Report 99-211

petroleum products tanker *Kakariki*

near grounding

Victoria Channel, Port Otago

23 September 1999

Abstract

On Thursday, 23 September 1999, at about 0703, the coastal tanker *Kakariki* was outbound from Dunedin with 19 crew, 2 supernumeraries, one harbour pilot and one trainee harbour pilot on board. The vessel was proceeding down Victoria Channel in the upper harbour of Port Otago at between 6 and 7 knots when it took a sudden sheer to port. The bridge team was able to counteract the sheer just short of the vessel running aground, realign it in the channel, and complete the outbound passage without further incident. There were no injuries and the vessel suffered no damage.

Safety issues identified included:

- the resources used to determine the feasibility of larger vessels transiting Otago Harbour
- the timing and validity of the findings of a risk assessment commissioned by the operator
- the level of corrective action taken by the operator based on the findings of the risk assessment
- the suitability of vessels with similar dimensions to the *Kakariki* transiting the upper harbour
- the level of communication, planning and dissemination of information between all parties involved in the operation.

Safety recommendations were made to the port company, operator and charterer of the *Kakariki* to address the safety issues.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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urtesy of Iain Lovie

Kakariki

Contents

Figures

List of Abbreviations

ARPA	automatic radar plotting aid
DGPS	differential global positioning system
ECDIS	electronic chart display and information system
GMDSS	global maritime distress and safety system
GPS	global positioning system
ISM Code	International Safety Management Code
kW	kilowatt(s)
m	metre(s)
m^3	cubic metre(s)
NZST	New Zealand Standard Time (UTC + 12 hours)
PIANC	Permanent International Association of Navigation Congresses
t	tonne(s)
UTC	universal time (co-ordinated)
VMS	voyage management system

Glossary

abeam	direction at right angles to the length of a ship
aft	rear of the vessel
amidships	middle section of a vessel, mid length
aweigh	when an anchor is broken out of the ground and the cable is vertical
ballast	weight, usually sea water, put into a ship to improve stability
beam	width of a vessel
bollard pull	measure of the static pull a tug can exert
bridge	structure from where a vessel is navigated and directed
by the head	said of a ship when its draught forward is greater than its draught aft
chart datum	zero height referred to on a marine chart
class	category in classification register
command	take over all responsibility for the vessel
con	direct the course and speed of a ship
deadweight	total weight of cargo, stores, fuel and ballast carried by a ship
draught	depth in water at which a ship floats
ebb tide	falling tide
even keel	draught forward equals the draught aft
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
leeway	allowance applied to the course steered to counteract the effect of wind
pivot point	imaginary point around which a vessel turns under helm
port	left-hand side when facing forward
quarter	that part of a ship between the beam and the stern
sounding	measure of the depth of a liquid
spring tide	period of highest and lowest tides in a lunar cycle
starboard	right-hand side when facing forward
supernumerary	non-fare-paying passenger
trim	difference between the forward and aft draughts of a floating vessel

Data Summary

Vessel particulars:

Name:	*Kakariki*
Type:	petroleum products tanker
Classification:	Lloyds Register of Shipping
Class:	VII foreign going cargo vessel (SOLAS)
Length overall:	183 m
Breadth (extreme):	32.54 m
Summer draught:	12.59 m
Summer displacement:	58 640 t
Gross tonnage:	27 795 t
Deadweight:	46 724 t
Cargo capacity (98% full):	46 697 m³
Construction:	steel, double hull
Built:	Stocznia Szczecinska S.A. Poland, delivered February 1999
Propulsion plant:	one 8840 kW, 2 stroke Sulzer 6RTA 52u diesel engine, driving a single fixed-pitch propeller
Service speed:	14.5 knots
Manoeuvring aids:	one 1300 kW bow thruster Schilling rudder
Owner:	Penagree Limited
Operator:	Silver Fern Shipping Limited
Charterer	Coastal Tankers Limited
Registry:	Wellington

Persons on board:	crew:	19
	supernumeraries:	2
	pilots:	2

Injuries:	nil
Damage:	nil
Location:	Victoria Channel, Otago Harbour
Date and time:	Thursday, 23 September 1999, at about 0703[1]
Investigator-in-charge:	Captain W A Lyons

[1] All times in this report are in New Zealand Standard Time (Universal Time Co-ordinated + 12 hours) and are expressed in the 24 hour mode.

1. Factual information

1.1 History of voyage

1.1.1 The *Kakariki* anchored off Otago Harbour on the evening of Monday, 20 September 1999, having completed a voyage south from Lyttelton. On board was 22 400 t of petroleum products for discharge at the Oil Wharf in Dunedin. The arrival draught was 7.5 m forward and 7.9 m aft. On board were 19 crew and 2 supernumeraries.

1.1.2 At 0845 on Tuesday, 21 September 1999, the bridge gear was tested and found to be operating correctly. By 1003 the anchor was aweigh and the acting chief harbour pilot (the pilot) for Port Otago Limited (the port company) boarded the *Kakariki*, accompanied by a trainee senior pilot (the trainee).

1.1.3 When the pilot and the trainee arrived on the bridge, the master gave them a pilot card which listed the relevant manoeuvring and arrival particulars for the *Kakariki*. In return, the pilot gave the master a standard port company passage plan for the transit of the harbour. The pilot and master agreed that the trainee would con the vessel up the channel under the pilot's supervision, and that the pilot would take over the con for berthing the vessel.

1.1.4 The master, chief officer, pilot and trainee then discussed the inward passage, in particular the underkeel clearance and speed for the approach to Port Chalmers and the transit of Halfway Islands and Victoria Channel. They also discussed the berthing details regarding the positioning of the tugs and swinging the vessel off the Dunedin wharves. (See Figure 1.)

1.1.5 The pilot and master discussed a recent decision made by Silver Fern Shipping Limited (the operator) to have an escort tug in attendance for the passage from Port Chalmers to Dunedin and vice versa. The pilot advised the master that the harbour tug *Karetai* would meet them at Port Chalmers to provide the escort. The pilot and master agreed that the tug would not be made fast for the inward transit of Halfway Islands, or for the transit of Victoria Channel until the *Kakariki* reached Ravensbourne Wharf.

1.1.6 The inbound passage went without incident. The *Karetai* met the *Kakariki* at Port Chalmers and escorted it through Halfway Islands without making fast. The *Karetai* then followed the *Kakariki* up Victoria Channel. At Ravensbourne Wharf it was joined by the second harbour tug the *Rangi*. Both tugs were made fast to assist with swinging and berthing the vessel. At 1227, the *Kakariki* was secured port side alongside the Oil Wharf at Dunedin.

1.1.7 During the inward passage the average speed of the *Kakariki* for the transit of Victoria Channel was about 7.5 knots.

1.1.8 The discharge of cargo commenced at 1440 and was completed at 2102 on Wednesday, 22 September 1999. The *Kakariki* lay alongside the Oil Wharf for the night, awaiting daylight for departure. The sailing time was posted for 0630 the next day. The departure draught was 5.76 m forward and 6.12 m aft.

1.1.9 At 0530 the first officer, who was on board for familiarisation training, tested the bridge equipment in preparation for sailing. The only deficiency he found was a fault with the port radar. The master arrived on the bridge at 0600. The first officer reported the fault with the port radar to the master. The chief officer, meanwhile, was in the cargo control room checking the final ballast figures and completing the paperwork to go ashore before departure.

1.1.10 At 0617 the duty engineer turned the main engine on air as part of the pre-sailing checks. The chief officer arrived on the bridge shortly afterwards where he and the master discussed the malfunction of the port radar and various aspects of the departure.

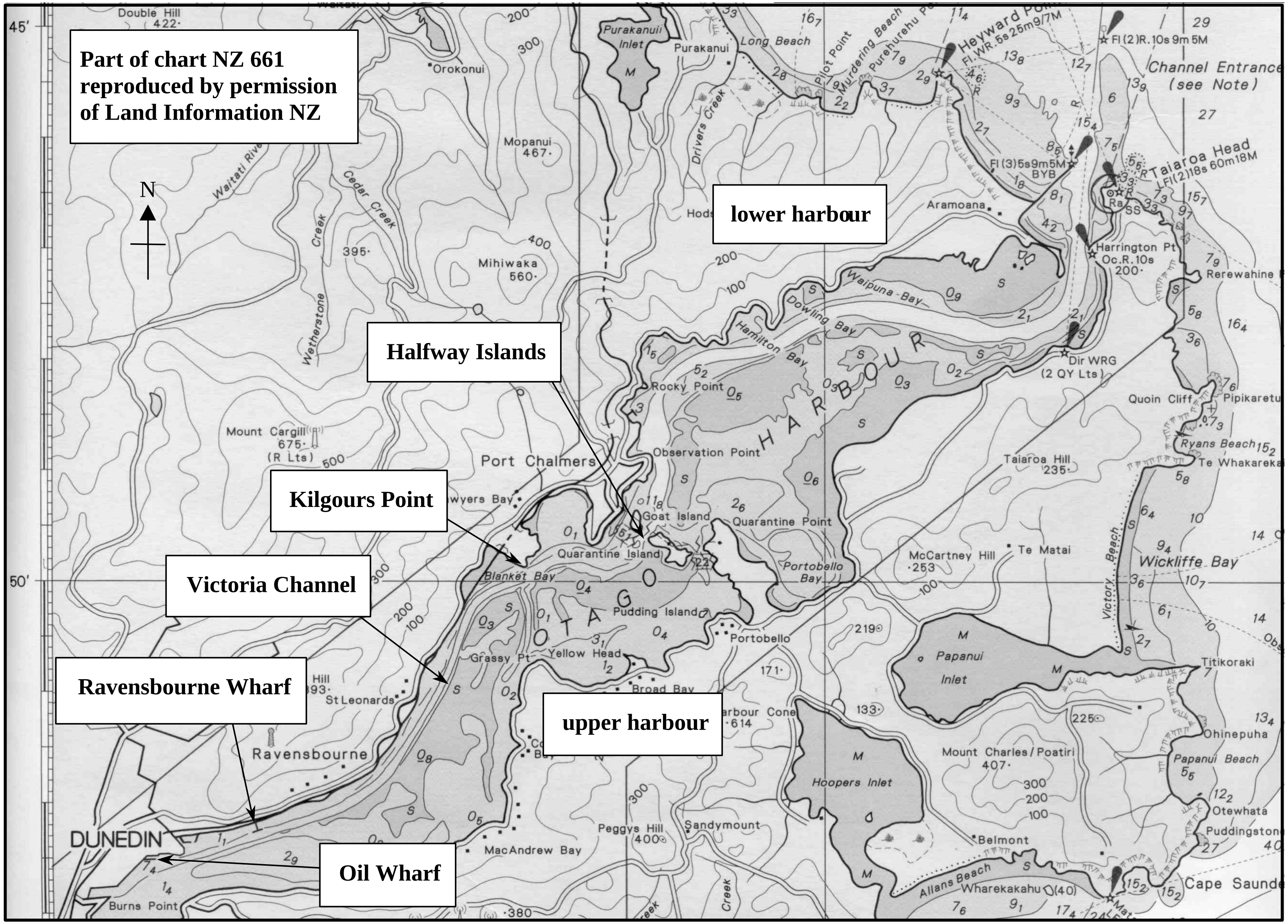


Figure 1
Part of chart NZ 661 showing Otago Harbour

1.1.11 At about 0626 the same pilot and the trainee returned to the *Kakariki*, checked the departure draught and joined the master and chief officer on the bridge. The pilot and master agreed that the trainee would have the con of the vessel for the departure, under the supervision of the pilot. They also agreed that the *Karetai* would be made fast only for the transit of Halfway Islands.

1.1.12 The pilot then asked the trainee to lead the exchange of information for the departure. The trainee discussed with the master and chief officer how he intended to manoeuvre the vessel off the berth and the passage plan for the transit of the harbour. The trainee gave the master a copy of the passage plan and the master gave the trainee the pilot card containing the updated information for the departure, and the completed pre-sailing checklist.

