Report 01-205

coastal container ship

Spirit of Enterprise

sheer and contact with channel side

Otago Harbour

15 March 2001

Abstract

On Thursday 15 March 2001, at about 0517, the coastal container ship *Spirit of Enterprise* was outbound from Dunedin in Otago Harbour with 11 crew on board under the control of its pilot exempt master, when it sheered violently to port turning through 180 degrees in the channel at Deborah Bend. The master took the ship back to the swinging basin off Port Chalmers where tests of the steering machinery were carried out. Finding no faults, the master resumed the outward passage but again the vessel sheered at Deborah Bend, this time touching the channel side.

Two consecutive channel light beacons had failed at Deborah Bend, which caused the master to make the turn into the bend prematurely and resulted in him losing situational awareness and the ship leaving the channel.

Safety issues identified included:

- the standard of bridge resource management aboard the *Spirit of Enterprise*
- fatigue-related performance impairment
- the monitoring of the operation of channel marking beacons in Otago Harbour
- the adequacy of legislation governing pilotage and pilotage exemption schemes operating in Otago Harbour and generally in New Zealand.

Safety recommendations were made to the chief executive of Pacifica Shipping (1985) Limited, the chief executive of Port Otago Limited, the chief executive of Otago Regional Council and the Director of Maritime Safety to address the safety issues.

Spirit of Enterprise

Contents

Figures

Abbreviations

GPS	global positioning system
IALA	International Association of Lighthouse Authorities
IMO	International Maritime Organisation
IR	integrated rating
ISM	International Safety Management
kW	kilowatt(s)
m	metre(s)
nm	nautical mile(s)
SOLAS	International Convention for Safety of Life At Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping, IMO
t	tonne(s)
TEU	twenty-foot equivalent unit (containers)
UTC	universal time (co-ordinated)
VHF	very high frequency

Glossary

ballast	weight, usually sea water, put into a ship to improve stability
beam	greatest width of a ship
bridge	structure from where a ship is navigated and directed
chart datum	zero height referred to on a marine chart
class	category in classification register
conduct	in control of the ship
draught	depth in water at which a ship floats
flood tide	rising tide
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
knot	one nautical mile per hour
pivot point	imaginary point around which a ship turns under helm
port	left-hand side when facing forward
shoulder	the part of a ship on each side of the bow where the straight sides begin
sounding	measure of the depth of a liquid
stability	property of a ship by which it maintains a position of equilibrium, or returns to that position when a force that has displaced it ceases to act
starboard	right-hand side when facing forward
track	the path intended or actually travelled by a ship

Data Summary

Ship Particulars:

Name:	*Spirit of Enterprise*
Type:	coastal container carrier
Classification:	Bureau Veritas
Class:	VII: foreign going cargo ship (SOLAS)
Length overall:	113.80 m
Beam:	16.20 m
Gross tonnage:	4529 t
Summer draught:	6.633 m
Built:	in 1999 at Gelibolu Shipyard, Turkey
Propulsion:	a single 4320 kW, MAK M32 diesel engine driving, through a reduction gearbox, a single controllable pitch propeller
Bow thruster:	560 kW BERK
Owner:	Ali Riza Aksoy Denizcilik, Turkey
Charterer/Operator:	Pacifica Shipping (1985) Limited
Port of Registry:	Lyttelton, New Zealand

Date and time:	15 March 2001 at about 0517[1]
Location:	Otago Harbour
Persons on board:	crew: 11 passengers: nil
Injuries:	nil
Damage:	minor to hull
Investigator-in- charge:	Captain John Mockett

[1] All times in this report refer to New Zealand Daylight time (UTC + 13 hours) and are expressed in the 24-hour mode.

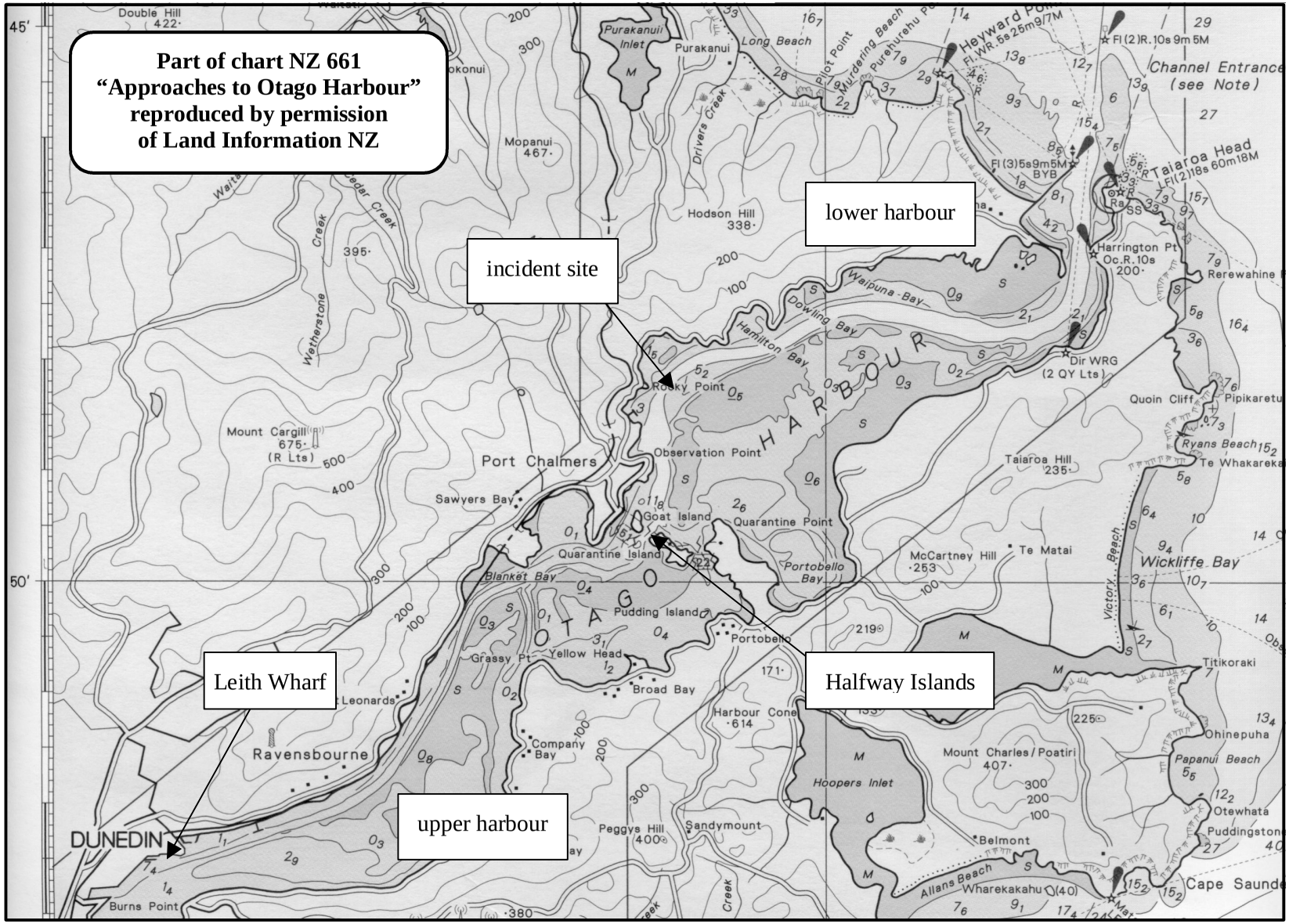

Figure 1
Part of chart NZ 661 showing Otago Harbour

1. Factual information

1.1 History of the trip

1.1.1 On Wednesday 14 March 2001, the coastal cargo ship *Spirit of Enterprise* arrived off the heads of Otago Harbour at 0412. The master reported to the signal station at Taiaroa Heads and, as a pilot exempt master, was given permission to enter the port.

1.1.2 The master navigated his ship through the lower harbour to Port Chalmers, where he berthed it alongside the General Purpose Berth at 0506.

1.1.3 Cargo was worked at the General Purpose Berth until 0700. After testing the bridge equipment, the ship was let go from the berth at 0704 and the master navigated his ship through the upper harbour to Dunedin where he berthed it alongside the Leith Wharf at 0755 (see Figure 1). The *Spirit of Enterprise* stayed alongside in Dunedin for the remainder of that day working cargo.

1.1.4 The estimated time of finishing cargo and departure from Dunedin was 0200 on Thursday 15 March. The chief and second mates shared the cargo watches between them. The chief mate was working the deck at midnight when he handed over to the second mate.

1.1.5 The chief mate left the deck shortly after midnight and went to his cabin. He was unable to sleep so he returned to the deck at about 0200 to supervise the completion of cargo.

1.1.6 The master had retired the previous evening at about 2100 in the expectation that departure time would be 0200. He awoke at 0220 and made enquiries of the chief and second mates regarding completion time. When he was told that cargo would not be complete until about 0400 he went to the bridge and advised Taiaroa Head signal station of the revised departure time.

1.1.7 The master went back to his cabin and readied himself for departure before returning to the bridge at about 0300 to wait for cargo to be completed.

1.1.8 When cargo work was completed at about 0400, the master tested the bridge equipment including the bridge control, engine pitch control, bow thruster and steering equipment. At this time he obtained clearance to depart from the signal station. The operator at the signal station told the master that beacon 8 was unlit and beacon 14 was lit with a temporary amber light. The *Spirit of Enterprise* was at a draught of 5.5 m forward and 6.2 m aft.

1.1.9 At 0421 the master took bridge control and the ship was let go from the berth at 0425. The second mate, who had been at the aft mooring station, went to the bridge to assist the master. The chief mate, who had been at the forward mooring station, went to his office to complete cargo papers and stability calculations.

1.1.10 The weather conditions at the time of departure were reported as good visibility, overcast with light wind. Low tide at Dunedin was at 0306 and high tide at 0839 so the ship would have had a flood tide against it for the full harbour transit.

1.1.11 The master took the *Spirit of Enterprise* through the upper harbour channel. He was navigating mainly by eye but with occasional reference to the radar. The second mate was monitoring the progress visually, by radar and occasionally consulting the navigational chart.

1.1.12 The *Spirit of Enterprise* was being steered by hand. The integrated rating (IR) at the wheel was the regular harbour helmsman, but because he was to be relieved at the next port was accompanied by another IR, who was undergoing familiarisation to become the harbour helmsman. Under the master's direction, the helmsman was also operating the engine controls.

1.1.13 The *Spirit of Enterprise* passed between the Halfway Islands at about 0510 and the master reported to the signal station as required. The master reduced the propeller pitch to slow his ship down to the 6-knot speed restriction for passing Port Chalmers.

1.1.14 At this time the master released the second mate and told him to get some rest. The second mate left the bridge and went to his cabin. The chief mate was still in his office completing his calculations.

1.1.15 The ship passed Observation Point at 0512 and the master recalled that the speed shown on the global positioning system (GPS) at that time was 5.8 knots and that his ship was midway between Observation Point to port and beacon 28 to starboard.

1.1.16 From Port Chalmers the channel curved to starboard through the area known as Deborah Bend. The master continued to navigate by eye, keeping his ship in the centre of the channel. He instructed the helmsman to head for the green lights on the far side of the channel, telling him to head for the next light as the turn progressed, but also making course or helm adjustments as required. At the same time the master was judging the ship's position by the red lights marking the channel on the starboard side of the ship.

