pilots to follow appropriate practices. To assist pilots, AMSA is already actively engaged in investigating with pilots and providers the improvements possible with predicting their fatigue levels. The types of initiatives being progressed are the use of individual FAID programs for each pilot that can be kept updated during the passage task, and real time reporting of the ship progress through the Great Barrier Reef pilotage area that can be monitored by AMSA.

Elsewhere, where appropriate, the text has been changed to correct the draft or reflect the submission.

Doric Chariot

IMO Number	9075670
Flag	Greece
Port of Registry	Piraeus
Classification Society	Lloyds Register
Ship Type	Bulk Carrier
Builder	Hyundai Heavy Industries Co., Ulsan, South Korea
Year Built	1994
Owners	*Doric Chariot* Corporation, Monrovia, Liberia
Ship Managers	Chios Navigation (Hellas) Ltd
Gross Tonnage	38 779
Net Tonnage	24 372
Deadweight (summer)	73 350 tonnes
Summer draught	13.765 m
Length overall	224.97 m
Breadth	32.25 m
Moulded depth	19.00 m
Engine	1 x B & W 5S60MC
Total power	9 180 kW
Crew	20 (Greece, Bulgaria, Philippines)

Independent investigation into the grounding of the Greek registered ship Doric Chariot at Piper Reef, North Queensland on 29 July 2002

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