1.1.13 At 0631, when all parties were satisfied with the exchange of information, the engine was put on stand by and engine control was transferred to the bridge. The crew stationed forward and aft commenced to single up the mooring lines. The *Karetai* was standing by to assist if required and to escort the *Kakariki* down the channel.

1.1.14 The bridge was manned by the master, chief officer, helmsman, pilot and trainee. The chief officer was using the control station on the port bridge wing to operate the engine, bow thruster and helm, to the trainee's instructions. The master was on the port bridge wing overseeing the departure operation and communicating with the crew forward and aft.

1.1.15 At 0641 the last line was let go and the vessel was manoeuvred clear of the wharf using 65 degrees of port helm on the rudder, dead slow ahead on the engine and 50% starboard thrust on the bow thruster.

1.1.16 When the vessel was about 30 m off the wharf, the trainee requested that the chief officer switch the controls to the wheelhouse. The trainee then ordered the helm to amidships and the bow thruster to zero thrust. At this point the helmsman took over the steering.

1.1.17 The *Kakariki* was equipped with a Schilling rudder. This type of rudder was capable of turning to an angle of 65 degrees in either direction. When the helmsman was steering he was under instructions that when given an order of hard to port or starboard he was to limit the rudder angle to 35 degrees either side, unless told otherwise.

1.1.18 As the sun was low in the sky ahead of the vessel the chief officer pulled the sun screen blinds down across the wheelhouse windows. He then positioned himself at the starboard voyage management system (VMS) display. From this position he could monitor the display, the helm and the chart as well as operate the engine and bow thruster controls. The person monitoring the VMS was responsible for observing the speed of the vessel from the water track display and periodically calling it out to keep the bridge team informed.

1.1.19 When the *Kakariki* was lined up with the channel the trainee advised the chief officer that he could "secure the bow thruster". The chief officer consulted the master and they decided to leave it running, as was the usual practice when in pilotage waters. The speed of the vessel was observed to be 2 knots at that time.

1.1.20 The pilot advised the trainee to increase the speed of the *Kakariki* in order to maintain good steerage as the vessel entered the channel. The trainee ordered slow ahead on the engine at 06:46:30 and half ahead at 06:50:30. The vessel was in the middle of the channel abeam of number 67 beacon at 0652 when the speed was observed to be 3.5 knots, and increasing. The chief officer continued calling out the speed of the vessel periodically. (See Figure 2.)

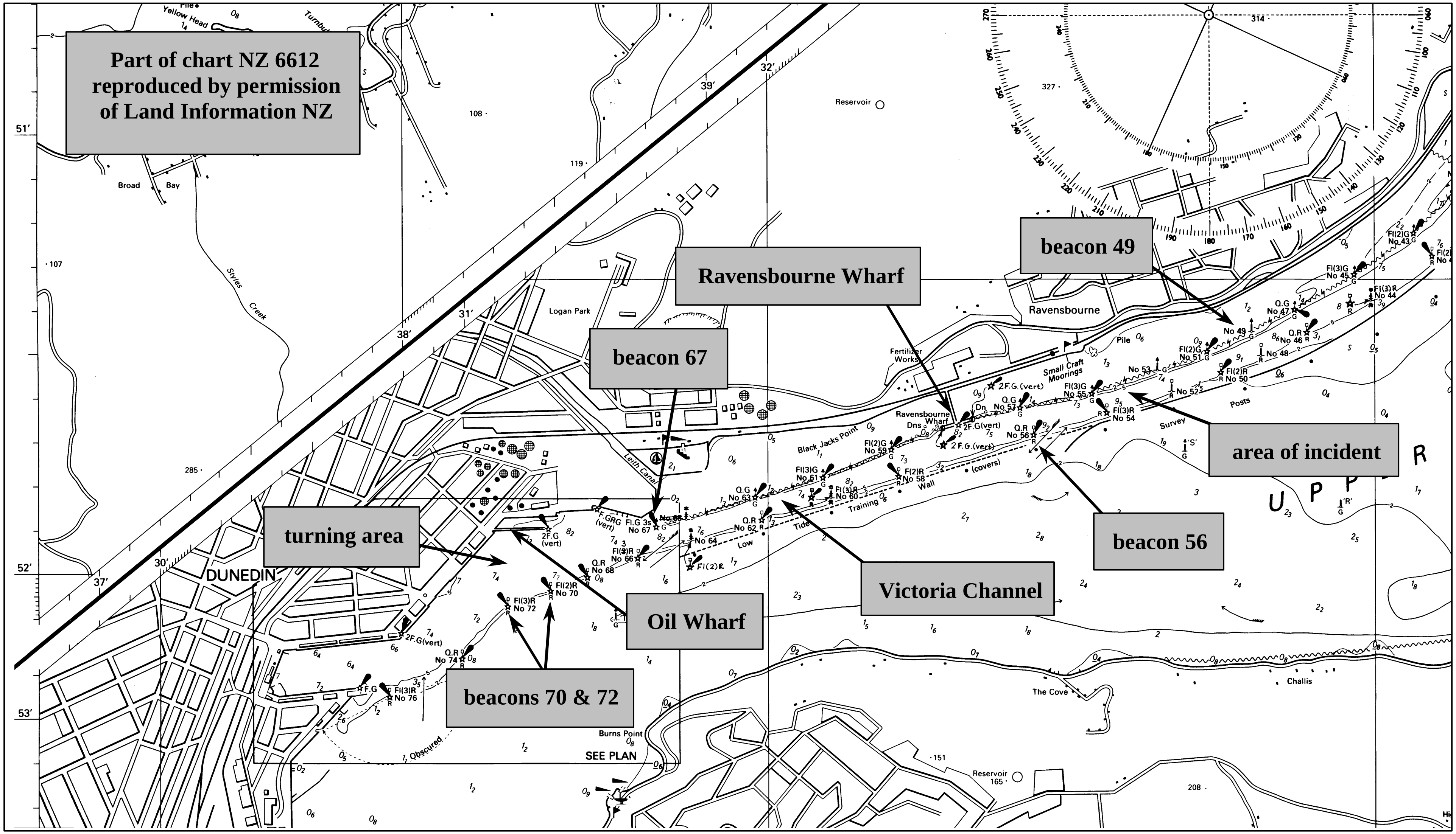


Figure 2
Part of chart NZ 6612 showing Dunedin Wharves and Victoria Channel in the vicinity of the incident

1.1.21 The helmsman was initially steering to helm orders given by the trainee. When the vessel was on the required course, the helmsman was requested to steer that course. When the *Kakariki* was in the vicinity of beacon 63 the helmsman was instructed to steady on a course of 072 degrees true.

1.1.22 Just before the *Kakariki* reached Ravensbourne Wharf the speed had increased to about 5.5 knots. The master went to the port wheelhouse door to check the height of the quarter wave that the vessel was making. The wave was building up so he recommended to the pilot that they should slow down to avoid too much wash on the shoreline.

1.1.23 The pilot reminded the trainee that the engine was on half ahead, which the trainee acknowledged. The vessel then proceeded for about 30 seconds before the pilot again remarked to the trainee that the speed needed to be reduced. The pilot then ordered slow ahead on the engine himself. This instruction was timed at 0658. The chief officer recalled that the *Kakariki* was abeam of Ravensbourne Wharf at a speed of 6.8 knots. The helmsman was at that time using 15 to 20 degrees of starboard helm to maintain his given course of 072 degrees true, but he did not inform the bridge team of this fact.

1.1.24 The chief officer went to the starboard side of the bridge where he observed that beacon 56 was closer than he had expected. He reported this to the pilot, trainee and master. The trainee immediately ordered 5 degrees of port helm to try and ease the vessel back to the centre of the channel. The master took up position at the starboard VMS monitor and the chief officer proceeded onto the starboard bridge wing to call out the distance off as the stern passed the beacon. The beacon was abeam of the bridge wing about 10 m from the hull and closing. By the time the stern cleared the beacon the chief officer estimated that the distance may have reduced to about 5 m.

1.1.25 The pilot had proceeded out to the starboard bridge wing to observe the beacon for himself. As the stern cleared the beacon the *Kakariki* took a sudden sheer to port. The chief officer and pilot hurried back into the wheelhouse, just as the trainee ordered 20 degrees of starboard helm to try and arrest the sheer. The master countermanded this order and ordered the helm hard to starboard (65 degrees), the engine to full ahead and the bow thruster to 100% starboard thrust. This was timed at 07:01:10 on the engine room data logger.

1.1.26 The pilot proceeded to the port side wheelhouse door in order to get a better view of the port side of the channel and ordered the helm to amidships and the engine to slow astern; this was timed at 07:01:34. He then ordered an increase to half astern at 07:01:38, followed by full astern at 07:01:52. The master concurred with this action and did not intervene.

1.1.27 The pilot asked the trainee to contact the skipper of the *Karetai*, which was close astern, and instruct him to make the tug fast to the *Kakariki* through the centre lead aft. This request was passed to the tug skipper who manoeuvred the tug into position, but there were no crew members at the stern of the *Kakariki* to take the tow line. They had been contacted by radio but had not arrived at the stern. Consequently, the tug was not made fast and provided no assistance.

1.1.28 The astern movements on the engine slowed the forward momentum of the *Kakariki* and the bow thruster began to take effect. The pilot requested the engine be stopped at 07:02:44 and put on slow ahead at 0703. With further helm orders and use of the bow thruster the vessel was realigned in the channel and continued the outward passage, passing beacon 49 at 0707.

1.1.29 The master had noted that the *Kakariki* was on a course of 072 degrees true before it sheered to port and that the heading reached 055 degrees true before the swing was arrested. With the heading on 055 degrees true the master recalled that the bow was pointing midway between beacons 55 and 53. (See Figure 3.)

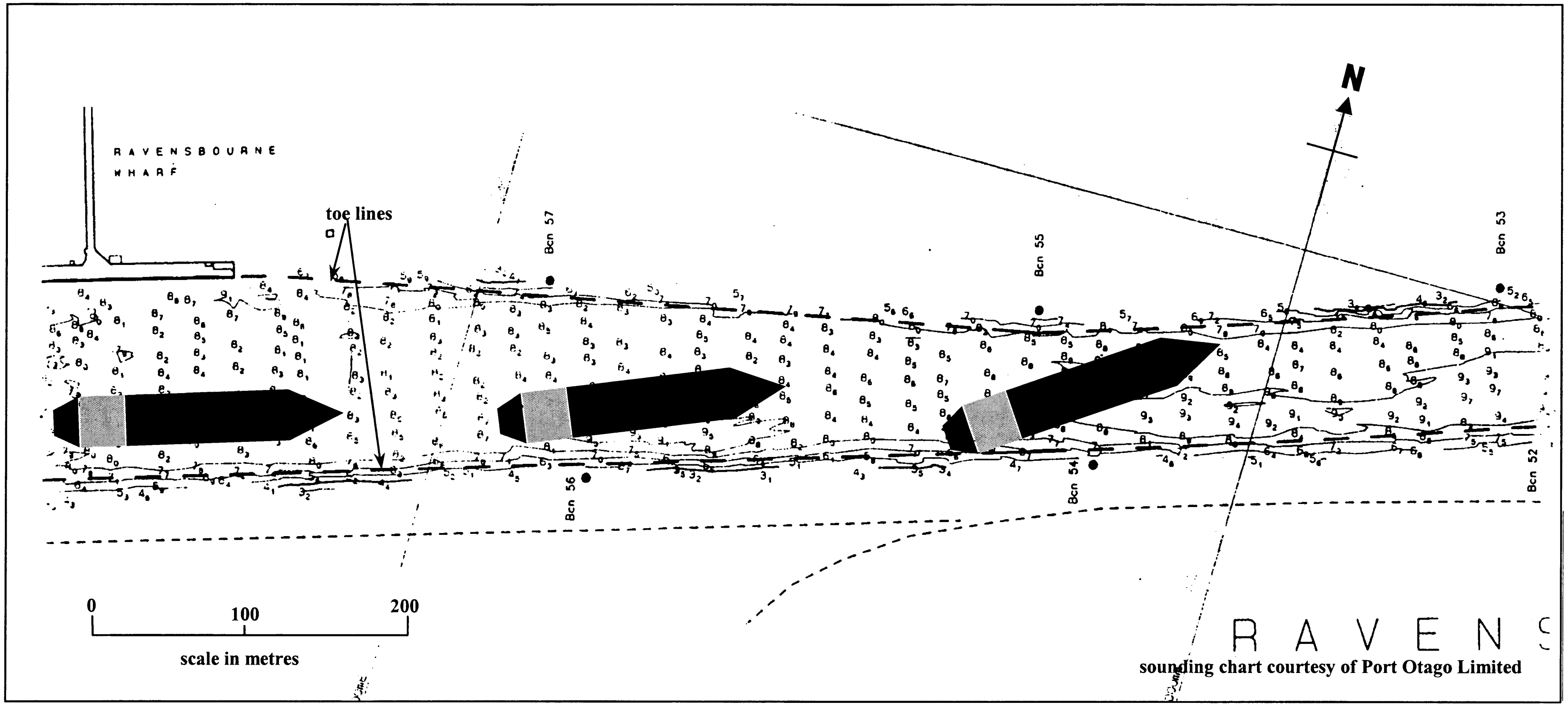


Figure 3
Diagram showing the probable track of the *Kakariki* in Victoria Channel

1.1.30 Shortly after the incident when the vessel was again proceeding down Victoria Channel the master had a brief discussion with the pilot and chief officer. He informed the pilot that he considered the incident a near miss due to bank effect and that he would be reporting it to the operator. The pilot agreed and told the master that he would report it to the port company.