1.1.17 The master recalled that the ship was turning to starboard as it passed beacon 24a. At that time he thought the ship was in the centre of the channel and heading in the direction of beacon 23 (see Figures 2 and 3).

1.1.18 At about 0517, soon after passing beacon 24a, the ship sheered rapidly to port. The helmsman reported to the master that he had lost steering. The master instructed him to put the wheel hard to starboard. The master and helmsman both recalled that the rudder indicator showed hard to starboard but the ship continued to swing rapidly to port.

1.1.19 The master put the propeller pitch from full ahead to full astern. Meanwhile he telephoned the engine room and asked the second engineer to check the steering gear. He sent the trainee helmsman to tell the chief mate to go forward and stand by the anchors.

1.1.20 The trainee helmsman met the chief mate, who had been on his way to the bridge, on the stairwell. The chief mate went forward and told the trainee helmsman to call the second mate.

1.1.21 The actions taken by the master significantly slowed the ship and reduced the rate of swing. However the ship had turned almost through 180 degrees and beacon 25 could be seen close on the port bow. The master told the helmsman to put the wheel hard to port. He put the propeller pitch to full ahead and operated the bow thruster to port.

1.1.22 The *Spirit of Enterprise* swung clear of beacon 25 and the master reduced speed and steadied the ship in the channel. The master called the signal station on VHF and told the operator that the ship was experiencing steering problems and that he was proceeding back to the swinging basin off Port Chalmers to conduct tests. The signal station operator logged that call at 0525.

1.1.23 Meanwhile the second mate had been called and was told to go forward, relieve the chief mate and ask him to return to the bridge. The second engineer had woken the chief engineer, requesting that he come to the engine room.

1.1.24 The master took the ship back to the swinging basin and held position there while the engineers checked the steering equipment. There had been no faults recorded on the data logger and the engineers could find no fault with any part of the steering system. After the master regained control of the ship following the initial sheer to port, the steering gear had followed the helm and the ship responded as expected.

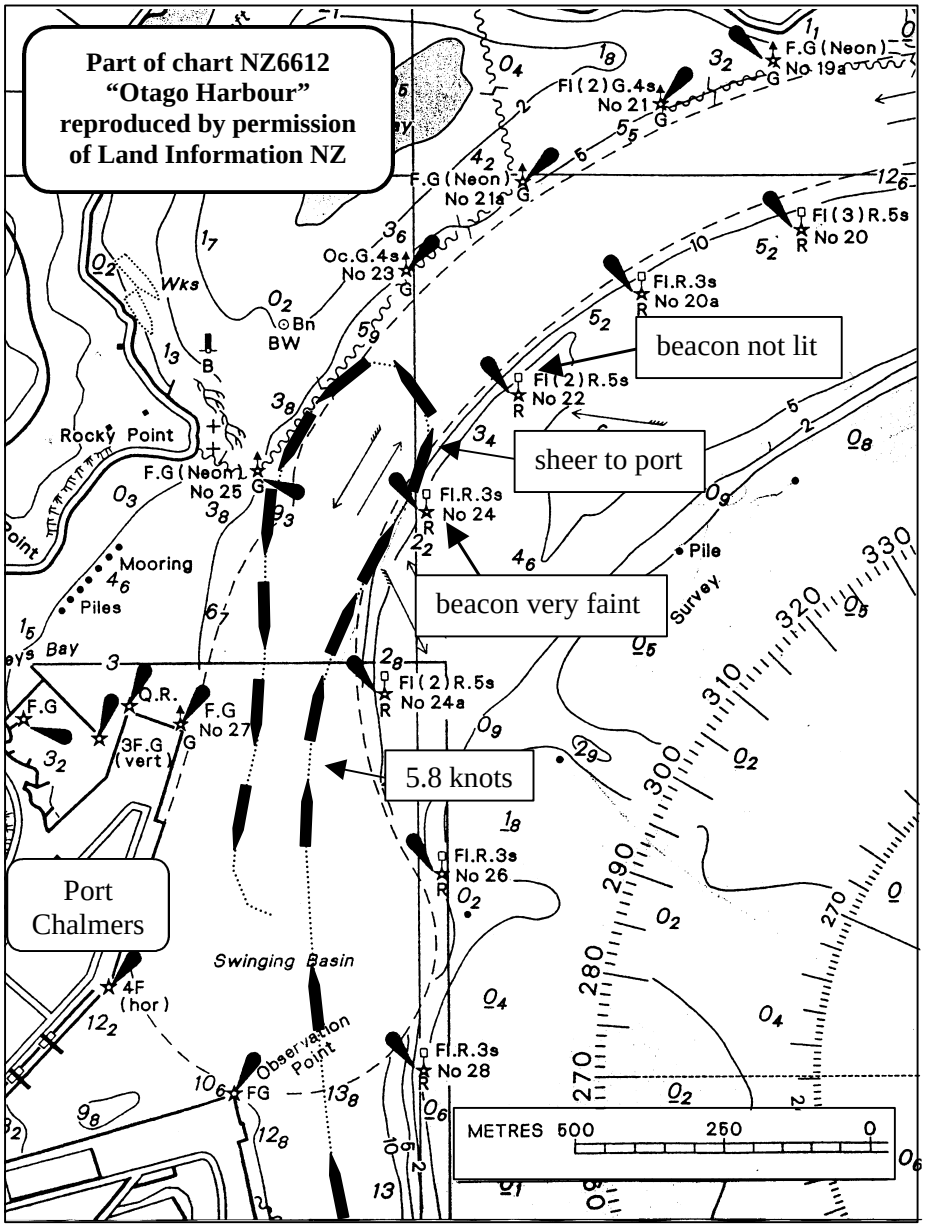

Figure 2
Part of chart NZ 6612 showing approximate track during first sheer

1.1.25 Finding no steering problem, the master decided to continue the outward passage. On this occasion the second mate remained forward with an IR, standing by the anchors and keeping a lookout, the chief mate stayed on the bridge to assist the master and the chief and second engineers were in the engine room.

1.1.26 The master turned the *Spirit of Enterprise* in the swinging basin and positioned it in the centre of the channel. He called the signal station and told the operator that no steering fault had been found and received clearance to proceed.

1.1.27 On the bridge the master was navigating by eye with the chief mate monitoring progress visually and by radar. The helmsman was again steering by hand with the trainee helmsman observing.

1.1.28 As the ship passed beacon 24a, the master started the turn to starboard. Shortly after passing beacon 24a the ship again sheered to port despite the helm being put hard to starboard. The ship was not travelling as fast as previously and the sheer was not as violent as the first time. As the ship sheered it was felt to touch the channel side (see Figure 4).

Figure 3
View of Deborah Bend showing intended track

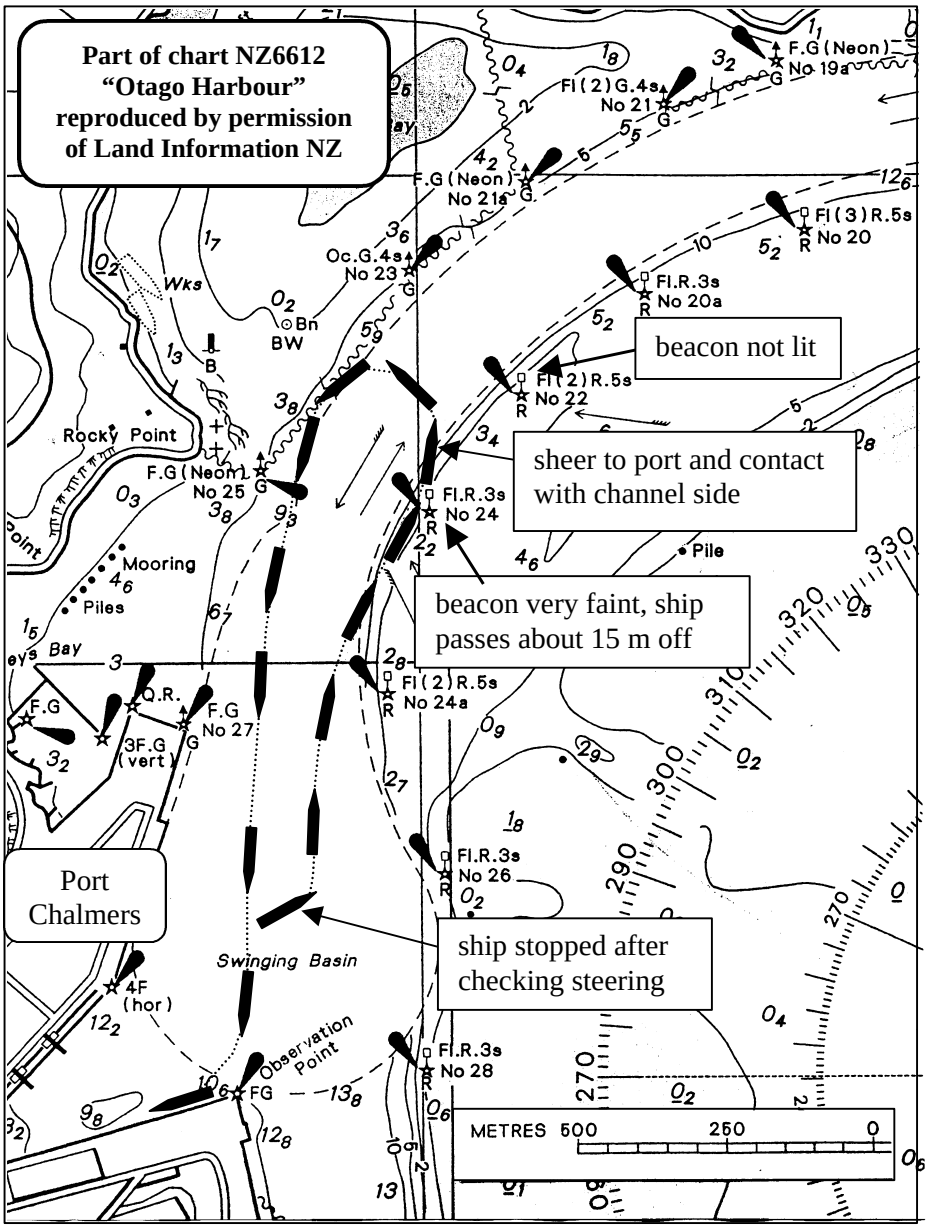

Figure 4
Part of chart NZ 6612 showing approximate track during second sheer

1.1.29 Just as the sheer started, the second mate reported to the bridge that a beacon with a very weak light had just passed the starboard bow at an estimated distance of about 15 m. The master asked the chief mate to look for the beacon but he was unable to see it and had not seen it on the radar.

1.1.30 The master was again able to regain control of his ship by use of the engines, bow thruster and helm. He called the signal station and told the operator that the ship had sheered again and had touched bottom. He requested permission to return to Port Chalmers and go alongside a berth. The operator told the master to go alongside Beach Street Wharf outer berth. The operator logged the call at 0535.

1.1.31 The master realised that during the second incident the rudder had reacted to the helm and that something else had caused the sheer. He saw the pilot launch *Potiki* approaching Port Chalmers having taken a pilot out to an arriving ship. The master asked the crew of the *Potiki* if the light beacons were all working. The crew of the *Potiki* replied that all the beacons in the area appeared to be working.