1.1.31 The *Karetai* followed the *Kakariki* down Victoria Channel and made fast through the centre lead aft at 0729 off Kilgours Point for the transit of Halfway Islands. The *Kakariki* passed Halfway Islands at 0741 and subsequently released and dismissed the tug at Port Chalmers.

1.1.32 The remainder of the outward passage went without incident. The pilot conned the vessel down the remainder of Victoria Channel and through Halfway Islands. The trainee took over the con for the transit of the lower harbour.

1.1.33 The *Kakariki* passed Taiaroa Head at 0824. The pilot and trainee disembarked at 0832 and the vessel commenced the passage to Marsden Point. From the position of the incident to Taiaroa Head the speed of the *Kakariki* averaged about 8.2 knots.

1.1.34 The operator's technical manager was travelling on the *Kakariki* as a supernumerary for a familiarisation trip. He was stationed in the engine control room with the chief and second engineers for the departure from Dunedin. At 0910 the technical manager informed the master that he thought the vessel had grounded as he and the chief engineer had felt 2 "bumps" in the engine room. They had logged the times of the "bumps" at 07:02:56 and 07:03:15.

1.1.35 The master discussed the possibility that the *Kakariki* may have grounded with the chief officer and other crew members, none of whom thought that the vessel had grounded. The master requested that the tanks be sounded as a precaution. The soundings concurred with those taken before departure.

1.1.36 In light of this new information the master notified the Maritime Safety Authority, the operator and the pilot that the *Kakariki* may have grounded during the incident.

1.1.37 The *Kakariki* continued on its voyage to Marsden Point without further incident where it loaded for Wellington. On 29 September 1999, while the vessel was in Wellington, divers inspected the hull and found no obvious signs that the vessel had touched the bottom or the channel sides during the departure from Dunedin.

1.2 Weather and tidal information

1.2.1 The weather at the time of the incident was light variable winds, calm sea and clear skies.

1.2.2 Sunrise at Dunedin on 23 September 1999 was at 0627.

1.2.3 On 23 September 1999, high tide at Dunedin was predicted for 0151 at a height of 1.9 m above chart datum and low tide was predicted for 0835 at a height of 0.2 m above chart datum.

1.2.4 At the time of the incident the height of the tide was about 0.4 m above chart datum, giving an average depth of water in the area of the incident of about 9.1 m. In this depth of water the *Kakariki* had an underkeel clearance of about 3 m.

1.2.5 The incident occurred about 90 minutes before the predicted time of low water. In the main, tidal streams in Victoria Channel tend to flow parallel to the direction of the channel at rates up to about 2.5 knots. At the time of the incident the tide was on the last of the ebb and the flow was reported as minimal.

1.3 Vessel information

1.3.1 The *Kakariki* was owned by Penagree Limited, bareboat chartered by Coastal Tankers Limited and operated by Silver Fern Shipping Limited. The charterer was responsible for the organisation of the cargoes and commercial aspects of the operation, while the operator was responsible for the general running and manning of the vessels.

1.3.2 In 1998, the charterer decided to obtain a new tanker to replace an existing vessel in its fleet. It wanted the replacement vessel to be of a standard design that would be as flexible as possible with regard to port utilisation and product carrying capability. The *Kakariki* was the last of 5 sister ships being built in Poland at the time.

1.3.3 After completion the *Kakariki* was manned by another management company for about 3 months. The New Zealand crew joined while the vessel was in Japan in April 1999.

1.3.4 The *Kakariki* was a double-hull oil tanker, 183 m long with an extreme breadth of 32.54 m. Vessels of this breadth were known as Panamax class vessels, as they were built to the maximum breadth allowable to transit the Panama Canal.

1.3.5 Propulsion was by a single, 8840 kW, 2 stroke Sulzer 6RTA 52u reversing diesel engine driving a single right-handed, fixed-pitch, 4-bladed propeller. The service speed was 14.5 knots.

1.3.6 The manoeuvring speeds as detailed on the pilot card were as follows:

engine order	rpm	speed (knots)	
		loaded	ballast
full ahead	90	11	12.5
half ahead	77	8	9.3
slow ahead	53	5	6.6
dead slow ahead	37	3	3.4

The astern power was 70% of the ahead power at the same rpm.

1.3.7 The *Kakariki* was fitted with a Schilling rudder. The design of this type of rudder and its ability to operate at angles of up to 65 degrees each way had the effect of deflecting the propeller slip stream up to 90 degrees to the fore and aft line of the vessel. The resultant thrust had virtually the same effect as a stern thruster. When the log speed of the *Kakariki* reached 8 knots the rudder angle was automatically limited to 35 degrees each side. The steering gear was capable of moving the rudder from 35 degrees to port to 35 degrees to starboard in 14 seconds.

1.3.8 The *Kakariki* was fitted with a 1300 kW bow thruster which was capable of producing about 22 t of thrust. By operating the bow thruster and rudder together the vessel could be made to move sideways when manoeuvring at slow speed.

1.3.9 The *Kakariki* had 22 cargo tanks giving a total capacity of 46 697 m^3 when 98% full. It also had 10 segregated ballast tanks which had a total capacity of 20 107 m^3. The vessel was capable of carrying crude oil, petroleum products and bitumen.

1.3.10 The bridge equipment included:

- one Plath magnetic compass
- one Anshutz gyro compass with repeaters
- one 10 cm Racal/Decca Bridgemaster automatic radar plotting aid (ARPA) radar (starboard)

- one 3 cm Racal/Decca Bridgemaster ARPA radar (port)
- one Elac echo sounder and recorder
- one Trimble differential global positioning system (DGPS) receiver
- one Litton Marine electronic chart display and information system (ECIDS)
- one Siemens course recorder
- one Sailor global maritime distress and safety system (GMDSS)
- one Norcontrol engine movement log
- one Andaraa anemometer
- one Anshutz rate of turn indicator
- one speed/distance indicator.

The gyro compass had no error and the repeaters were all aligned with the master compass.

1.3.11 The *Kakariki* was equipped with a VMS. This consisted of 2 monitors that were capable of displaying either course and speed information for use when the vessel was on passage, or conning information for use when the vessel was in confined waters. Information was collated from a number of sources and displayed on the monitor screens.

The conning display information included:

- gyro heading
- course over ground
- waypoint information
- engine revolutions
- rate of turn
- required rate of turn
- rudder angle
- true wind
- relative wind
- depth of water
- water speed
- ground speed.

1.3.12 On each bridge wing was a control station from which the engine, helm and bow thruster could be operated. Above each wheelhouse door, facing the bridge wings, were helm and engine revolution indicators.

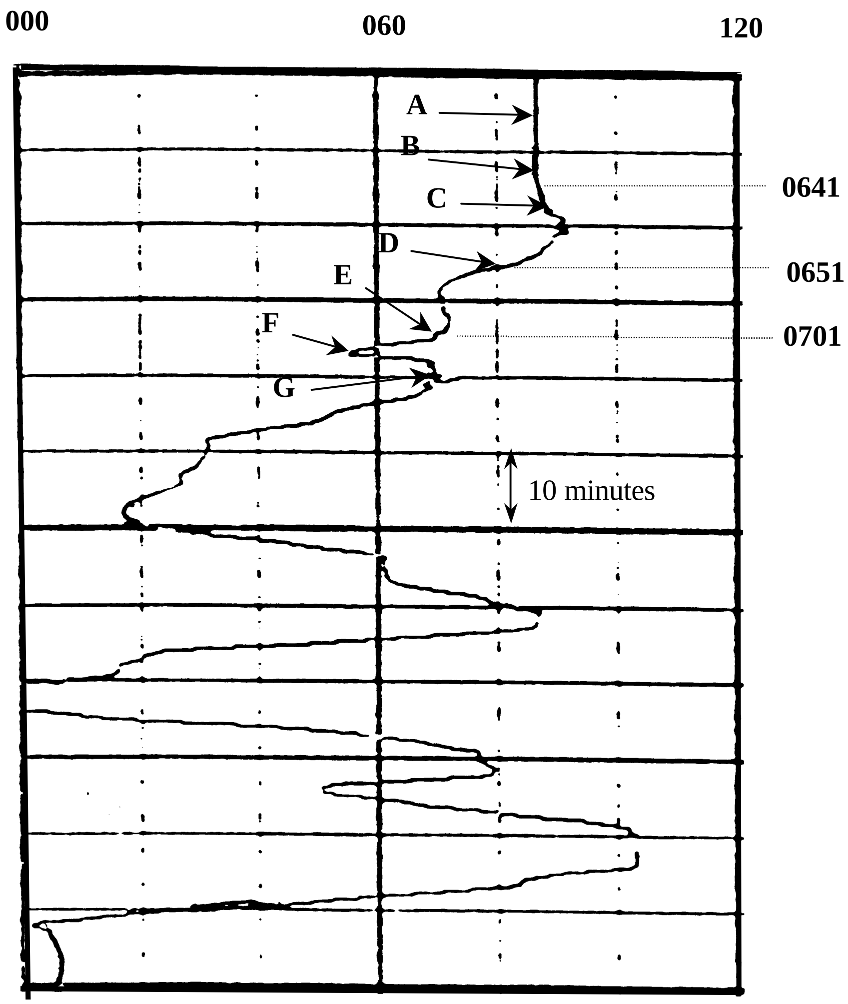
1.3.13 The bridge of the *Kakariki* was modern, well appointed and spacious. The wheelhouse was about 13 m wide and the distance from each door to the extremity of the bridge wing was about 10 m. Looking forward there was an uninterrupted view over the fore-part of the vessel.

1.3.14 The *Kakariki* was operating under the International Safety Management (ISM) Code. It had been issued with an Interim Safety Management Certificate that was valid until 6 October 1999. The operator had been issued with a Document of Compliance that was valid until 1 September 2002. Both documents were issued by Lloyds Register of Shipping.

1.3.15 The *Kakariki* had called at Dunedin previously in July and August. The master for the incident trip was not on board on either occasion. The speed of the vessel, averaged over the 4 previous transits of the harbour from Taiaroa Head to beacon 67, was about 8.7 knots. The average speed between Kilgours Point and Ravensbourne Wharf was about 7.5 knots. All 4 transits were made under similar but not identical conditions, without incident.