1.1.32 The master asked the skipper of the *Potiki* if he would return to the area of beacon 24 and check the lights. The skipper agreed and later reported that beacon 24 was lit but so faint as to be hardly visible, and beacon 22 was not lit. The skipper placed temporary amber lights on both beacons.

1.1.33 Meanwhile the master instructed the mates and engineers to check for signs of hull damage. The engineers sounded the fuel and ballast tanks and the mates checked the holds and the external hull. No damage was apparent. The tanks remained at previously recorded levels and the draught was unchanged.

1.1.34 At 0652 the master again contacted the signal station and informed the operator that no steering fault had been found, no hull damage was apparent and with the temporary lights fitted to beacons 24 and 22, he requested permission to depart. The signal station operator granted clearance.

1.1.35 The *Spirit of Enterprise* was clear of Beach Street Wharf at 0655 and the master took the ship through the lower harbour and out to sea without incident, clearing the heads at 0728. During the passage, he reported to the signal station that beacon 18A was unlit.

1.2 Interaction

1.2.1 When a ship is making headway, a positive pressure builds up forward of the pivot point and the flow of water down the sides of the ship creates a low pressure area which extends out from the ship (see Figure 5). When the ship is in deep open water the pressure areas are not a problem. However, when the ship is in confined or shallow water, the pressure areas cause interaction between the ship and the seabed or sides of a channel.

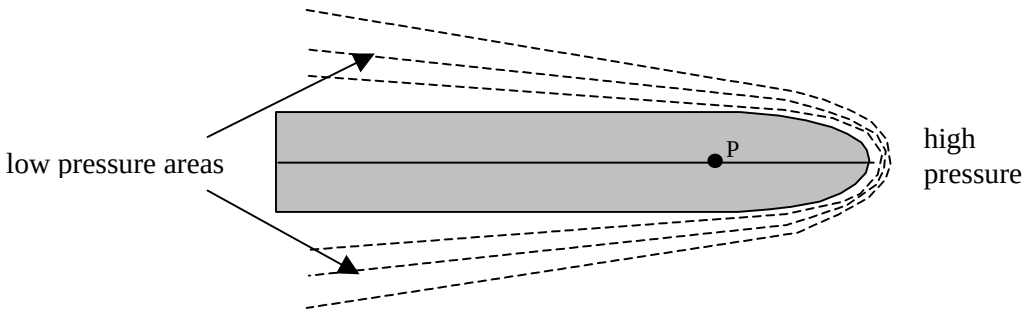

Figure 5
Simplified diagram of pressure areas

1.2.2 As a ship starts to close with a vertical obstruction, such as a shoal or channel side, the areas of high and low pressure become restricted and the ship is influenced by the resultant forces and suffers what is known as bank effect. The positive pressure at the bow builds up and cushions the bow away from the obstruction, while the low pressure area at the stern creates a suction towards the obstruction. The suction effect is greater than the cushion effect due to the longer distance from the pivot point. The combined forces can be very strong. Under such conditions constant corrective rudder, sometimes as much as hard over, is required to control the heading. If left uncorrected, the ship is liable to sheer away from the side of the channel, sometimes violently. The higher the speed of the ship, the more pronounced the effects of interaction will be (see Figure 6).

1.2.3 When a ship transits the centre of a channel, the interaction forces are present on both sides of the ship and counteract each other. If the ship moves closer to one side of the channel then it will be influenced by bank effect on that side, and may need considerable corrective helm.

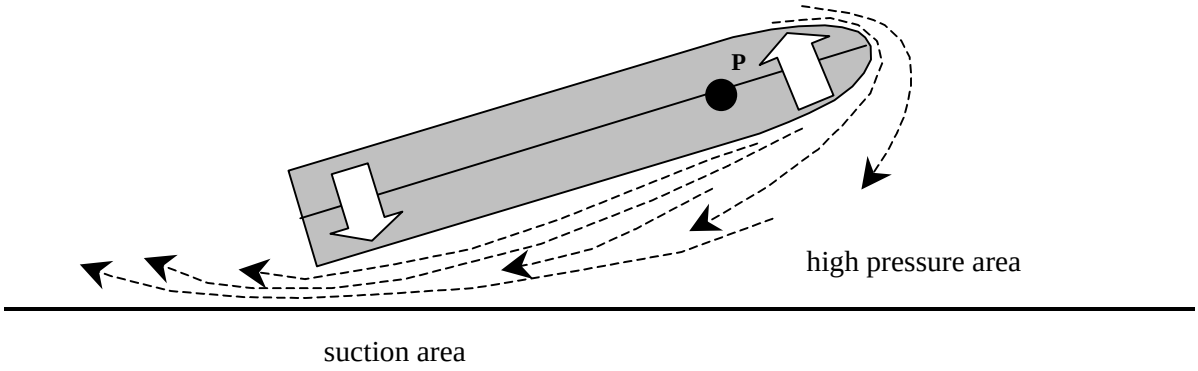

Figure 6
Bank effect

1.3 Vessel information

1.3.1 The *Spirit of Enterprise* was bareboat chartered to and operated by Pacifica Shipping (1985) Limited (Pacifica). It was built in 1999 for its Turkish owner and chartered by Pacifica in August 2000.

1.3.2 The *Spirit of Enterprise* was a 113.8 m long container ship with a capacity of 486 TEU. The ship was trading on the New Zealand coast and a speed of 14.5 knots was required to maintain the schedule.

1.3.3 The *Spirit of Enterprise* had suffered a previous steering malfunction, which required repair with the aid of a shore technician. The master on board at the time of this incident had been master on that occasion.

1.3.4 The accommodation and engine room of the *Spirit of Enterprise* were situated aft, with the cargo spaces forward. The bridge was 7 decks above the main deck and was totally enclosed with no bridge wings. On the port side of the main deck there were 2 cargo cranes, which were minor obstructions to what was otherwise good all-round visibility.

1.3.5 In the wheelhouse there was a central console which housed, among other equipment, the steering controls, radars, echo sounder, engine controls and bow thruster controls. There was space all round the console, allowing the watchkeeper access to the bridge front windows over the full width of the wheelhouse. The chart table was on the port side of the wheelhouse and the communication equipment on the starboard side.

1.3.6 When the *Spirit of Enterprise* was berthed in Lyttelton later on 15 March, divers inspected the hull. No indentations were found but an area of bottom paint 6 m long and 2 m wide had been rubbed off on the starboard side aft of the shoulder.

Analysis 1

1. The master had unknowingly altered to starboard early, causing the ship to close with the channel side. As the ship approached the bank by beacon 24, bank effect would have caused the bow to be cushioned off and the stern to be sucked into the bank. Thinking that his ship was in the middle of the channel, the master would not have expected bank effect and only small amounts of helm were being applied to make the turn. In order to control bank effect, a mariner would need to expect that it might happen. Once a ship has begun to sheer, it can be difficult to recover.

2. Without any additional helm to counteract the bank effect, the ship sheered rapidly to port and the larger helm applied was too late to correct it. The master's actions to control the sheer with engines and the bow thruster broke the bank effect but left him with a drastic manoeuvre in a confined space to control his ship.

3. Not realising that his ship had been close to the bank, the master's initial thoughts of a steering failure were understandable, particularly as the helmsman had reported a loss of steering, and the master was aware that the ship had previously experienced a steering failure. However, given that the rudder reacted to the helm when correcting the sheer and tests revealed no faults, he should have been searching for some other cause of the sheer.

4. On the second attempt the ship was travelling more slowly but neither the master nor the chief mate realised that the ship was again out of position and it came closer to the bank than on the first attempt, having been stopped in the swinging basin and probably starting from a different position from that in the first transit of the basin.

5. Bank effect again caused the ship to sheer rapidly to port and the sighting of beacon 24 by the second mate came too late to avoid the sheer. On this occasion the ship touched the channel side, probably because of the closer approach and possibly due to a slightly later reaction from the master or helmsman.

6. The Otago Harbour channels were the longest and most complicated of those that the *Spirit of Enterprise* transited on its trading pattern. The upper harbour was narrower than the lower harbour and the Halfway Islands formed a natural break between them. There was a commonly held attitude among regular callers that once past the Islands the departure "was all over", implying that the lower harbour was a much easier passage. In fact the lower harbour was still a more exacting pilotage than most other harbour transits in New Zealand.

7. The helmsman was an experienced seaman who regularly took the helm on the *Spirit of Enterprise* for harbour transits. Although on this occasion he was instructing a trainee helmsman, there was no evidence to suggest that he had been distracted from his primary function.

8. The master reacted instinctively and with commendable speed, avoiding a grounding after the first sheer. His decision to return to the swinging basin to conduct tests was appropriate. Given that the ship continued to react to the helm on the way back to the swinging basin and no steering faults were found during checking, the master should have been considering alternative reasons for the sheer, but remaining mindful that an intermittent steering fault could be present.

9. The master took the *Spirit of Enterprise* into the lower harbour channel again and while monitoring the passage, he and his crew were watching for signs of a loss of steering. Again the master, and on this occasion also the chief mate, thought the ship was in the middle of the channel but when it was in what he believed was "roughly the same spot", it sheered again. On this occasion the position became known because of the sighting by the second mate of the dimly lit beacon passing close down the starboard side.

10. The master was navigating by eye on both occasions but on the second occasion did not instruct the chief mate specifically how he wanted him to monitor the progress of the ship. It would have been prudent for him to have had the chief mate monitoring only the radar to give a different perspective on progress, which might have given early warning of the ship heading to one side of the channel.

11. In channels such as in Otago Harbour, it would not be unusual for pilots and exempt masters to navigate by eye. However, with good bridge resource management, supporting crew should be available to monitor the progress, preferably using all available bridge equipment.

12. The lights on 2 beacons in the area of the sheers were subsequently found to have failed and were therefore not visible from the bridge of the *Spirit of Enterprise*. The master mistook the more distant red-lighted beacons for those that he could not see, causing him to adjust the course and manoeuvre his ship prematurely into the starboard turn.

13. Dedicated radar monitoring might have averted this incident. The chief mate thought that, from visual observation, the ship was in the centre of the channel but also said that when he had looked at the radar, he did not see the beacons close to the ship at the time of the second sheer. While those beacons may have been lost in the sea clutter as the ship approached them, the more distant beacons and the track that the ship was taking into Deborah Bend should have been obvious on the radar.

1.4 Personnel information

1.4.1 The master went to sea in about 1964, serving on various deep-sea ships. He gained his Masters Certificate in 1975. About that time he took a shore position as stevedoring operations manager in Lyttelton, where he stayed until returning to sea in 1994 with Pacifica. He became relieving master in 1998 and permanent master in 2000. He had served on the *Spirit of Enterprise* since it was chartered by Pacifica.

1.4.2 The master held pilotage exemption certificates for all the ports on which the Pacifica ships traded. He gained his pilotage exemption for Dunedin in March 1998, and had made an estimated 75 transits of Otago Harbour since that time.