1.4 Course recorder

1.4.1 The relevant section of the course recorder trace was obtained and later analysed (See Figure 4). The trace was not referenced to either NZST or UTC but the relevant section of the trace was able to be identified. By assuming that the vessel commenced to swing to starboard at 0641 when the last line was let go, the times were inserted as shown in Figure 4. The trace below indicates the true heading of the vessel at various stages of the incident.



position	occurrence
A	*Kakariki* port side alongside the Oil Wharf
B	let go last line
C	*Kakariki* swings to starboard manoeuvring off berth
D	abeam of beacon 67
E	*Kakariki* steering 072 degrees true takes sheer to port
F	*Kakariki* heading 055 degrees true before sheer is arrested
G	*Kakariki* realigned with the channel

Figure 4
The course recorder trace

1.5 Personnel information

1.5.1 The pilot was 44 years old and had commenced his sea-going career in 1972, he gained a master foreign going certificate in 1982 and was employed by a number of shipping companies in various capacities until 1993, when he was employed by the port company as tug master/relieving pilot. He gained his pilot's licence in 1994 and was promoted to acting chief pilot in March 1999.

1.5.2 The pilot had piloted the *Kakariki* on all 5 of its previous transits of the harbour.

1.5.3 The trainee was 62 years old and had commenced his sea-going career in 1952 as ordinary seaman, he completed an apprenticeship in 1957, and gained a master foreign going certificate in 1968. He was employed by a number of shipping companies in various capacities including about 7 years as master. He also spent 2 years as tug mate/relieving skipper for the Otago Harbour Board and was a pilot in Australia for 12 years before being employed by the port company as a trainee senior pilot on 6 September 1999. Since commencing his training the trainee had accompanied other pilots on about 16 transits of Otago Harbour to familiarise himself with the harbour and the port company procedures.

1.5.4 The master of the *Kakariki* was 50 years old and had commenced his sea-going career in 1966 as an apprentice. He gained a master foreign going certificate in 1979 and joined Union Steam Ship Company of New Zealand Limited in 1970. He had sailed mainly on coastal tankers in various capacities since. The management of the coastal tankers had changed several times over the years. The master remained employed through each change of management. He was promoted to master in 1994 and had commanded 4 different coastal tankers since. He took command of the *Kakariki* in April 1999 in Japan, and completed the delivery voyage and the first 3 months in service. After taking leave he had been back in command of the *Kakariki* for about 4 weeks before the incident.

1.5.5 The chief officer was 42 years old and had commenced his sea-going career as apprentice in 1974 and obtained a master foreign going certificate in 1984. He was employed by a number of shipping companies in various capacities before spending 12 years as lecturer at a nautical college. He returned to sea with the operator in 1996. He joined the *Kakariki* in Japan, initially as first officer for the delivery voyage and then chief officer for a further 8 weeks before taking leave. He had been back on the *Kakariki* for 2 weeks before the incident.

1.5.6 Both the master and chief officer had visited Dunedin on several occasions aboard other coastal tankers but this was the first time for both of them on board the *Kakariki*. On previous visits they had both worked with the pilot.

1.5.7 The helmsman commenced his sea-going career as deck boy in 1971. He had remained at sea since, sailing as able seaman and then integrated rating. He had joined the *Kakariki* in Japan and had been helmsman on at least 6 other occasions. The outward bound transit was the first time he had steered the vessel in Otago Harbour.

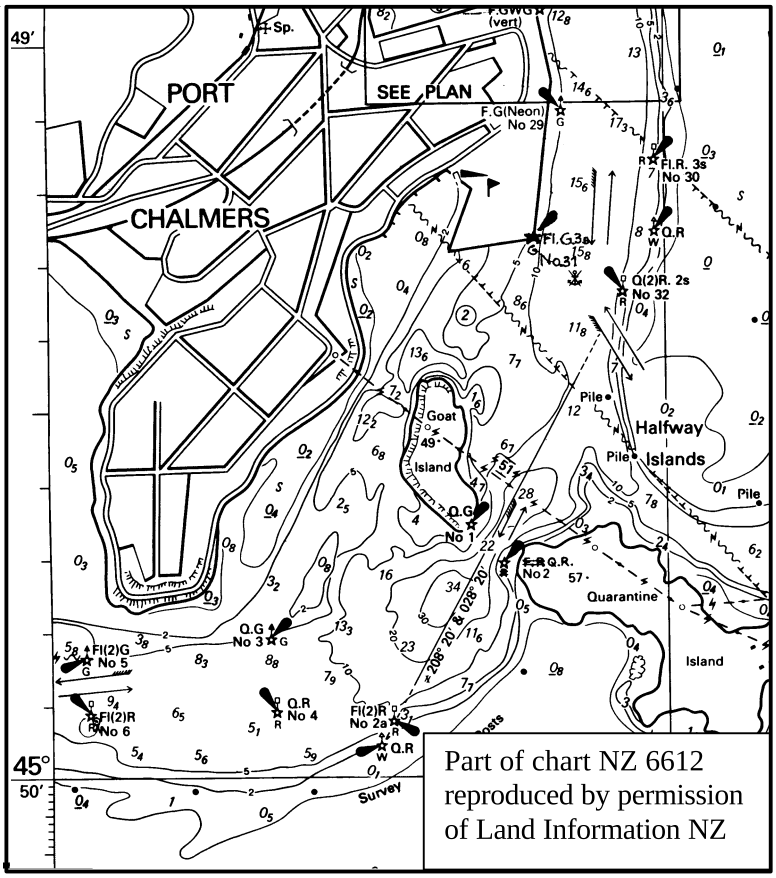
1.5.8 The pilot, master and chief officer had all attended a bridge resource management course.

1.5.9 All personnel spoken to stated that they were not tired or fatigued at the time of the incident, which was supported by their work/sleep history.

1.6 Port information

1.6.1 Otago Harbour consisted of a dredged channel about 12 miles 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.

1.6.2 At its narrowest point the cut between Goat and Quarantine Islands is about 95 m wide, measured between the toe lines[2]. The depth of water in the immediate vicinity of the cut increased to about 28 m on the north side and 34 m on the south side. The channel bottom and sides in this vicinity are rock. (See Figure 5.)



Part of chart NZ 6612 reproduced by permission of Land Information NZ

Figure 5
Part of chart NZ 6612 showing Halfway Islands

1.6.3 From Halfway Islands to Dunedin the channel was named Victoria Channel, which was about 6 miles long and was dredged to a minimum depth of 7.3 m. The bottom and sides in the channel consisted mainly of sand, mud and clay. Both sides of Victoria Channel were marked by spar beacons, most of which were lit.

1.6.4 The distance measured between the toe lines on each side of the upper section of Victoria Channel varied from a minimum of about 73 metres in the vicinity of beacon 38 to a maximum of about 130 m off Ravensbourne Wharf. For the majority of the channel the distance between the toe lines was less than 80 m.

1.6.5 The distance between the toe lines in the vicinity of beacon 55, where the incident occurred, was about 76 m and the depth across the channel, as indicated on the sounding chart, averaged about 8.7 m. (See Figure 6.)

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

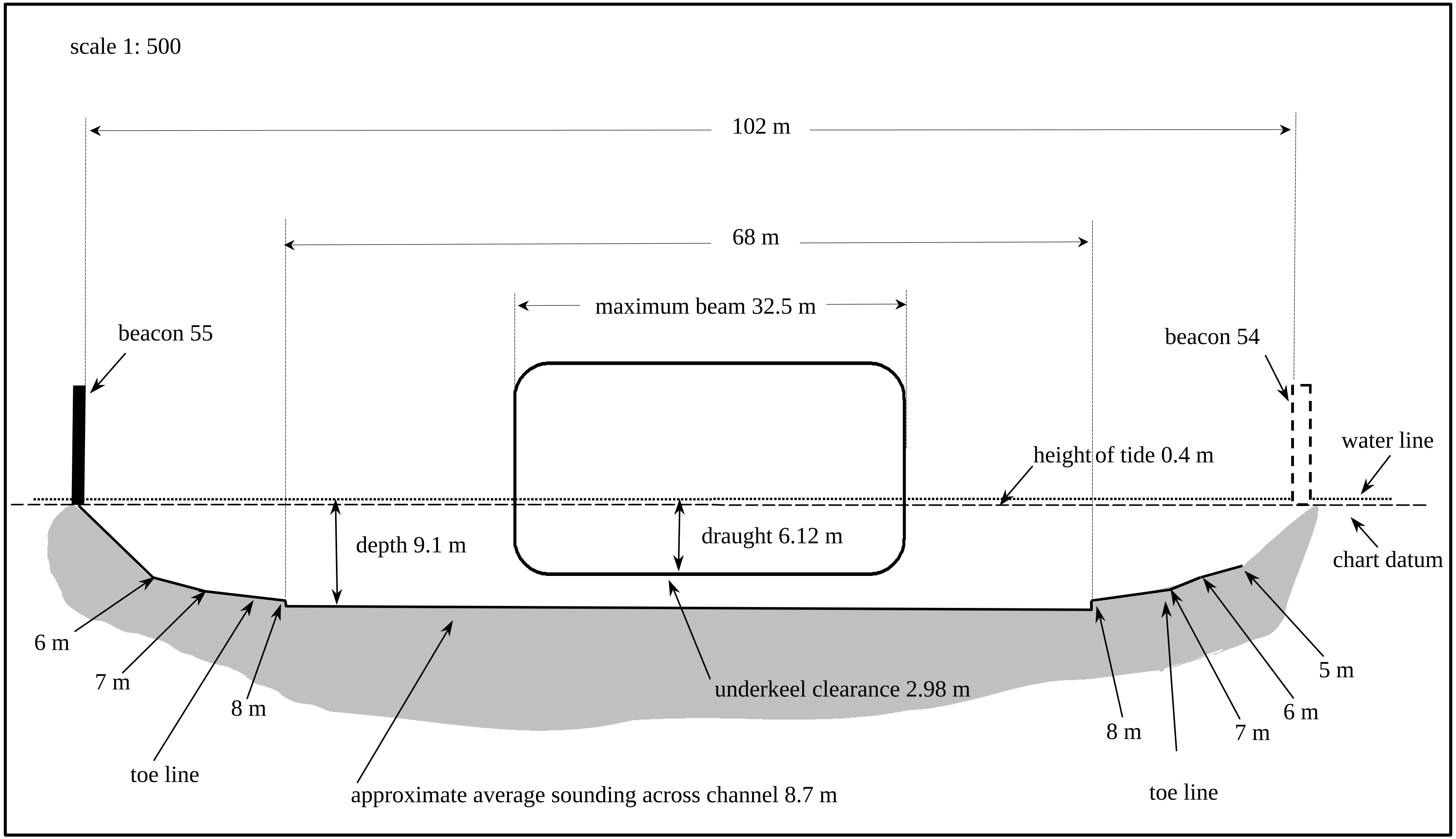


Figure 6
Cross section of Victoria Channel in vicinity of beacon 55 at approximately 0700 on 23 September 1999, showing the *Kakariki* mid-channel, drawn to scale 1: 500

1.6.6 There was no designated swinging basin at Dunedin. Vessels that transited the harbour to Dunedin or Ravensbourne Wharf were swung off the Dunedin wharves, where there was a
275 m diameter area available.

1.6.7 Port Otago had 2 harbour tugs, the *Karetai* and the *Rangi*. Both were reverse tractor[3] tugs fitted with twin Schottel azimuth thrusters, each having a bollard pull of 30 t and a maximum speed of 12 knots.

1.6.8 The New Zealand Pilot (NP51) states with regard to tidal streams in Port Otago:

> In Upper Harbour streams may attain a maximum rate of 2¼kn and generally follow the channel, except off Kilgours Point (45º50'.0 S, 170º36'.1 E) and in the vicinity of Ravensbourne Wharf where local sets are experienced.

1.7 Fast time simulation study 1995 (Port Otago Limited)

1.7.1 In October 1994, the port company commissioned an Australian firm of consulting engineers to investigate the possibility of transits of Victoria Channel by vessels with beams greater than 29 m, which was the maximum permitted at that time.

1.7.2 The fast time simulation was achieved by carrying out computer based navigational simulations using fast time simulation software. The objective was to simulate larger loaded vessels transiting the channel in-bound and the same vessels transiting outbound in ballast condition, at a speed of 8 to 10 knots.

1.7.3 The study involved ship models transiting a model of the harbour. To obtain the computer model of the channel it was divided into 30 segments and varying effects of wind and tide were simulated to act on the ship model. The ship models were derived from actual manoeuvring and handling characteristics of similar vessels. Where such information was not available it was derived from the experience and expertise of the port company, pilots and consultants.

1.7.4 Three vessels were modelled, a bulk carrier and 2 tankers. One tanker modelled had a length of 180 m and a beam of 32 m, which closely resembled the dimensions of the *Kakariki*.

1.7.5 Once the information for each type of vessel was collated, tuning tests consisting of simulated "runs" were conducted and fine tuned until a satisfactory ship model was developed.

1.7.6 The effect of wind was simulated from 2 directions, southwest and northeast. The wind was assumed to act on the beam of the vessel at a steady rate commencing at a maximum of 30 knots and decreasing in 5 knot intervals. As the vessels aspect to the simulated wind changed in each segment of the channel so did the component of the wind simulated to act on the beam of the vessel. The effect of current was simulated for spring tides in a direction of flow along the channel.

1.7.7 Bank effect was simulated by calculating a torque on the vessel based on its proximity to the bank. This was algebraically added to the component for wind and applied to the simulation as necessary.

1.7.8 The simulation made no allowance for squat, human factors and other variables nor did it take into account emergency situations such as mechanical failure. There did not appear to be any margins of safety allowed for within the parameters of the simulation. The models either made a successful transit or grounded.

[3] A tug with the propulsion units aft.

1.7.9 Simulated transits of the channel under varying conditions of wind and tide were undertaken and the results recorded. The model similar to the *Kakariki* successfully transited the channel on all occasions.

1.7.10 The conclusions drawn from this study were that a tanker similar to the *Kakariki* could transit the existing Victoria Channel in both directions, on ebb or flood tides in winds up to 30 knots from the north-east or south-west.

1.7.11 The bulk carrier model was 10 m longer and had a beam 1.5 m less than the model similar to the Kakariki. It made 2 unsuccessful transits during simulation. As a result the study recommended that the channel be widened in 2 places in order to accommodate vessels of similar dimensions as follows:

> Widening of the channel has been proposed at two locations. On the northern side of the channel just west of Halfway Islands, the water depths (over 20 m) exceed the minimum channel depth and no dredging is necessary.
>
> At the second location, just east of Kilgour's Point on the southern side of the channel, (between Beacons 4 and 12) existing minimum water depths are indicated on the hydrographic plans as low as 5 m, with adjacent channel minimum depth being about 8 m. Dredging this area to –8 m would entail the removing of approximately 40 000 cubic metres of spoil.

1.7.12 Between 1994 and 1998 the port company dredged the 2 areas recommended, and other areas on both sides of Victoria Channel, removing a total of 95 000 m^3 of spoil. Eleven beacons were moved to facilitate the widening of the channel. The recommended parts of the channel were widened by up to 30 m in the first instance and 35 m in the second. Other areas of the channel were widened by up to 15 m.

1.7.13 In December 1997, following completion of the dredging, the port company increased the maximum size of vessels permitted to transit Victoria Channel to 195 m in length and 31.5 m beam. The maximum permissible draught remained the same at 8 m. The port company also stated that vessels with a beam greater than 31.5 m would be considered.

1.7.14 To ensure that accurate current and wind information was available to the pilots the port company installed 3 wind and tidal stations in the port. These provided real time information which was collated at a base station and available to the pilots on demand.

1.8 The Permanent International Association of Navigation Congresses (PIANC)

1.8.1 PIANC was founded in 1885 and was an international non-profit making and non-political technical and scientific organisation. The objective of PIANC was:

> to promote the maintenance and operation of both inland and maritime navigation by fostering progress in the planning, design, construction, improvement, maintenance and operation of inland and maritime waterways and ports and of coastal areas for general use in industrialised as well as in industrialising countries. . .

1.8.2 Since 1973 PIANC had been studying and making recommendations on the optimum design and dimensions of shipping channels, taking into account the advancements in knowledge, analytical methods and technology over the years.

1.8.3 In 1997, PIANC published a report called Approach Channels: A Guide for Design. PIANC recognised that in order to design the approach channel to a port to an acceptable level of navigability and safety, a number of factors must be taken into account, including:

- vessel size
- manoeuvrability
- ship handling characteristics
- human factors in ship handling
- effects of the physical environment
- maritime engineering
- cost.

1.8.4 From the report it was possible to calculate the optimum dimensions for straight and curved channels as well as swinging basins and other design aspects of a port. The method utilised the beam of the vessel and factors of it. For straight sections of a channel the manoeuvrability of the vessel dictated the basic width of the channel. Added to this were factors of the beam, based on the following criteria:

- vessel speed
- prevailing cross wind
- prevailing cross current
- prevailing longitudinal current
- significant wave height
- aids to navigation
- bottom surface
- depth of waterway
- cargo hazard level
- bank clearance.

1.8.5 The factors of the beam for these criteria varied depending on whether the channel was an outer channel exposed to open waters, or an inner channel protected from open waters.

1.8.6 PIANC guidelines recommended that areas used to turn vessels through 180 degrees should consist of a circular swinging area having a diameter of between 1.8 and 2 times the length of the ship.

1.9 Risk assessment 1999 (Coastal Tankers Limited and Silver Fern Shipping Limited)

1.9.1 In early 1999, the charterer assessed the limiting factors of each of the ports its vessels called at. It determined that in Otago Harbour the beam of the vessel was the limiting factor. They consulted with the port company and established that following the fast time simulation study and the completion of dredging, the port company would permit vessels with a beam of up to 32.5 m, such as the *Kakariki*, to transit the harbour, subject to limiting conditions of wind and tide.

1.9.2 The operator made its own in-house assessment of the ports and decided that Otago Harbour warranted a more detailed examination. In April 1999, it employed a team of consultants from Mobil Oil Australia to undertake a risk assessment of its vessels transiting Otago Harbour. Three main elements were identified by the operator as warranting the risk assessment being undertaken:

> 1. The dimensions of the turning/swinging basin adjacent to Dunedin wharves.
> 2. The width of the navigable channels in the upper harbour.
> 3. Night time berthing/sailing operations.

1.9.3 The objectives were as follows:

> 1. To evaluate the risk levels with respect to the characteristics of vessels managed by Silver Fern Shipping Ltd. (SFSL) whilst negotiating the channel between Halfway Islands, then Victoria Channel in the upper harbour, given channel alignments, widths and depths:
>
> (a) In daylight
> (b) In darkness
>
> 2. To evaluate the risk levels of the upper harbour swinging basin adjacent the Oil Wharf to determine the risk levels for SFSL managed vessels being manoeuvred and berthed port side to the Oil Wharf as above.
>
> (a) In daylight
> (b) In darkness
>
> 3. To evaluate the effectiveness of the existing harbour tugs in assisting with manoeuvring the vessel as above.
>
> 4. To identify environmental factors and conditions which would significantly impact upon the safety of any pilotage and berthing operation.
>
> 5. Once the assessment of the risk is established and quantified, make recommendations (if required, in addition to normal safe navigation procedures) to Silver Fern Shipping Ltd. on ways and means of managing that risk to acceptable levels consistent with efficient operations.

1.9.4 The consultants visited Otago Harbour in April 1999, and witnessed an inward and outward transit of the port by the coastal tanker *Toanui*, which had a length of 182 m and beam of 27 m. After the transit they interviewed the pilot and master. From this they concluded:

> At all times during both passages the ship was seen to be under control. The ship was manoeuvred in the channel with helm settings of typically 5 to 10 degrees with the exception of the outward passage through the cutting between Goat and Quarantine Islands when a brief but planned use [of] 20 degrees of helm was required.
>
> For most of each passage the ship was positioned mid channel and despite strong evidence of the hydrodynamic effect with the channel and close by shallow water areas, the ship remained responsive to modest helm movements.

1.9.5 As part of the risk assessment the consultants calculated the minimum required channel width based on the PIANC recommendations and commented as follows: (note B = the beam of the vessel)

• basic manoeuvring lane	1.3 B
• vessel speed (5-12 knots)	0.0 B
• prevailing cross winds	0.1 B
• prevailing cross currents	0.0 B
• prevailing longitudinal current	0.1 B
• significant wave height	0.0 B
• aids to navigation	0.1 B
• bottom surface	0.1 B
• water depth (<1.25 draught)	0.2 B
• cargo hazard level	0.7 B
• total channel width	2.6 B

Whilst this estimation of the required channel width is modest and the comparison with the beam of the *Toanui* and *Kakariki* indicates that the *Toanui* is acceptable whereas the *Kakariki* is not, the evidence observed during the site visit must be taken into account.

The ease with which the *Toanui* was controlled in the channel leads to the conclusion that the additional beam of the *Kakariki* (5.4 metres) can be managed.

1.9.6 When the consultants calculated the channel width as recommended by the PIANC guidelines, they unintentionally omitted the allowance for bank clearance of 1.0 B. Hence the total recommended channel width should have read 3.6 B. The omission was not noticed by either the consultants or the operator.

1.9.7 The risk assessment indicated that the *Kakariki* required a minimum channel width of 84.5 m; 8.5 m more than that available in the area in which the incident took place. When taking into account the omission in the calculation, the PIANC guidelines actually recommended a minimum channel width of 117 m, 41 m more than that available.

1.9.8 When the omission in the calculation was brought to the attention of the consultants after the incident they acknowledged that there had been a miscalculation but stated that it made no difference to their recommendations.

1.9.9 The first 2 objectives of the risk assessment were each given a risk rating which was obtained by multiplying a severity value by a likelihood value, determined as follows:

severity value (health & safety)	**consequence** (damage & loss)	**consequence**
1. low	one or more FAIs	less than $5000
2. medium	one or more MTIs	$5000-$50 000
3. serious	one or more LTIs, paraplegia	$50 000 -less than $500 000
4. catastrophe	one or more fatalities	more than $500 000

FAI-first aid injury; MTI-medical treatment injury; LTI-lost time injury

likelihood value	**occurrence**
1. remote	less than once in 50 years
2. occasional	more often than for 1, but less often than once per 10 years
3. probable	more often than for 2, but less often than once per year
4. frequent	once or more per year

The resulting risk rating was graded as below:

Risk:	Action
1-4	no action unless cost effective solution
6-8	action within next 3 years
9-16	action immediately

The 2 objectives in the risk assessment were rated as follows:

1. Halfway Islands Channel
   daylight 8
   night 12

   Victoria Channel
   daylight 6
   night 12

2. Swinging Basin
   daylight 4
   night 9

How the individual values for likelihood and severity used to obtain the risk rating were calculated was not specified.

1.9.10 As a result of their study the consultants recommended for the *Kakariki* that:

- transits of Halfway Islands, Victoria Channel and the use of the swinging basin should not be made at night
- the transit of Halfway Islands and Victoria Channel during daylight was associated with an elevated risk level but that alterations to operational practices would reduce that risk level
- the daylight use of the swinging basin be continued only if existing operational limits were adhered to, usual good marine practices were employed and the level of tug assistance was maintained.

1.9.11 Further recommendations were made as follows:

- to determine the cost/benefit and feasibility of relocating the oil terminal to Port Chalmers
- to make an escort tug fast, bow first, through the centre lead aft of the tanker whilst transiting Halfway Islands and the Victoria Channel
- to develop emergency response plans to cover ship’s main engine and steering gear failure and address selecting areas within the channel for deliberate grounding of a ship to minimise damage
- not to transit Halfway Islands and the upper harbour or use the swinging basin at night
- to review the strength of the ebb tide currently permissible for the transit of Halfway Islands by the *Kakariki*
- to review the structural integrity of the Dunedin Oil Wharf

- to review the fire fighting capabilities at the Dunedin Oil Wharf
- to review the access path to the Dunedin Oil Wharf
- to adapt the passage plan to allow for a minimum speed when passing a ship berthed at Ravensbourne Wharf
- to reflect on the passage plan that the minimum visibility range for ships entering Otago Harbour is 0.25 miles
- to address the failure of the real time wind and current information system.