1.4.3 The chief mate went to sea as a deck cadet in 1990 with an Indian company, serving mostly on bulk carriers until 1995, when he gained his Class 3 Deck Officer Certificate. He then served for over 4 years with a United Kingdom company, progressing to a Class 2 Deck Officer Certificate. He joined Pacifica in December 1999 as relieving chief mate and had served on the *Spirit of Enterprise* since it was chartered by Pacifica.

1.4.4 The second mate went to sea in 1978 as a deck boy. He gained his Second Mate Certificate in 1993 and worked with various companies as third and second mate until joining Pacifica in 1999. He had served on the *Spirit of Enterprise* since it was chartered by Pacifica.

1.4.5 The helmsman went to sea in 1982 working as a deck rating with various companies. He had been employed by Pacifica since 1995. He had served on the *Spirit of Enterprise* since it was chartered by Pacifica. He was the regular harbour helmsman when rostered on duty.

1.5 Schedules and routines

1.5.1 At the time of the incident the *Spirit of Enterprise* was operating on a weekly schedule from Dunedin to Dunedin via Lyttelton, Tauranga, Auckland and Lyttelton.

1.5.2 The advertised schedule was as follows:

Depart Dunedin	Wednesday 2000	Arrive Lyttelton	Thursday 0900
Depart Lyttelton	Thursday 1800	Arrive Tauranga	Saturday 1000
Depart Tauranga	Saturday 1800	Arrive Auckland	Sunday 0400
Depart Auckland	Sunday 1000	Arrive Lyttelton	Tuesday 0700
Depart Lyttelton	Tuesday 1100	Arrive Dunedin	Wednesday 1200

1.5.3 The schedule was a guideline for Pacifica's customers, and both shore and sea staff attempted to maintain it. Many factors affected the schedule such as berth availability, cargo working times or reduced speed due to mechanical or weather restraints.

1.5.4 A service speed of 14.5 knots was required to maintain the schedule. When the *Spirit of Enterprise* was first put onto the service, it was unable to maintain the required speed. Over time, various outstanding machinery overhauls were carried out and the schedule speed was improved to a point where, by the time of this incident, the ship was generally able to meet schedule requirements.

1.5.5 Should the ship fall behind schedule, Pacifica had a number of options available to make up lost time, including the ability to use a variety of berths, subcontracting cargo by road, rail or sea, omitting a port call, using shore cranes to reduce port time or diverting the ship to a different service with another company ship taking over.

1.5.6 The sea staff normally worked on a 2-week duty roster followed by 2 weeks off duty, but could opt for a maximum of a 3-week duty roster followed by 3 weeks off duty. At the time of the incident the 3 deck officers were on 3-week swings in order that they and their opposite numbers could attend various courses to upgrade their certificates for Standards of Training Certification and Watchkeeping (STCW) 95.

1.5.7 When at sea, the bridge was manned in the conventional 3-watch system. The master kept the 8 to 12 watches, the chief mate kept the 4 to 8 watches and the second mate kept the 12 to 4 watches.

1.5.8 For arrival and departure stations at each port, the master generally required that while he was on the bridge, the chief mate was forward and the second mate was aft, although Pacifica policy allowed him discretion to reduce the manning for departures if conditions allowed.

1.5.9 In port the chief mate and second mate shared the deck watches supervising cargo operations. The chief mate kept the 6 to 12 watches and the second mate kept the 12 to 6 watches. The master worked varying hours and dealt with branch managers and shore contractors as well as completing other routine tasks.

1.5.10 The hours worked by the master, chief mate and second mate were recorded in the deck logbook in accordance with company policy. The recorded hours covered all work carried out, not just watchkeeping hours. The 3 officers all stated that at the end of a duty roster, whether it was 2 or 3 weeks, they felt tired and were not performing to standards they normally felt capable of.

1.5.11 The hours recorded in the logbook by the master, chief mate and second mate during the week preceding the incident are attached as Appendix A.

Analysis 2

1. The trading pattern on which the *Spirit of Enterprise* was engaged was demanding. Significant maintenance work had improved the speed to an extent that the ship was capable of the required schedule speed. If required, Pacifica had a number of options available to manage cargo, port calls, port time and ship use to make up time should the ship fall behind its schedule.

2. The master and deck officers maintained navigational watches at sea and the deck officers maintained the cargo watches in port while the master attended to other duties. In isolation the watchkeeping routine would allow for appropriate rest periods. The master's requirement for all 3 watchkeepers at arrival and departure stations meant that any 2 of them were working in their off-watch periods at those times. The officers also had routine tasks that could only be undertaken when not on watch.

3. Within the schedule were 2 longer passages, namely Lyttelton to Tauranga and Auckland to Lyttelton, which gave the officers some respite while keeping routine sea watches.

4. Such a routine over a 2-week period would be tiring and the officers acknowledged a reduction in performance over the duty roster. At the time of this incident the officers were working 3-week rosters. While this was done to enable required courses to be completed and was followed by a 3-week leave period, it did mean that the reduction in individual performance levels was probably increased.

5. The master kept the second mate on the bridge to assist for the transit of the upper harbour but released him once past the Halfway Islands. Although the master probably released the second mate for fatigue management purposes, he nevertheless deprived himself of assistance to monitor the passage through the lower harbour. The master's use of the available officers showed a lack of good crew resource management. The chief mate was expected to arrive shortly to relieve the second mate and in any case the lower harbour transit would only have taken about another 35 minutes.

6. On the second attempted transit of the lower harbour, the master was assisted on the bridge by the chief mate. Although he was the master's senior deck officer, he was also the one who had worked the most hours. The master might have been better assisted on the bridge by the second mate who, although he had worked for about 6 hours, had done considerably fewer hours than the chief mate.

7. The chief mate had been feeling good about successfully completing what he considered a difficult loading followed by satisfactory calculations for stability and the next port's loading. While he was concerned over the incident of the first sheer, he had not witnessed it, and its dramatic effect would not have been impressed upon him. Once no steering fault was found and the master decided to proceed again, the chief mate probably reverted partly to his elated state and together with his tiredness would not have been sufficiently alert to properly assist the master.

1.6 Fatigue

1.6.1 Pacifica recognised fatigue as a potential problem and issued instructions to reflect those concerns. The company policy for managing working hours was contained in its Standard Practices Manual, the International Safety Management (ISM) Policy Manual, and the officers employment contract.

1.6.2 The section of the Standard Practices Manual titled "Master's role and responsibility" contained the following provision:

> The Master shall ensure the ship meets all national and international statutory requirements, laws, procedures and contractual agreements.
>
> At his discretion the Master will delegate responsibilities, watches, work programme and duties. The Master shall ensure shipboard procedures reflect Company policy and aims.

A similar provision was contained in the ISM Policy Manual.

1.6.3 Section 12 of the officers employment contract contained the following instructions:

> **AVOIDANCE OF PHYSICAL EXHAUSTION**
>
> The requirements of STCW 95 as amended by the Maritime Rules 31A in force at 13 November 1999 shall be observed.
>
> Having regard to the foregoing, duty hours shall be organised to ensure the efficient operation of the ship and to ensure that projected cargo operations and departure times may be achieved.

1.6.4 Maritime Rules Part 31A, Minimum Personnel and Watchkeeping (Fitness for Duty) Foreign Going and Coastal, came into force on 1 August 1998 and mirrored the requirements of STCW 95. Rule 31A.4 was as follows:

> 31A.4 Fitness for Duty
>
> (1) Subject to rules 31A.4(3) and (4), the owner and master of a ship to which this rule applies must ensure that all persons who are assigned duty as –
>
> (a) officer in charge of a navigational watch; or
>
> (b) officer in charge of an engineering watch; or
>
> (c) a rating forming part of a navigational watch; or
>
> (d) a rating forming part of an engineering watch;
>
> are provided with a minimum of 10 hours of rest[1] in any 24 hour period.
>
> [[1] Minimum rest periods should not be interpreted as implying that all other hours are to be devoted to watchkeeping or other duties.]
>
> (2) The owner or master of a ship to which this rule applies must ensure that the hours of rest required by rule 31A.4(1) are divided into no more than two periods, one of which is to be six hours or more in length.
>
> (3) The rest period requirements prescribed by rules 31A.4(1) and (2) need not be maintained in the case of emergency or in other overriding operational conditions or in the case of a drill.
>
> (4) The 10 hours of rest required by rule 31A.4(1) may be reduced to not less than six consecutive hours provided that –
>
> (a) any such reduction does not extend beyond two days; and
>
> (b) not less than 70 hours rest are provided in each seven-day period.

1.6.5 Rule 31A.5 was titled Watch Schedules and rule 31A.5(4)(b) was as follows:

> The owner and the master of a ship to which this rule applies that does not operate in the unlimited area must keep a daily record of actual watchkeeping hours of all the watchkeeping crew[2]. This record must be retained on board and made available to the Director for a period of three years.
>
> [[2] This record may be kept in the official logbook or deck and engine-room logbooks.]

1.6.6 The above rules were those to which the Pacifica employment contract referred. However, on 1 February 2001 Maritime Rules Part 31A, Amendment 1, Crewing and Watchkeeping Unlimited, Offshore and Coastal (Non-Fishing Ships) came into force and revoked Part 31A. In respect of the working hours and avoidance of fatigue, the amended rule was similar to the old rule, but was expanded to incorporate some of the International Maritime Organisation (IMO) guidance regarding fitness for duty.

1.6.7 Under the amended Rule Part, those rules dealing with working hours and the management of fatigue were as follows:

31A.24 Hours of Rest

(1) Except as provided in rule 31A.24(3) and (4), the owner and the master of a ship must ensure that each person who is assigned navigation or engineering watchkeeping duty is provided with a minimum of 10 hours of rest in any 24 hour period.

(2) The owner and the master of a ship must ensure that the hours of rest required by rule 31A.24(1) are divided into no more than two periods, one of which is at least six hours in length.

(3) The rest period requirements prescribed by rule 31A.24(1) and (2) need not be maintained in the case of emergency, or of other essential on board work that for safety or environmental reasons cannot be delayed, or that could not reasonably have been anticipated at the commencement of the voyage.

(4) The 10 hours of rest required by rule 31A.24(1) may be reduced to not less than six consecutive hours provided that –

(a) any such reduction does not extend beyond two days; and

(b) not less than 70 hours rest are provided in each seven-day period.

31A.25 Watch Schedules

(4) The owner and the master of a ship that does not operate in the unlimited area must:

(a) ensure that a watch schedule is:
(a) posted where it is easily accessible to the crew; and
(b) available for inspection at all reasonable times by the Director; or

(b) keep a daily record of actual watchkeeping hours of all watchkeeping crew. This record must be retained on board for a period of three years and made available to the Director on request.

31A.26 Fitness for Duty

(1) The owner and master of a ship must establish and implement procedures in respect of the ship's crew, taking into account the requirement in 31A.27(1), to ensure that all crew are fit for duty when keeping a watch.

(2) The crew of a ship must ensure, taking into account the requirement of 31A.27(2), that they are fit for duty at all times when keeping a watch.

31A.27 Fatigue

(1) When the owner or master establishes and implements procedures for ensuring a seafarer's fitness for duty, they must take into account that:

(a) the level of alertness of a person keeping a navigational watch or engine room watch may be affected by fatigue; and

(b) that whenever alertness is affected by fatigue, performance can be impaired.