1.9.12 After receiving a draft copy of the risk assessment, the operator's marine superintendent contacted the consultants and queried why there was no allowance for cross currents in the PIANC calculation. The marine superintendent had consulted 2 masters who had informed him that cross currents did affect the transit of Otago Harbour. The consultant replied that the local pilots had told him the effect of cross currents was negligible, but he recommended that if this was of concern the calculation could be reconsidered. On 6 August 1999, the marine superintendent contacted the masters of the *Toanui* and *Kakariki* for their input. At that time the master on board during the incident was on leave.

1.9.13 No subsequent allowance for cross currents was made. The PIANC guidelines recommended that at a speed of 8 knots with a cross current of between 0.5 and 1.5 knots, an extra 0.5 beam or, in this case, about 16 m would need to be added to the total beam width. This would have made the total in the risk assessment 3.1 times the beam of the vessel. The corrected figure, allowing for bank clearance would have been 4.1 times the beam of the vessel.

1.9.14 The incident trip was the first visit on the *Kakariki* to Dunedin for the master; consequently it was also the first time he had the use of an escort tug.

1.9.15 The master was aware that the risk assessment had been conducted, but had not received a copy of the report. He had been told verbally of the decision to use an escort tug, but he had not received any written instructions advising him of the decision to use an escort tug or how it was to be utilised. The marine superintendent provided a copy of a facsimile dated 20 September 1999, addressed to all masters which read in part as follows:

> To negate any confusion prior to the receipt of the report, all Coastal Tanker vessels are to employ the practice of using an escort tug for both inward and outward passages.

The facsimile did not clarify how the tug was to be utilised.

1.9.16 There had been other correspondence between the previous master of the *Kakariki*, the marine superintendent and the consultants concerning aspects of the risk assessment. This correspondence had not been brought to the attention of the current master, neither was his opinion sought.

1.9.17 On the previous 5 transits of the upper harbour by the *Kakariki*, an escort tug had been in attendance from Port Chalmers to the berth and vice versa. In July, for the first inward and outward passage, the tug was made fast as recommended in the risk assessment. After discussion with the pilot, the master at the time expressed concern to the operator's marine superintendent regarding the effectiveness of a tug being made fast at the usual transit speed of about 8 knots.

1.9.18 After further discussion the marine superintendent instructed that master at the time verbally that the tug would be in attendance as recommended, but that it was the master's decision, in consultation with the pilot, whether it was made fast. This was clarified in the facsimile dated 20 September 1999.

1.9.19 Consequently, for the second visit in August the tug was made fast as recommended for the inward passage, but only for the transit of Halfway Islands on the outward passage. During the inward passage of the incident voyage it was only made fast at Ravensbourne Wharf and assisted with turning and berthing the vessel. On the outward passage the intention was to make the tug fast only for the passage through Halfway Islands, as happened after the incident.

1.10 Escort tug

1.10.1 Typical objectives of an escort tug are to:

- reduce the risk of pollution caused by groundings or collisions due to technical or human failures aboard a vessel
- apply steering or braking forces to a vessel to keep it afloat or limit the impact of collision or grounding until further assistance arrives.

1.10.2 Many recent trials and studies of purpose-built escort tugs, and harbour tugs escorting vessels in confined waters and harbour channels, agree that there are a number of factors influencing the effectiveness of such tugs. One important point to consider is whether the tug is secured to the vessel or not. When it is secured it is called an active escort tug. When not secured it is called passive.

1.10.3 The concept of having an escort tug in attendance is often to provide a source of immediate assistance in the event of mechanical or human failure. The time elapsed from the moment of such a failure to the moment that the tug is able to provide effective assistance is crucial. In confined areas such as Victoria Channel, a matter of seconds could make a significant difference. In some cases this time delay may defeat the purpose of having the escort tug in attendance.

1.11 Interaction

1.11.1 When a vessel is travelling in calm, open, deep water the water pressure system around the hull reaches equilibrium. If the vessel moves into shallow or confined water this equilibrium can become upset as the pressure system around the hull interacts with the seabed or sides of a channel.

1.11.2 Squat is the term given to the increase in draught and/or trim a vessel can experience due to its movement through the water. The water accelerates as it flows past the hull to fill the hole the vessel has left in its wake. This increase in velocity causes a decrease in water pressure under the vessel and a resultant loss of buoyancy. The effect is usually more pronounced in shallow water where the flow of water past the hull can be restricted by the sea bed.

1.11.3 The effect of squat on a vessel with an even keel, similar to the *Kakariki* departing Otago Harbour, often causes the vessel to trim by the head. A vessel squatting by the head in shallow water can experience an over-steering phenomenon caused by the pivot point shifting aft. This reduces the turning lever of the rudder, together with an increase in lateral resistance forward; however, in shallow water a vessel does not attain as large a drift angle as it would in deep water, which has the counter effect of slowing the rate of turn.

1.11.4 There have been many practical and theoretical studies undertaken to determine and calculate the effects of squat on vessels under varying conditions. As a result many complicated formulae have been derived to calculate the sinkage and change of trim a vessel may experience. The effect of squat on a vessel at any one time is unique to that vessel and the operating conditions at the time. Therefore, the results obtained by calculation will vary according to the method used.

1.11.5 In much the same way as a vessel squats towards the seabed, a vessel travelling close to the side of a channel can experience bank effect. An increase in water pressure at the bow forms a cushion between the bow and the bank, deflecting the bow towards the centre of the channel. At the same time, aft of the pivot point, the flow of water accelerates between the bank and the side of the vessel, drawing the stern of the vessel towards the bank. If not compensated for, the resultant forces may cause the vessel to sheer across to the other side of the channel.

1.11.6 The influence that squat and bank effect have on a vessel varies with the square of the speed of the vessel. Therefore, a small reduction in speed will dramatically reduce the effects of squat and bank effect.

2. Analysis

2.1 The incident

2.1.1 The *Kakariki* had previously made 5 successful transits of Port Otago all under the con of the pilot. The master and pilot had previously worked together on other vessels, but the inward transit of the harbour was their first time together on the *Kakariki*. It was also the first time a trainee pilot had been involved.

2.1.2 The weather conditions for departure were good and did not compromise the *Kakariki* leaving the wharf or entering the channel. The wind was not of sufficient strength to require any allowance for leeway. Even though the sun was low in the sky, ahead of the vessel the sunscreens on the wheelhouse windows would have made the channel markers easily identifiable in the glare.

2.1.3 The predicted time of low tide was about 90 minutes after the incident occurred. The tidal flow at the time would have been minimal and probably did not significantly affect the passage of the *Kakariki* in Victoria Channel.

2.1.4 Although the exchange of information between the master, chief officer, pilot and trainee before the inward and outward transits of the harbour was of a high standard, it would have been prudent to have involved the helmsman in these discussions. He should have been made aware of all aspects of the intended operation, briefed on the effects that interaction may have on the steering and asked to report any excessive helm movements required to maintain course. When steering to a course the helmsman is often the first to detect when the vessel is not responding as expected.

2.1.5 When a vessel is transiting a confined channel, speed is a crucial factor as the effects of interaction vary with the square of the speed. There can be a fine balance between the minimum speed necessary to adequately control the vessel and the speed that can be safely maintained without the effects of interaction influencing the safe passage of the vessel.

2.1.6 The bridge team intended to transit the channel at about 8 knots, as the vessel had done on previous occasions. The reduction in speed was made for what appeared to be environmental issues rather than control issues. The maximum speed attained was reported as 6.8 knots. A speed of 6.8 knots is not considered excessive, under the circumstances, provided the bridge team was aware of the factors likely to affect the progress of the *Kakariki* and was monitoring it accordingly.

2.1.7 The bridge team was monitoring the position of the *Kakariki* in Victoria Channel by observing the 2 lines of beacons ahead of the vessel. There were only about 23 m of navigable water either side of the vessel in some parts of Victoria Channel. It can be difficult to detect sideways drift one way or the other from the bridge of a large vessel. With so little margin for error, the bridge team was confronted with a difficult task each time the *Kakariki* transited Victoria Channel.

2.1.8 When the *Kakariki* departed from the Oil Wharf at Dunedin the trainee had the con. He was reminded by the pilot of the need to attain an adequate speed in order to maintain good steerage in the channel. As a result the engine was put to half ahead, which would normally give a speed of about 9.3 knots. The bridge team was aware that a reduction in the engine setting to slow ahead would be required in order to attain their planned speed of about 8 knots.

2.1.9 The *Kakariki* was aligned with the middle of the channel when it passed beacon 67. The speed of the vessel increased from about 3.5 knots at beacon 67 to about 5.5 knots just before Ravensbourne Wharf. The *Kakariki* would have been influenced by bank effect at this time, but it would have been acting uniformly on either side of the vessel.

2.1.10 In the area that the incident occurred the underkeel clearance was about 3 m. At a speed of between 6 and 7 knots the *Kakariki* would have been influenced by the effects of squat to some extent, probably causing it to trim more by the head.

2.1.11 As the vessel passed Ravensbourne Wharf the distance from the starboard side of the vessel to the edge of the channel would have remained relatively constant at about 23 m, but the distance from the port side to the edge of the channel would have increased to in excess of 70 m.

2.1.12 The hydrodynamic forces acting on each side of the hull would have become uneven. On the starboard side of the *Kakariki* the bow would cushion off the bank and the stern would be drawn into it, causing the vessel to sheer to port. (See Figure 7.) The start of the sheer appears to have coincided with the reduction in engine speed, and associated decrease in the effectiveness of the rudder. A sheer of this nature was a predictable event given the size of the vessel and the configuration of the channel, an event that should have been considered in the passage plan.

2.1.13 The helmsman was at the time having to apply 15 to 20 degrees of starboard helm in an attempt to maintain his given course to steer. Ideally, a helmsman should report such an event to the person with the con. Ideally, the bridge team monitoring the progress of the vessel should have noticed the unusually large helm applications. Neither occurred, so when the chief officer commented that the stern was closing with the starboard side of the channel, the trainee instinctively ordered 5 degrees port helm to regain the centre of the channel. Because it was taking 15 to 20 degrees starboard helm to maintain course, this had the same effect as ordering 20 to 25 degrees of port helm.

2.1.14 It was probably the start of the sheer that alerted the chief officer to the fact that the stern was closer to the beacon on the starboard side than normal. The sheer may have been exacerbated by the vessel squatting by the head.

2.1.15 When the *Kakariki* departed the berth the *Karetai* was standing by to assist if required. It then followed the *Kakariki* down the channel as an escort tug. After departing the berth the crew of the *Kakariki* left the poop unattended. As it was necessary for the tug to be made fast to be effective the master should have ensured that sufficient personnel remained at the stern to take the tugs line if required. If this had been the case the *Karetai* would have been able to assist in realigning the *Kakariki* with the channel after the sheer occurred.

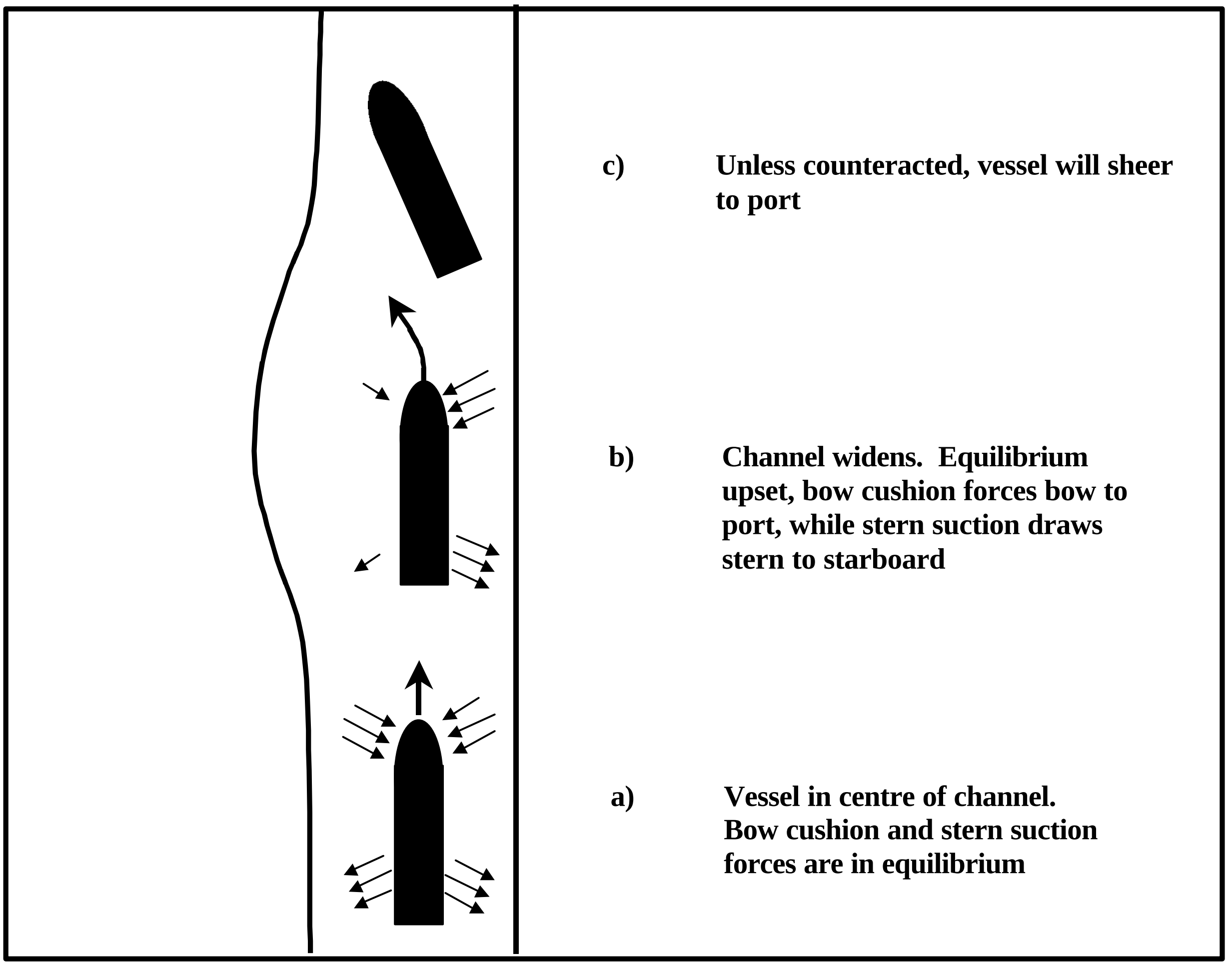


Figure 7
Diagram showing the effects of interaction as a channel widens

2.1.16 The time taken from when the speed was reduced to slow ahead until the engine was stopped after the sheer was about 4½minutes. During this time, the chief officer alerted the bridge team with regard to the position of the vessel in the channel, and the con transferred from the trainee to the master and to the pilot in quick succession.

2.1.17 The way in which the bridge team responded to the incident was an example of good bridge resource management. The bridge team assessed the situation rapidly, and responded as a team to good effect. Even though the events occurred in rapid succession and the con of the vessel transferred without discussion, the situation was managed in a calm, professional manner which had the desired outcome. Anything less would probably have resulted in the vessel grounding.

2.1.18 It was wise of the master and chief officer not to act on the trainee's advice to "secure the bow thruster". Due to the speed of the vessel it would have been virtually ineffective when first operated, but as the speed reduced it would have taken effect and thrust the bow back towards the centre of the channel. Without that lever acting on the fore-part of the vessel, it may have made contact with the side of the channel.

2.1.19 The "bumps" heard by the chief engineer and technical manager in the engine room were coincidental with the vessel being realigned within the channel. They would have been aware from the abnormal engine movements that something was amiss. Although they were correct in not distracting the bridge team immediately by reporting the "bumps" it would have been prudent to have informed the bridge team as soon as the situation had returned to normal. The master could then have acted on the information, sounded the tanks and checked for damage earlier. Later tests of the steering gear identified that when the helm was put hard over to port or starboard a shudder was evident that could explain the "bumps" felt in the engine room.

2.2 Fast time simulation study 1995

2.2.1 Simulation is not reality. It is based on theory and constrained by the parameters that are used to set up the mathematical model and does not take account of all the variables. While simulation is a useful tool to assess different situations, it should not be used as the sole method of determining the viability of a safety-critical operation.

2.2.2 The fast time simulation undertaken by the port company in 1995 was based on information gleaned from many sources and collated to form a computer based representation of vessels of varying characteristics transiting Otago Harbour. As such, it should only have been used as a broad indication of the ability of these vessels to transit the harbour.

2.2.3 The handling characteristics of the vessels modelled was based on information from the actual sea trials of similar vessels. When the information was not available it was supplemented with information gained from the experience of the pilots, port company and consultants. To construct a model from such wide and varying sources left some margin for error. The handling characteristics of the *Kakariki* and the similar tanker modelled could in reality be vastly different.

2.2.4 The turning circles for the vessels modelled would have been conducted in deep water, and would not truly represent the turning characteristics of the same vessel in a narrow, shallow channel where influence from interaction and human factors would be brought to bear.

2.2.5 The simulation was based on fixed parameters and did not take into account many variables including:

- squat
- wind gusts
- current variations
- fluctuations in the speed of the vessel
- human factors
- environmental considerations.

2.2.6 The simulation concluded that certain vessels modelled could successfully transit the existing harbour. To facilitate the safe passage of other vessels some dredging needed to be carried out. If the simulated vessel transited the harbour without grounding or contacting the channel sides it was assumed to be acceptable. If it did not, then dredging needed to be undertaken until the transit was successful. It appeared that there was no safety margin allowed for in the simulation.

2.2.7 The decision by the port company to allow a tanker with the dimensions of the *Kakariki* to transit the harbour to Dunedin was virtually based on this study. Considering the variables not allowed for in the simulation it would have been prudent to have used this study in conjunction with more practical assessments of successive transits of the harbour by a vessel of that size.

2.2.8 Judging by the findings of the 1999 risk assessment which was based on the PIANC guidelines and the fast time simulation study, the *Kakariki* should not have been permitted to enter Otago Harbour using standard position monitoring and ship handling techniques.

2.3 Risk assessment 1999

2.3.1 The 1999 risk assessment was based broadly on guidelines recommended by PIANC. Ideally these guidelines are used when designing a port and the approach channels from new. They can be applied to an existing port to assess the feasibility and alterations required for a larger vessel to transit an existing channel, as was the case in Otago Harbour.

2.3.2 The levels of risk associated with various aspects of the operation were calculated by multiplying the severity by the likelihood. For the scenario of a vessel deviating from the channel due to hydrodynamic forces the assessment calculated a risk level of 3. The likelihood was deemed to be 1 (less than once in 50 years) and the severity 3 (serious, one or more lost time injuries or paraplegia, or a cost of between $50 000 and $500 000).

2.3.3 The report did not describe how the value for likelihood was arrived at, but in this case, once in 50 years appeared to have been somewhat underestimated for a vessel of the dimensions of the *Kakariki* in such a confined channel.

2.3.4 The difference between near and actual deviation from the channel is of little consequence. To come as close to grounding as the *Kakariki* did on the day of the incident is of as much concern as if it had actually grounded. Assuming that the figures in the study were based on the projected number of transits of Otago Harbour by the *Kakariki* in 50 years, the level of risk to the port company must have been significantly higher considering other vessels with similar dimensions were going to be allowed to transit the harbour during the same period.

2.3.5 One of the main objectives of the risk assessment was to evaluate the transit of Halfway Islands and Victoria Channel by the tankers. The consultants based their assessment and recommendations on the fast time simulation and the PIANC guidelines. The fast time simulation concluded that the channel was just big enough for the tankers. The risk assessment which underestimated the required channel width by 32.5 m, concluded that the *Kakariki* was outside the PIANC guidelines, but manageable if certain defences were put in place.

2.3.6 The risk assessment, with the omission of one beam width in the calculation, identified some deficiencies with regard to the suitability of a tanker the size of the *Kakariki* transiting the Upper Harbour. These included:

- the beam was about 5.4 m over that recommended in the PIANC guidelines at the narrowest part of the channel
- the vast majority of Victoria Channel was less than 84.5 m wide (2.6 x beam)
- the transit of Halfway Islands carried an elevated risk level
- the wharf may not be strong enough
- the turning area off Dunedin wharves was too small
- the access to the Oil Wharf was inadequate.

2.3.7 The erroneous PIANC calculation led the consultants to believe that the minimum channel width required by the PIANC guidelines for the *Kakariki* was 84.5 m. In fact it was 117 m. This indicated that the *Kakariki* was significantly oversized for the existing channel and indicated that safety countermeasures needed to be studied and successfully implemented to allow the vessel to transit the channel within acceptable risk limits.

2.3.8 After a draft copy of the risk assessment was received by the marine superintendent he queried the calculation with regard to cross currents. The marine superintendent and consultant had received differing information regarding cross currents in the channel from the port company pilots and masters spoken to. In collating the information to be used as a basis for risk assessment, it would have been prudent to seek advice from all parties involved in the operation being assessed.

2.3.9 The consultants observed the *Toanui* transit the harbour and commented that there was "strong evidence of the hydrodynamic effect with the channel and shallow water". With the knowledge that the hydrodynamic effect on the *Toanui* was "strong" they still recommended that the *Kakariki*, with a beam of 5.5 m greater, was manageable. It may have been prudent to analyse the situation further before commenting on the suitability of the *Kakariki* to transit the channel.

2.3.10 The speed of a vessel in a narrow channel is a major contributing factor to the effects of interaction. The risk assessment made no recommendations with regard to speed. The only reference made to speed in the assessment was in the description of the current operation. The fast time simulation used speeds of 8 to 10 knots.

2.3.11 The area off Dunedin wharves where vessels are turned was not a designated swinging basin. Part of the objectives of the risk assessment was to evaluate the use of this area to turn the vessels. The PIANC guidelines recommended that an area used to turn vessels through 180 degrees should be a circle with a diameter of 1.8 to 2 times the length of the ship. In the case of the *Kakariki* this should have been 329 to 366 m. The clear area off Dunedin wharves was 275 m in diameter. This would be further reduced if any vessels were berthed at the wharves.

2.4 Escort tug

2.4.1 The operator in conjunction with the port company had decided to engage the services of a harbour tug as an escort tug for all its tankers while transiting Halfway Islands and Victoria Channel, as was recommended in the risk assessment to reduce the "elevated level of risk" identified for the transit. It was recommended that the tug be made fast bow first through the centre lead aft of the tanker. The assessment did not describe how the escort tug was to be utilised in order to reduce the risks. Neither did it outline the expected procedures, tug operational requirements or any training that may be necessary.

2.4.2 The decision to use the escort tug was made purely on the recommendations of the risk assessment. In making this decision the operator did not first discuss the operation or effectiveness of an escort tug with the masters. The masters had not received a copy of the risk assessment, even though the draft was completed in April 1999, before the *Kakariki* first visited Dunedin.

2.4.3 In order to maintain optimum steerage the *Kakariki* transited Halfway Islands and Victoria Channel at speeds of about 7 to 8 knots. At that speed a tractor tug, like the *Rangi* or *Karetai*, would be able to give only limited assistance to turn the vessel within the confines of Halfway Islands or Victoria Channel in an emergency situation. The higher the speed of the tug the less available power for bollard pull. There are methods of assisting a ship in a turn at higher speeds, such as indirect towing, but the tugs must be suitable, there must be sufficient room in the channel for the tugs to manoeuvre and the operation must be practised.

2.4.4 The port company provided the tug as requested by the operator but did not discuss the operation with the tug skippers. The tug skippers were not briefed with regard to the intended operation, nor were they able to have input into the viability of the operation.

2.4.5 The escort tug was utilised as recommended during the first visit to Dunedin by the *Kakariki*. The master at the time, in consultation with the pilot, expressed concern to the operator and the port company with regard to having the tug made fast. As a result the marine superintendent instructed the masters to use the tug at their discretion. This resulted in the tug not being secured on a number of occasions.