(2) When considering his or her fitness for duty, a seafarer must take into account –

(a) the signs, symptoms, and effects of fatigue1; and
(b) that fatigue affects alertness; and
(c) that the performance of any person whose alertness is affected by fatigue can be impaired.

[1 Guidance on the effects and the signs and symptoms of fatigue is provided in the Advisory Circular to Part 31A.]

1.6.8 Under the above company instructions, Pacifica management expected its masters and officers to manage their hours under the requirements of both STCW 95 and rule 31A.

1.6.9 Pacifica management regularly inspected the working hours recorded in the ship's logbook to check that the minimum rest period requirements were being met. It was satisfied that the provisions of both STCW 95 and rule 31A were generally met, although aware that under clause 31A.24(4) daily rest periods were occasionally reduced to less than 10 hours, but that an aggregate of 70 hours over 7 days was achieved.

1.6.10 The STCW 95 Convention included "guidance regarding fitness for duty", which included the following:

1. In observing the rest period requirements, "overriding operational conditions" should be construed to mean only essential shipboard work which cannot be delayed for safety or environmental reasons or which could not reasonably have been anticipated at the commencement of the voyage.

2. Although there is no universally accepted technical definition of fatigue, everyone involved in ship operations should be alert to the factors which can contribute to fatigue, including, but not limited to those identified by the Organisation, and take them into account when making decisions on ship operations.

3. In applying regulation VIII/1, the following should be taken into account:

.1 provisions made to prevent fatigue should ensure that excessive or unreasonable overall working hours are not undertaken. In particular, the minimum rest periods specified in Section A-VIII/1 should not be interpreted as implying that all other hours may be devoted to watchkeeping or other duties.

.2 that the frequency and length of leave periods, and the granting of compensatory leave, are material factors in preventing fatigue from building up over a period of time; and

.3 the provisions may be varied for ships on short-sea voyages, provided special safety arrangements are put in place.

1.6.11 The hours of duty, including the tasks undertaken and the sleep taken within the rest periods, for the master, chief mate and second mate are attached as Appendix A to this report. As is commonly reported by mariners in a variety of operations, the officers all reported that their sleep on board was of poorer quality than when on leave due to engine noise, ship movement, cargo operations and the proximity of other crew in the accommodation.

1.6.12 The Commission engaged the director of the Sleep/Wake Research Centre of the Wellington School of Medicine to assess whether fatigue contributed to this incident. For the assessment a method developed by the United States National Transportation Safety Board and the NASA Fatigue Countermeasures programme was used. The method seeks information on the following factors known to produce fatigue-related performance impairment:

- extended wakefulness
- acute sleep loss and cumulative sleep debt
- presence of a sleep disorder
- critical times in the daily cycle of the circadian body clock.

1.6.13 The duty times of the master and chief mate were assessed as the master had control of the ship during both times when the ship sheered and the chief mate was on the bridge assisting during the second sheer.

1.6.14 Analysis 3 uses the report submitted to the Commission by the director of the Sleep/Wake Research Centre where it considers the effects of fatigue-related impairment.

Analysis 3

1. Pacifica recognised fatigue as a potential problem and issued instructions to reflect those concerns. The instructions were based on the requirements of STCW 95 and Maritime Rules Part 31A, and were coupled with the need to arrange duty times in order to achieve efficient operation and scheduled timings.

2. The legislation recognised that due to the nature of maritime operations, there could be times when the required rest periods would not be available and may be reduced.

3. Clause 31A.24(3) and the similar clause in STCW 95 addressed those times of emergency or exceptional circumstances, and no minimum rest periods were stipulated.

4. Clause 31A.24(4) and the same clause in STCW 95 addressed those times when for operational reasons the minimum rest periods may not be available. However, under such circumstances, rest periods could not be reduced below 6 consecutive hours in any 24-hour period. Additionally the total rest periods in each 7-day period must still total at least 70 hours.

5. Pacifica recognised that there were times when for operational reasons, the minimum rest period requirements could not be met, but had satisfied itself that on those occasions the circumstances were such that the limitations in clause 31A.24(4) would be satisfied.

6. In the 7-day period prior to the incident, there were no emergency or exceptional circumstances that might have required the provisions of clause 31A.24(3) to have been considered. The hours of rest provided during that week therefore had to comply with the general requirements in clauses 31A.24(1) and (2), except as might be reduced for operational reasons under clause 31A.24(4).

7. The Commission examined the hours of work as recorded in the logbook by the watchkeeping officers for the week before the incident to establish whether the provided rest periods complied with the provisions of STCW 95 and rule 31A. All 3 had rest periods totalling in excess of 70 hours for the 7-day period.

8. The following observations were made regarding the master's rest periods:

    1. Considering the 24-hour period from 0800 on 10 March to 0800 on 11 March he had rest periods totalling 11.25 hours, made up of 3 rest periods and the first hour of his next rest period. His longest rest period of 5.25 hours was below the minimum 6 consecutive hours required.

    2. Considering the 24-hour period from 0730 on 13 March to 0730 on 14 March he had rest periods totalling 9.75 hours, made up of 4 rest periods. His longest rest period of 4 hours was below the minimum 6 consecutive hours required.

    3. Considering the 24-hour period from 2000 on 13 March to 2000 on 14 March he had rest periods totalling 11.25 hours, made up of 5 rest periods and the first hour of his next rest period. His longest rest period of 3.75 hours was below the minimum 6 consecutive hours required.

9. The following observations were made regarding the chief mate's rest periods:

    1. There were two 24-hour periods in which the chief mate did not have 10 hours' rest. From 0700 on 8 March to 0700 on 9 March he had a total of 9 hours made up of 2 rest periods, one of which was 7 hours. From 0400 on 14 March to 0400 on 15 March he had one rest period of 4.5 hours, which was below the minimum 6 consecutive hours required. In this instance there was a discrepancy between the work hours recorded and those reported verbally by the chief mate. He recorded working from 0000 on 15 March whereas he reported that he was not working between 0000 and 0200 that day. Regardless of this rest period, the minimum requirements were not achieved.

    2. Considering the 24-hour period from 0400 on 13 March to 0400 on 15 March he had rest periods totalling 10 hours, one of which was 8 hours but the remainder was split into 2 periods. Having had 2 days in the week with less than 10 hours' rest, his rest on this day should have been split into no more than 2 periods.

10. The following observations were made regarding the second mate's rest periods:

    1. In any 24-hour period during the week, the second mate achieved rest periods totalling at least 10 hours. In every case one rest period was of at least 6 consecutive hours. However there were five 24-hour periods during which the balance of the required 10-hour rest was taken in multiple periods rather than a single period.

11. Rest periods are time off duty to be used for personal tasks, recreation and sleep. An individual must be provided with appropriate rest periods and it is their responsibility to manage the time to ensure that sufficient sleep is taken to avoid fatigue, bearing in mind that each person's sleep needs vary. On average an individual needs between 7 and 8 hours' sleep per day.

12. Pacifica granted leave periods equal to the time spent on board ship. Such a leave ratio would enable an individual to fully recover from the effects of any fatigue built up while at work and to return to work refreshed. However, irrespective of the length of the leave period, once back at work, if either rest periods or sleep were not properly managed, fatigue could still reduce an individual's performance.

13. The amount and quality of sleep are the relevant factors when considering the effects of fatigue, rather than the total time off duty provided as rest periods.

14. At the time of the incident the master had been awake for about 3 hours after a 5-hour sleep and so extended wakefulness was not a contributing factor. In the 26-hour period before the incident he had 3 sleep periods amassing about 9.5 hours of sleep. However, his sleep on the previous night was about 3 hours and on the night of the incident about 5 hours. Acute sleep loss could have contributed to fatigue-related impairment. The master reported no sleep disorder that may have affected his quality of sleep. The master's loss of situational awareness and his fixation on a steering problem as a cause of the sheers were both characteristic of the type of impairment caused by sleep loss and fatigue.

15. In the case of the chief mate, the incident occurred about 12.5 hours after the end of a short daytime sleep and about 25.5 hours after the end of his last major night-time sleep. Extended wakefulness may have been a contributing factor to fatigue-related impairment. Within that 25.5-hour period he had only about 3.5 hours' sleep and it is highly likely that he was experiencing fatigue-related impairment due to acute sleep loss. The chief mate did not have good situational awareness and failed to appreciate the position of the ship in the channel. The chief mate reported no sleep disorder which may have affected his quality of sleep.

16. The master and chief mate could not remember their sleep patterns beyond the day before the incident. However, both commented on the poorer quality of onboard sleep and the difficulty getting enough sleep with the schedule. The master was at the end of his third week rostered on duty and the chief mate at the end of his second week. It is reasonable to assume that both were experiencing the effects of cumulative sleep debt at the time of the incident.

17. The incident occurred at about 0530, close to the time of the daily low point, when both officers would be expected to be at their least efficient and most sleepy. Inadequate prior sleep exacerbates the performance dip at this time.

18. Given the work/sleep history of the navigating officers during a normal schedule of the *Spirit of Enterprise*, it is likely that the various crews on the ship were routinely operating with varying degrees of fatigue.

1.7 Port information

1.7.1 Otago Harbour consisted of a dredged channel about 12 nm long, surrounded by shallow or drying sand banks. The harbour is divided into an upper and lower harbour by Quarantine and Goat Islands, which are collectively known as Halfway Islands. These islands are about 6 miles from the harbour entrance. Port Chalmers is on the seaward side of Halfway Islands.

1.7.2 The lower harbour channel was maintained at a minimum depth of 12.2 m across a minimum channel width of 183 m. The beacons marking the lower harbour channel were 45 m outside the toe line[2] (see Figure 7). The upper harbour was maintained at a minimum depth of 7.3 m and a minimum channel width of 80 m. The beacons marking the upper harbour channel were 15 m outside the toe line.

1.7.3 An estimated 90 % of the channels was self maintaining because of the scouring effect of the tidal flow which conformed to the channels. Port Otago Limited had a dredger permanently stationed in the harbour and routinely dredged the channel on a year-round basis.

[2] Dredging term for the depth contour on each side of a channel which indicates the extremity of the minimum depth within the channel.

1.7.4 With the exception of the passage between the Halfway Islands, the bottom and sides of the channels consisted mainly of sand, mud and clay and any build-up would generally occur in the inside of the bends in the channel. Across the width of the navigable channel between the toe lines, the bottom was generally flat while the sides of the channel were quite steep. The tidal flow generally followed the course of the main channels.

1.7.5 Soundings for the full channel were carried out each year, with soundings taken of each section after dredging. The area of Deborah Bend was last dredged in February 2001. Soundings were taken in the area after the incident and no significant shoaling was found (see Figure 7).

1.7.6 The distance between the toe lines in the vicinity of beacon 24 in the lower harbour was about the 183 m minimum width of the channel.

1.7.7 The Otago Harbour channel was marked by beacons along its full length. From Dunedin to the heads there was a total of 135 channel marking beacons, all of which were fitted with lights.

1.7.8 Port Otago Limited was responsible for the maintenance of the navigation beacons and had maintenance and reliability monitoring systems in place. It did not, however, have a policy of routinely inspecting the beacons to identify light failures, but relied on transiting mariners to report extinguished lights to the signal station. In turn the signal station would advise other transiting mariners of any unlit beacons.

1.7.9 Once a beacon was reported as being unlit, the harbour services staff went to the beacon to inspect it. A repair was carried out if possible, but otherwise a temporary flashing amber light was fitted and the normal light taken away for repair. Reported unlit beacons were inspected as soon as possible but in any case before any expected traffic was due to transit the area.

1.7.10 The light beacons in the Otago Harbour channels had been subject to an ongoing upgrade over the 2 years before the incident involving the *Spirit of Enterprise*. The lights used to be all fed by shore power, and each electric cable fed several lights. Any failure of a cable meant that all of those lights were affected. At the time of the incident, all the red beacons had individual lights that were battery powered with solar panels to keep the batteries charged. Many of the green lights were also battery powered but there were still some on shore power.

1.7.11 The upper harbour was upgraded first. A solid state battery and solar-powered light, a Sealite fitting, was trialed and found to be reliable and required only low maintenance. The beacons in the upper harbour were lit mostly using this type of light. The lights in the lower harbour were mostly of the Tideland type which were fitted with an automatic lamp changer which held 8 lamps and rotated to the next lamp when it sensed a lamp failure. These lights were fitted with solar-powered battery packs or in some cases replaced by Sealite lights.

1.7.12 Beacon 22, which was unlit on the day of the incident, was a Tideland light and its lamp changer was found to be faulty and had not moved to the next lamp after a failure. The previously recorded failure of this beacon was in February 1998.

1.7.13 Beacon 24, which was showing only a very faint light on the day of the incident, was a Sealite light that had been fitted in January 2000. On inspection a faulty diode was found which had resulted in a low battery voltage. The light had a new battery fitted in February 2001 and had needed its circuit board replaced in January 2001 after water had entered the battery compartment. A similar problem was found to be the cause of beacon 43 being unlit.

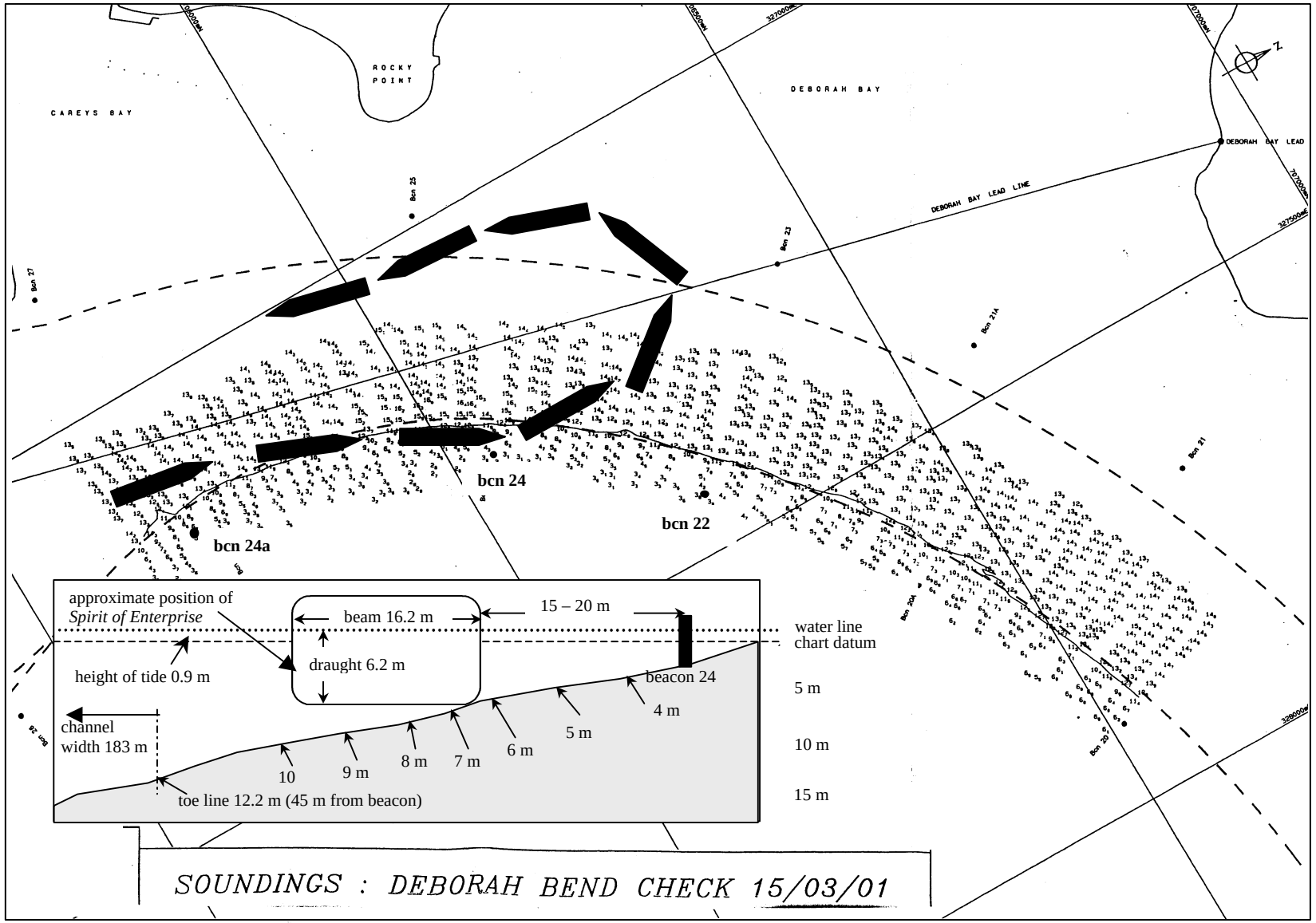

Figure 7
Sounding chart showing probable track of the *Spirit of Enterprise* with channel profile insert

Analysis 4

1. With 135 lit beacons over a distance of 12 nm, the channels of Otago Harbour were adequately marked. With such a large number of beacons it would not be a reasonable expectation to inspect all the lights each night, and anyway the correct operation of a light is only established at the time of the inspection and it could conceivably fail immediately afterwards.

2. The number of lights in the channel allowed for some failures without significantly affecting the safety of navigation in the channel. The reliability of the lights in areas such as the passage through the Halfway Islands and bends in the channel was more critical than in the straight sections of the channel, despite there being significant numbers of available navigation aids in those areas.

3. Other than some form of automatic monitoring system, the policy of light failures being reported by channel users was probably the most efficient method of monitoring available, but it did have limitations. When navigating through a complicated channel, a mariner may not notice one extinguished light among many lit ones. As an example, on the morning of this incident, the master passed beacon 43 which the inbound pilot later reported as extinguished, and conversely the pilot passed beacon 18A which the master later reported as extinguished. Although apparently missed by one mariner, each extinguished light was noticed by another and thus reported. Because of the availability of other light beacons nearby, neither vessel's safety was compromised.

1.8 Reliability of aids to navigation

1.8.1 A port authority determines the type and number of aids to navigation required to properly mark the channels within its harbour, and positions them accordingly. The port authority then has the responsibility to ensure that as far as practicable the aids continue to function and exhibit the appropriate characteristics.

1.8.2 Any type of equipment, mechanical or electrical, is subject to occasional failure, but those responsible for the upkeep of navigable channels should ensure that the equipment is of a high standard and that procedures are in place to repair any failures with a minimum of delay.

1.8.3 The International Association of Lighthouse Authorities (IALA) issues guidelines for the availability and reliability of aids to navigation. The guidelines recommend that lights on fixed structures or lanbys should have an availability of at least 99% and that an absolute minimum level of availability should be set at 95%.

1.8.4 IALA recognises that it is possible to provide a system of aids, say when marking a channel, that has an overall acceptable level of availability even though individual lights within that system may occasionally fall below the minimum level.

1.8.5 Availability of an aid to navigation can be calculated by dividing the total time of correct operation by the expected total time of operation. As an example, where a navigation mark was expected to operate for 1000 nights but failed for 2 nights, its availability is calculated as follows:

$$\frac{1000 - 2}{1000} = 0.998 \text{ or } 99.8\%$$

The calculation should use a sufficiently long period and should be at least 2 years.

1.8.6 Beacon 22 had been reinstated on 2 December 1997 and had one failure in February 1998 before failing on the morning of 15 March 2000. From the time of its reinstatement to the day of the incident was a period of 1199 nights and using the above formula its availability could be calculated as follows:

$$\frac{1199 - 2}{1199} = 0.998 \text{ or } 99.8\%$$

1.8.7 Beacon 24 had a new Sealite fitted on 17 January 2000 and had one failure in January 2001 before failing on the morning of 15 March 2001. From the time of fitting to the day of the incident was a period of 423 nights and although that period is shorter than required, its availability could be calculated as follows:

$$\frac{423 - 2}{423} = 0.995 \text{ or } 99.5\%$$

Analysis 5

1. If a channel is sparsely marked then each of the lights must have a high reliability, whereas if a channel is heavily marked then the failure of individual lights would not necessarily affect the safety of that channel. Otago Harbour had a total of 135 lit beacons, and individual failures, particularly if known, would not significantly reduce the availability level of the channel as a whole.

2. On the morning of this incident, the signal station was warning mariners of one extinguished light and one beacon with a temporary light. Subsequently 4 other light failures were reported. This number of failures should not normally have significantly affected the overall safety of the channel. However, of consequence was the fact that 2 adjacent lights on a bend in the channel failed at the same time, albeit for different reasons.

3. The failures caused the master's loss of situational awareness, as he mistook the more distant visible lights for the extinguished ones. Consequently he prematurely altered his course to starboard to make the turn in the channel and came close to the channel side in the vicinity of beacon 24.

4. While the failure of 2 consecutive lights on a bend in the channel, each for a different reason, could be considered as a low probability event, it is nevertheless possible. This incident serves as an important lesson to mariners to never rely on one system of navigation alone.

1.9 Pilotage and pilotage exemption

1.9.1 Pilotage was compulsory in Otago Harbour for merchant vessels over 100 gross tonnage. Vessels transiting the harbour had to engage a harbour pilot or the master had to hold a pilotage exemption certificate appropriate for the size of the ship.

1.9.2 The master of the *Spirit of Enterprise* held a pilotage exemption certificate for Otago Harbour, enabling him to pilot any ship up to 152.5 m long of which he was master. He had gained that certificate in March 1998.

1.9.3 During this investigation, enquiries were made into the requirements of pilotage and pilotage exemption and the Commission was satisfied that the master's qualification and currency met local and national legislation in force at the time. However, the enquiries raised concerns over the adequacy of the regulations and training expectations for pilots and masters in general.

1.9.4 Pilotage regulation was in a transitional phase at the time of this incident. Pilotage was formerly regulated by the Harbours Act 1950 which dealt with the appointment, licensing and employment of pilots and the issuing of pilotage exemption certificates. Under the Act, local authorities were able to make bylaws with respect to navigation and safety within the harbours under their jurisdiction.

1.9.5 The Harbours Act was repealed by section 10 of the Local Government Amendment Act (1999) (No 2). Under the Local Government Act, bylaws made under the Harbours Act continue in force until 31 March 2003 and may be amended. However, there was no power to make new bylaws.