2.4.6 An escort tug is only as good as the assistance it can provide. Whether it is used in the active or passive mode should be determined by the circumstances of each case.

2.4.7 In confined waters a passive escort tug is really only there to assist once an incident or accident has occurred, to limit any further danger to the vessel and its crew until further assistance arrives. In Otago Harbour the combination of a narrow channel and a relatively fast transit speed meant that a vessel could deviate from the channel in a matter of seconds; an escort tug in the passive mode could do little to prevent this occurring.

2.4.8 An active escort tug can be used to assist in turning or slowing a vessel in an emergency, provided the speed of the ship is consistent with the capabilities of the tug and method of towage being used.

2.4.9 In all cases, the method and use of towage in confined waters require careful planning and thorough analysis of all the factors likely to affect the operation. All involved should be given a thorough briefing to ensure everyone shares the same mental picture of the intended operation. It appeared that few of these processes had preceded the decision to assign an escort tug to the *Kakariki* while transiting Victoria Channel and Halfway Islands.

2.5 Summary

2.5.1 The PIANC report into approach channels was a set of guidelines, not hard and fast rules as such. The risk assessment commissioned by the operator sought to use those guidelines to establish the risk level for the *Kakariki* transiting Otago Harbour. The resulting calculations showed that the *Kakariki* was outside the limits of the PIANC guidelines, which are considered as a benchmark for safe operating limits. This was not taking into account the error in the calculations discovered after the incident, which put the *Kakariki* even further outside those limits.

2.5.2 That was not to say the *Kakariki* should not transit Otago Harbour, but rather, a more in-depth study was required to ensure that the safety of operations was not compromised.

2.5.3 There were a number of options available to the operator and the port company to bring the level of risk down to that maximum recommended by PIANC. A number of those options were identified in the risk assessment. They ranged from using an escort tug to relocating the oil terminal to Port Chalmers. These were options that required further assessment.

2.5.4 The operator appears to have chosen the suggestion of providing an escort tug, and assumed that this action alone was sufficient to bring the level of risk down to an acceptable level. It is apparent from this investigation that further assessment resulting in better defences against this type of event will be required before the *Kakariki* can transit Otago Harbour with a level of safety commensurate with prudent seamanship, and with appropriate port company and ship management.

3. Findings

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

3.1 The *Kakariki* had valid statutory certificates and the crew and port company pilots were appropriately licensed and experienced to conduct the trip.

3.2 Neither mechanical or equipment failure, nor weather or tidal factors contributed to the incident.

3.3 The size of the *Kakariki* in relation to the dimensions of the Victoria Channel it was following meant that the progress of the ship was constantly influenced by interaction with the channel bottom and sides.

3.4 The *Kakariki* took a sheer to port in the channel and came close to grounding. The cause of the sheer was a combination of the following factors:

- the trainee requested port helm to bring the vessel back to the centre of the channel when the helmsman was applying starboard helm to counter bank effect
- the ship moved from a narrow part of the channel with equal bank effect on both sides, to a widened section of the channel where the bank effect was stronger on the starboard side
- the change in bank effect coincided with the reduction in engine speed, resulting in a drop in rudder effectiveness
- the ship was likely to have been squatting down by the head, resulting in an over-steering phenomenon
- the bridge team may not have appreciated the effect of interaction until the sheer had already developed, and was not effectively monitoring all the factors contributing to the progress of the vessel.

3.5 Once the sheer had developed, the actions of the pilots and crew were controlled, appropriate and consistent with a high standard of bridge resource management.

3.6 The escort tug was not able to assist in recovering the situation due to the manner in which it was used. The role of the escort tug had not been well thought out before and after the directive from the operator and port company that its use was mandatory.

3.7 The fast time simulation conducted by the port company in 1995 to determine if larger vessels could transit the port was based on theoretical calculations, taking little account of the many variables affecting vessels transiting Otago Harbour. Technological advances since this study, and considerations outlined in the latest risk assessment indicate that the port company may need to reassess the limiting conditions on large vessel transits.

3.8 The risk assessment commissioned by the operator to determine the level of risk for the *Kakariki* transiting Otago Harbour contained a significant error in calculation that favoured the suitability of the ship for the channel. Notwithstanding the error in calculation, indications were that the *Kakariki* was still too big to transit the Victoria Channel and Halfway Islands with the current level of resources used to monitor and control its progress.

3.9 The logic used in the risk assessment to justify the *Kakariki* transiting Victoria Channel and Halfway Islands, in spite of indications to the contrary, was questionable.

3.10 There were other considerations for the safe operation of the *Kakariki* in Port Otago raised in the risk assessment, some of which were generic to the port, which required addressing.

4. Safety Recommendations

4.1 On 2 August 2000 it was recommended to the Chief Executive of Port Otago Limited that he:

4.1.1 Consider using the PIANC guidelines when reviewing company policy and procedures (052/00)

4.1.2 Use the PIANC guidelines and other technology available, to reassess the limiting conditions for large vessels transiting Otago Harbour. (053/00)

4.2 On 15 August 2000 the Chief Executive of Port Otago Limited replied, in part:

4.2.1 The PIANC guidelines "Approach Channels, A Guide for Design" can be applied as a guide for the theoretical or conceptual design for new navigation channels. The guidelines recommend the conceptual design is subsequently supported by more detailed assessment allowing for human response an environmental criteria using both fast time and real time simulation. These techniques are then also able to be used to determine whether or not operational limits need to be applied and if so, what the limiting conditions are.

Port Otago is neither developing a new navigation channel or at present undertaking redevelopment of an existing facility.

The use of human, environmental and vessel response techniques can similarly be applied to existing navigation channels which is of relevance to the Port Otago situation in Otago Harbour. It is these techniques which have and are at present being used to determine the operating guidelines for vessels such as the *Kakariki* transiting Victoria Channel. This work is being carried out in accordance with the detailed recommendations contained in the Maritime Safety Authority report on the *Kakariki* incident. It is also being carried out in association with NZ Coastal Tankers.

As reported in our submission to the draft report, Port Otago developed the initial limiting conditions for the use of Victoria Channel by vessels of a similar size as well as those larger than the *Kakariki* . This work was carried out in conjunction with Coastal Tankers. It also involved experienced Senior Pilots from Port Otago who ultimately set the limiting conditions for such vessels and have subsequently undertaken a significant number of transits of the channel. This work is currently being reviewed through the use of a real time simulator developed at the Australian Maritime College based at Launceston.

Joint exercises have been carried out between Port Otago pilots and bridge team of the *Kakariki* .

Based on the above a new set of operation criteria is being developed to be confirmed and followed up by further simulation work, scheduled to be carried out during the first quarter of 2001. This is to allow time for adjustments to be made to the simulator at Launceston.

It is our belief the work as outlined above more than complies with the PIANC guidelines for reviewing company policy and procedures for the use of Victoria Channel by vessels such as the *Kakariki* and the appropriate technology is being used to establish limited conditions. This work is further supported by input from Coastal Tankers and the process is being undertaken by the senior pilots within the Marine Services section of Port Otago Limited.

4.3 On 2 August 2000 it was recommended to the Marine Superintendent of Silver Fern Shipping Limited and the Chief Executive of Coastal Tankers Limited that they:

4.3.1 Correct the calculations in the risk assessment, and focusing on its objectives, re-evaluate the level of risk and safety of the *Kakariki* transiting Otago Harbour. (054/00)

4.3.2 Liaise with Port Otago Limited and combine the resources of all parties to reassess the risk level for the *Kakariki* transiting Otago Harbour and take whatever action is required to achieve a level of safety commensurate with prudent seamanship, and appropriate ship and port company operations. (055/00)

4.3.3 Liaise with Port Otago Limited and the appropriate regional council to consider the other factors affecting the safe operations of ships and tankers at the Oil Wharf as identified in the risk assessment. (056/00)

4.3.4 Implement a policy of conducting risk assessments before the company becomes committed to the purchase, chartering in or management of future new or existing tankers. (057/00)

4.4 On 11 August 2000 the Marine Superintendent of Silver Fern Shipping replied:

4.4.1 With the intent of improving safety at reducing risk, Silver Fern Shipping Ltd (SFSL) has liaised with Port Otago Ltd prior to , and post, the near miss incident on the *Kakariki* . SFSL instigated the risk assessment in the Port of Otago with the intent of understanding and reducing the risk to our vessels in that port. Succinct guidelines have been put in place since the risk assessment was conducted. As a responsible ship manager, SFSL recognise that the error in the original risk assessment will impact on our follow up actions.

SFSL's policy and practice on managing risk is one of, if not the, highest in New Zealand. I understand that no other New Zealand port or shipping company conducts risk assessments similar to that which SFSL conducts. A similar risk assessment conducted at another port has resulted in the eventual withdrawal of SFSL managed vessels due to the risk being considered high.

In the last 18 months, SFSL vessels have traded in ports within Poland, Latvia, France, Greece, Japan, Singapore, Hong Kong, Indonesia, Australia, New Zealand, Fiji and New Caledonia. It is impractical for any international shipping company to conduct comprehensive port risk assessments for every port their ships visit. Indeed, SFSL understands it is normally the role of Port to conduct risk assessments on the handling vessel in their port, rather than independent shippers who visit the port.

Although Silver Fern Shipping has conducted navigational exercises at the AMC [Australian Maritime College] simulator in Australia, TAIC [Transport Accident Investigation Commission] should be aware that several port companies in New Zealand have refused to allow SFSL access to the models of their ports.

4.5 On 11 August 2000 the Chief Executive of Coastal Tankers Limited replied, in part:

4.5.1 Recommendations 5.2.1 and 5.2.2: As these recommendations stand, they are incapable of implementation given the lack of definition, enumeration and timelines within them. The CTL [Coastal Tankers Limited] Board has endorsed the following operational philosophy with respect to safety assessments utilising the PIANC guidelines.

High risk:	Immediate cessation of operations.
Medium risk:	Operations must be moved to standard risk within 2 years.
Standard risk:	Satisfactory.

Within that context, the above TAIC recommendations will be implemented.

Recommendation 5.2.3: CTL does not understand the import of this recommendation which is too vague as currently drafted to be implemented. Given CTL's response to the 2 recommendations above, CTL would query the need for this recommendation to be made at all.

Recommendation 5.2.4: The recommendation as drafted is incorrect: CTL already has such a policy and has demonstrated that it walks the talk with regard to implementation. CTL would be greatly assisted if TAIC could
[a] spell out what risk assessments should be carried out and at what current locations, and
[b] assure CTL that other companies contemplating such arrangements are to be subject to similar scrutiny.

CTL notes in passing that the trend for CTL and others is that any future new or existing vessels are likely to be bigger than current new or existing vessels. With regard to my comment [a] above, if TAIC has in mind simulation studies, for example on the AMC simulator at Launceston, Tasmania, then I would like to add the following. A decision to model an earlier sister ship to *Kakariki* i.e. the *Helix* on the AMC simulator had to be reviewed when it was found the 2 vessels had dis-similar handling characteristics **in service**. The decision to model *Kakariki* itself was then taken, but implementation was delayed due to confidentiality issues with regard to her Schilling rudder. *Kakariki* has been so modelled since early 2000, and a joint session between CTL and POL [Port Otago Limited] has been scheduled at AMC in July 2000.
A final point to note in this regard is that assessments using the AMC simulator are subject to the relevant port agreeing to its port modelling being released. CTL places no restrictions on the availability of the *Kakariki* model for such purposes, nor does it charge for such release. Currently, only 4 ports in New Zealand reciprocate on that basis, 2 ports have refused such use, and another would like a financial arrangement to be entered into. I am informed that Australian ports that are modelled at AMC make their modelling freely available to anyone in the world, free of charge. In CTL's view this situation warrants a ministerial and/or regulatory review in its own right as a pre-requisite to any recommendations made by TAIC and/or MSA [Maritime Safety Authority] which require CTL and/or SFSL to utilise "currently available technology" to conduct risk assessments within New Zealand ports.

Approved for publication 2 August 2000

Hon. W P Jeffries
Chief Commissioner