1.9.6 On 4 November 1999 Maritime Rules Part 90 – Pilotage (Appointment of Pilots and Pilotage Exemptions) came into force. The rule was intended to provide a mechanism for the appointment of pilots and exemption of masters equivalent to that which had been in the repealed Harbours Act. The initial Rule Part 90 was a temporary measure until a more comprehensive Part 90 could be put into place. It was intended that the full Rule replace the current Rule once consultation on the new pilotage regime has been completed.

1.9.7 The various legislation detailed the requirements for candidates to be eligible to be appointed or licensed as a pilot or to be certificated as a pilot exempt master. In both cases the candidate had to be examined with regard to ship handling ability and local knowledge and, if successful, the certification was issued by the local authority. The eligibility requirements did not stipulate any minimum number of transits to be made through a harbour for either licence. The number of transits made before examination was left to the discretion of a candidate's employer or might, in some cases, have been required by local bylaw.

1.9.8 Under the transitional Rule 90, there was no provision for the certification of a pilot or exempt master to be suspended or cancelled, except that an exempt master must use the exemption on at least 2 occasions in any year for it to remain valid.

1.9.9 The new and more comprehensive Rule 90, due to come into force in April 2003, will be in 2 parts, the first dealing with pilot's qualifications and the second dealing with compulsory pilotage requirements and pilotage exemptions. The Rule is intended to clarify the anomalies left by the transitional stage of legislation. The draft consultation document recommends that pilots will have to hold a national pilot licence, which will be a maritime document subsequently endorsed by a local authority for use in its area, and that the system for licensing pilot exempt masters will change so that a ship owner will have to hold an approval under Maritime Rules Part 35 for the training, assessment and monitoring of its masters, and other officers qualified to be master, in pilotage.

1.9.10 In Otago, in common with other ports, both pilots and pilot exempt masters had to pass an examination set and examined by Otago Regional Council. The harbour pilots were licensed to pilot vessels only within Otago Harbour and were employed by Port Otago Limited

1.9.11 Although there was no regulatory minimum standard, Port Otago Limited expected trainee pilots to undertake about 120 harbour transits under the supervision and tuition of a qualified pilot before being put forward for examination and licensing. Port Otago Limited imposed its own controls by initially limiting a newly licensed pilot to smaller ships, gradually increasing the size of ships to be piloted as further experience was gained.

1.9.12 Otago Regional Council expected a master wishing to obtain a pilotage exemption to have completed 5 transits; 3 outbound and 2 inbound, under the supervision and tuition of a licensed pilot. The master was then eligible for examination on ship handling ability and local knowledge. Exemption certificates were issued to successful candidates on the basis of the length of ship and the area used for the examination. Previously a certificate was issued for vessels up to 152.5 m if the vessel used for examination exceeded 90 m, otherwise the exemption was specified for a lesser length, usually 76 m. In late 1999, examiners were instructed to issue certificates more closely linked to the actual size of the ship used for examination. A certificate could be issued to allow a master to transit as far as Port Chalmers only or right to Dunedin depending on the assessment transits undertaken.

1.9.13 Pacifica encouraged its chief mates to obtain pilotage exemptions for the ports to which they traded. Before putting them forward, Pacifica expected candidates to have worked with and been assessed regarding harbour experience by experienced exempt masters over a period of about 6 months.

1.9.14 The examining board in both cases had to consist of at least 2 officers holding certificates as master of a foreign-going vessel, one of whom must have a thorough knowledge of the harbour and its approaches for which the candidate was to be examined.

Analysis 6

1. With respect to this incident, the master was duly qualified and having made about 75 transits as exempt master without incident, the extent of his local knowledge at the time of the incident would have been reasonable.

2. The master's 75 transits of Otago Harbour were not made in succession, but were made over some considerable time with other ports and periods of leave in between. He would have built a thorough knowledge of the handling characteristics and capabilities of his own ship, but it is doubtful whether the master's local knowledge would have been as complete as that of a pilot working only in the same port for the same period of time.

3. In the wider respect, pilots must hold a foreign-going certificate of competency not lower than master, and exempt masters must hold a certificate of competency appropriate for the vessel of which they are master. Pilots are trained specifically for a port and must be capable of handling a wide variety of ship type and size. Exempt masters on the other hand would pilot only their own ship with which they should be thoroughly familiar, and although they may change ships, those were likely to be of a similar class and anyway, restricted to a certain size.

4. Common to both is the requirement for a thorough local knowledge. Under regulations current at the time, there was no minimum level of harbour experience required by the candidates for either licence to substantiate their local knowledge before being examined. While the examination process should highlight any deficiencies in a candidate, it is conceivable that a newly licensed pilot or exempt master could have inadequate local knowledge.

5. In the situation for Otago Harbour at the time, a Port Otago Limited pilot gains this knowledge through a long training process. The exempt master has possibly observed transits through the port while serving in junior ranks and may have made many more than the minimum transits as master under pilotage. However, if a candidate for pilotage exemption has only the number of transits expected by Otago Regional Council, it is questionable whether sufficient local knowledge can be gained in such a short time.

6. In any port, a large proportion of a pilot's training would be involved in learning the handling requirements, capabilities and limitations of the variety of ships expected to be piloted. The trainee would gain local knowledge as a by-product in that process apart from specific time spent doing so. Presuming that a master is capable of handling his or her own ship, any training period would involve only local knowledge.

7. If a local authority had any concerns over an individual's capabilities, it was not able to suspend or revoke a pilot or exempt master's licence. However, under the Maritime Transport Act, the Director of Maritime Safety could, under certain circumstances, require that a pilot be taken. In the same way the harbourmaster, under the Local Government Act, could require a pilot to be taken. Should there be sufficient concern, the Director of Maritime Safety could suspend or revoke a pilot or master's seagoing certificate, thereby making either piloting licence invalid.

8. Under the anticipated new Rule 90, a pilot's licence will probably become a maritime document and could be suspended or revoked by the Director of Maritime Safety. Likewise, the approval for a ship owner's masters to conduct pilotage could be withdrawn.

9. Internationally, it is becoming an accepted principle that candidates for pilotage exemption should be trained to the same base standard as harbour pilots.

2. Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

2.1 The *Spirit of Enterprise* twice took a rapid sheer to port due to bank effect when the master lost situational awareness and twice inadvertently conned the ship too close to the inside of the same bend in the channel. The second sheer resulted in contact with the channel side.

2.2 The master lost situational awareness for the following reasons:

- two consecutive light beacons on the inside of the bend had failed, unbeknown to the master
- the bridge was not adequately manned at the time of the first sheer
- the progress of the vessel was not being adequately monitored at the time of either sheer
- fatigue-related performance impairment.

2.3 From recent work patterns the master was probably suffering fatigue-related performance impairment due to acute sleep loss and cumulative sleep debt. The chief mate was likely to be suffering fatigue-related performance impairment due to extended wakefulness and cumulative sleep debt. Additionally the incident happened at a time when both men would have been close to the low point in the daily cycle of their circadian body clocks.

2.4 The master and chief mate both suffering fatigue-related performance impairment through the normal operations of the ship is an indication that, despite having leave periods equal to time at work, the crew of the *Spirit of Enterprise* might be routinely operating the ship in a fatigued state in contravention of New Zealand maritime rules.

2.5 The manning of the bridge was not consistent with good bridge resource management, and did not allow effective passage monitoring that might have alerted the master to his mistaken assessment of the position of his ship in the channel and prevented the sheers and the contact with the channel side.

2.6 The light beacons in the Otago Harbour channels had a history of reliability that conformed with the International Association of Lighthouse Authorities' guidelines. The lights that failed were adjacent to each other, of different types and developed different faults. Such a failure pattern would be considered a significantly unusual event. Had either of the beacons been lit or the master known about the double failure, the sheers and contact with the channel side would probably have been prevented.

2.7 The level of harbour experience required by candidates for pilot or pilotage exemption licences was not specified in current national legislation but left to the discretion of the employers of trainee pilots and masters, and to local authorities.

2.8 The expectations for the issue of a pilotage exemption certificate for the Otago Harbour were significantly less than those for a pilot's licence, to an extent that newly exempted masters may have insufficient local knowledge to safely conduct their own pilotage.

2.9 The master of the *Spirit of Enterprise* had conducted his own pilotage through Otago Harbour on sufficient occasions to have gained adequate local knowledge.

3. Safety Actions

3.1 Following the incident involving the *Spirit of Enterprise*, Port Otago Limited instigated a full inspection of the beacon lights in the channels. There was a particular concern that there might have been a production fault with the Sealite as the failures of beacons 24 and 43 were found to have the same cause. None of the 70 other Sealites was found to have failed in the same way.

3.2 The Marine Services Manager of Port Otago Limited issued an instruction to the senior pilot to warn other pilots of the possible problem and the need for utmost vigilance during the hours of darkness.

3.3 The Marine Services Manager of Port Otago Limited also requested the signal station operators to advise all pilot exempt masters transiting the harbour that they should:

> be aware that lighted beacons may from time to time fail and masters should maintain full situational awareness at all stages of the transit of Otago Harbour using all means at their disposal.

3.4 Port Otago Limited investigated the feasibility of an automated continuous monitoring system to cover the full length of the channels in Otago Harbour. It considered that the cost of such a system, estimated at between $600,000 and $700,000, was not warranted by the perceived risk in Otago Harbour, and did not meet the criteria established by the Maritime Transport Act 1944 of safety at reasonable cost.

3.5 Port Otago Limited instigated investigations into the feasibility of selective automated continuous monitoring systems being fitted to critical sections of the channels in Otago Harbour.

3.6 As part of the certificate upgrade training that was in progress at the time of this incident, all Pacifica masters and all but one of its deck officers completed the STCW 95 (Bridge) Upgrade Course at the New Zealand Maritime School. A place on a future course was reserved for the one outstanding officer. Bridge resource management training was included in the upgrade course.

3.7 Pacifica inserted the "Principles of Bridge Resource Management" into its Standard Practices Manual and International Safety Management Policy Manual.

3.8 All Pacifica masters and all but one of its deck officers received training in precision navigation, including simulator exercises, as part of the STCW 95 (Bridge) Upgrade Course. The one outstanding officer will complete this training when he attends the course.

3.9 Pacifica revised its Standard Practices Manual to clarify its requirements for bridge manning. The revision, dated 28.04.01, was contained in section 5.1.7 which stated:

> **Special Instructions within Harbour Limits and Harbour Limits with extended Pilotage areas**
>
> (a) While in harbour limits, the Master and the helmsman shall be stationed on the navigating bridge while the ship is underway.
>
> (b) When in extended pilotage areas (in particular the Manukau Channel from the Manukau Bar to the port at Onehunga, and Harbour of Otago from Taiaroa Heads to Leith Wharf) the bridge shall be manned by the Master, a Mate and the Helmsman.
>
> (c) During the passage the Mate will monitor the vessel's position and give the Master adequate warning if the vessel strays from the planned track.

Similar instructions were inserted into the International Safety Management Policy Manual.

3.10 To enhance and maintain the bridge team's situational awareness, Pacifica fitted electronic chart plotters to its vessels that call at Otago Harbour. The plotters included charts for the extended pilotage areas of Otago Harbour and Manukau Harbour.

3.11 Pacifica changed the operating schedule of the *Spirit of Enterprise*, alternating it and another company vessel on the east and west coast services. The new schedule resulted in a reduction of working hours and an increase in the number of nights in port. Additionally Pacifica expects that in the near future the port call in Otago Harbour will be confined to Port Chalmers only, thus reducing extended pilotage time and overall working hours.

3.12 The Otago Regional Council produced a new examination syllabus for pilotage exemption applicants. To date the new syllabus has been used for 3 examinations and is currently under review.

3.13 Maritime Rules governing pilotage were in draft form at the time of this report but are expected to address the issues of training, assessment and monitoring of pilots and pilot exempt masters.

4. Safety Recommendations

4.1 On 18 February 2002 the Commission recommended to the chief executive of Pacifica Shipping (1985) Limited that he:

4.1.1 include in the policy manuals instructions to ship's staff on how the company expects the principles of effective bridge resource management should be complied with. (083/01)

4.1.2 critically review the scheduling and manning level of all Pacifica ships, and ensure that the maritime rules for the prevention of fatigue can be complied with, and if not, take the necessary action that will enable crews to safely operate the company ships in compliance with the rules. (086/01)

4.2 On 5 March 2002, the chief executive of Pacifica Shipping (1985) Limited replied:

4.2.1 [083/01] We are in the process of revising our Policy section of our ISM system to elaborate further on how the company expects the principles of bridge resource management contained in our Fleet Procedures Manual to be complied with. We anticipate that this will be completed by the end of March.

4.2.2 [086/01] The recommended review of the scheduling and manning level on Pacifica vessels with respect to ensuring compliance with the Maritime rules relating to the prevention of fatigue has been completed and we are closely monitoring the hours of work and rest periods on a daily basis. We have also undertaken a 3 month period of review in conjunction with MSA from the beginning of February and anticipate completion by the end of May.

4.3 On 18 February 2002 the Commission recommended to the chief executive of Port Otago Limited that he:

4.3.1 introduce a documented policy where the crews of company vessels, including the pilot vessels and tugs, routinely verify the operation of the channel beacons in any area transited at night, with logbook entries to record results. (014/02)

4.3.2 maintain the requirement that the signal station operator informs masters of transiting ships of any unlit or temporarily lit beacons and also include a reminder to advise the signal station should any other beacons be discovered extinguished. (015/02)

4.3.3 conduct a cost/benefit analysis of the establishment of an automated monitoring system of the beacon lights in selected critical areas, such as major bends in the channel, of Otago Harbour, and if feasible establish a monitoring system. (016/02)

4.4 On 13 February 2002 the Marine Services Manager of Port Otago Limited replied to the Commission's preliminary safety recommendations, which remained unchanged and became final:

4.4.1 [014/02]: The existing network of reporting from Port Otago Ltd vessels with regard to light outages will be formalised through written procedure.

4.4.2 [015/02]: Signal station will continue to advise vessels transiting the harbour of known outages and of the dangers of unexpected light failures.

4.4.3 [016/02]: The practice of relying upon passing ships to report light failures is to the best of our knowledge standard industry practice in similar harbours throughout New Zealand.

Our program of upgrading all lights on the harbour has been proceeding for more than 2 years and is nearing completion.

We are actively investigating opportunities to monitor more closely the operation of the lights to compliment our comprehensive reliability monitoring and we look forward to the development of national standards for light outages and monitoring by the Maritime Safety Authority.

We are in the process of installing a camera surveillance system in the Port and Channel areas the installation of which will also enable monitoring of harbour navigation lights and the effectiveness of this will be scrutinised closely once installed."

4.5 On 18 February 2002 the Commission recommended to the chief executive of Otago Regional Council that he:

4.5.1 ensure that any new pilotage exemption certificates issued are subject to the existing size and area limitations currently applicable. (087/01)

4.6 On 12 March 2002, the chief executive of Otago Regional Council replied:

4.6.1 I advise that the Otago Regional Council supports recommendation 087/01 and that this recommendation is, and will continue as, current practice. Pilotage exemptions are specific, according to examination result, as being for Port Chalmers, Dunedin, or Port Chalmers and Dunedin. Also pilotage exemption certificates are limited as to dimension of vessel, the dimension limits being directly associated with the size of vessel the practical component of the examination was conducted on.

4.7 On 18 February 2002 the Commission recommended to the Director of Maritime Safety that he:

4.7.1 include in an advisory circular to Maritime Rule 90 minimum standards that a monitoring and currency system for pilot exempt masters must meet. (081/01)

4.8 On 22 February 2002 the Director of Maritime Safety replied:

4.8.1 This recommendation will be forwarded to the Manager, Safety and Environmental Services of MSA, for inclusion in the development process for Maritime Rule 90.

Approved for publication 05 February 2002

Hon. W P Jeffries
Chief Commissioner

Appendix A

A.1 Working times of the master as recorded in logbook

Date	Start duty	Finish duty	Hours on duty	Hours off duty	Total on duty	Total off duty	Comments from master and logbook narrative
8 March 2001				8.0			Alongside Lyttelton
	0800	1100	3.0				
				4.0			
	1500	1700	2.0				
				1.5		13.5	
	1830	2400	5.5		10.5		Depart Lyttelton for Tauranga
9 March 2001				8.0			At sea all day
	0800	1200	4.0				Bridge watch
				1.0			
	1300	1400	1.0				
				6.0		15.0	
	2000	2400	4.0		9.0		Bridge watch
10 March 2001				8.0			
	0800	1230	4.5				Bridge watch + arrive Tauranga
				2.5			
	1500	1700	2.0				Depart Tauranga for Auckland
				2.5		13.0	
	1930	2400	4.5		11.0		Bridge watch
11 March 2001				5.25			
	0515	0700	1.75				Arrive Auckland
				3.0			
	1000	1200	2.0				Depart Auckland for Lyttelton
				8.0		16.25	
	2000	2400	4.0		7.75		Bridge watch
12 March 2001				8.0			At sea all day
	0800	1200	4.0				Bridge watch
				3.0			
	1500	1700	2.0				
				3.0		14.0	
	2000	2400	4.0		10.0		Bridge watch
13 March 2001				7.5			
	0730	1200	4.5				Arrive Lyttelton
				1.0			Lunch
	1300	1600	3.0				Depart Lyttelton for Dunedin
				4.0		12.5	
	2000	2400	4.0		11.5		Bridge watch
14 March 2001				3.75			Slept 0030 to 0330
	0345	0530	1.75				Arrival Port Chalmers
				1.0			In Port Chalmers waiting to shift
	0630	0830	2.0				Shift to Dunedin
				1.5			Went for walk ashore
	1000	1200	2.0				Paperwork
				1.0			Lunch
	1300	1400	1.0				Paperwork
				3.0			Slept for 1½ to 2 hours
	1700	1900	2.0		8.75		Paperwork
				5.0		15.25	Slept from 2100
			PLUS				
15 March 2001				2.5			Awoke at 0220
	0230	0530	3.0				**Incident occurred at about 0530**

A.2 Working times of chief mate as recorded in logbook

Date	Start duty	Finish duty	Hours on duty	Hours off duty	Total on duty	Total off duty	Comments from interview and logbook narrative
8 March 2001				7.0			Alongside Lyttelton
	0700	1200	5.0				Cargowork
				2.0			
	1400	2100	7.0		12.0		Depart Lyttelton for Tauranga
				3.0		12.0	
PLUS							
9 March 2001				4.0			At sea all day
	0400	0800	4.0				Bridge watch
				0.5			
	0830	1030	2.0				Cargo paperwork
				5.5			
	1600	2000	4.0		10.0		Bridge watch
				4.0		14.0	
PLUS							
10 March 2001				4.0			
	0400	0800	4.0				Bridge watch
				3.5			
	1130	1400	2.5				Arrive Tauranga
				1.5			
	1530	2050	5.3		11.8		Depart Tauranga for Auckland
				3.2		12.2	
PLUS							
11 March 2001				4.0			
	0400	0700	3.0				Arrive Auckland
				3.5			
	1030	1130	1.0				Depart Auckland for Lyttelton
				2.5			
	1400	2000	6.0		10.0		Bridge watch
				4.0		14.0	
PLUS							
12 March 2001				4.0			At sea all day
	0400	0800	4.0				Bridge watch
				0.5			
	0830	0930	1.0				
				1.5		14.0	
	1100	1200	1.0				Fire drill
				4.0			Afternoon rest
	1600	2000	4.0		10.0		Bridge watch
				4.0		14.0	Probably 6 hours' sleep
PLUS							
13 March 2001				4.0			
	0400	1200	8.0				Arrive Lyttelton + cargo work
				1.0			Lunch
	1300	1530	2.5				Depart Lyttelton for Dunedin
				1.0			
	1630	2000	3.5		14.0		Bridge watch
				4.0		10.0	Probably 6 hours' sleep
PLUS							
14 March 2001				4.0			
	0400	1300	9.0				Arrive Port Chalmers + Dunedin
				4.5		8.5	Sleep from 1330 to 1700
	1730	2400	6.5		15.5		Cargo work
PLUS							
15 March 2001	0000	0530	5.5				Rest in cabin from 0000 to 0200
							Incident occurred at about 0530

A.3 Working times of the second mate as recorded in logbook

Date	Start duty	Finish duty	Hours on duty	Hours off duty	Total on duty	Total off duty	Comments from interview and logbook narrative
8 March 2001	*Log shows 0000 to 0800 but this previous second mate*						Alongside Lyttelton
	1000	1930	9.5		9.5		Second mate joins ship 1000
				4.5		4.5	Depart Lyttelton for Tauranga
9 March 2001	0000	0400	4.0				Bridge watch
				6.5			At sea all day
	1030	1130	1.0				Safety equipment
				0.5			
	1200	1630	4.5				Bridge watch
				0.5			
	1700	1730	0.5		10.0		Bridge meal relief
				6.5		14.0	
10 March 2001	0000	0400	4.0				Bridge watch
				7.5			
	1130	1630	5.0		9.0		Arrive + depart Tauranga for
				7.5		15.0	Auckland
11 March 2001	0000	0400	4.0				Bridge watch
				2.0			
	0600	1100	5.0				Arrive + depart Auckland for
				1.0			Lyttelton. Cargo work
	1200	1600	4.0				Bridge watch
				1.0			
	1700	1730	0.5		13.5		Bridge meal relief
				6.5		10.5	
12 March 2001	0000	0400	4.0				Bridge watch. At sea all day
				6.0			About 5 hours' sleep
	1000	1130	1.5				Safety equipment
				0.5			Lunch
	1200	1600	4.0				Bridge watch
				1.0			
	1700	1730	0.5		10.0		Bridge meal relief
				6.5		14.0	About 3 hours' sleep
13 March 2001	0000	0400	4.0				Bridge watch
				4.0			About 3 hours' sleep
	0800	1000	2.0				Arrive Lyttelton
				2.0			
	1200	1700	5.0		11.0		Depart Lyttelton for Dunedin
				7.0		13.0	Slept 1830 to 2330
14 March 2001	0000	0530	5.5				Bridge watch + Port Chalmers
				2.0			Lying down in cabin
	0730	0830	1.0				Arrival Dunedin
				3.5			Went for a run + coffee. No sleep
	1200	1800	6.0		12.5		Cargo work
				6.0		11.5	About 3½hours' sleep
15 March 2001	0000	0530	5.5				**Incident occurred at about 0530**