

**Report 07-206, tug *Nautilus III* and barge *Kimihia*, barge capsized while under tow,
Wellington Harbour entrance, 14 April 2007**

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Report 07-206

tug *Nautilus III* and barge *Kimihia*

barge capsized while under tow

Wellington Harbour entrance

14 April 2007

Abstract

On Saturday 14 April 2007 at about 0300, the tug *Nautilus III* was towing the barge *Kimihia*, which was loaded with a cargo of rock, through the Wellington Harbour entrance channel when the barge unexpectedly capsized and deposited its cargo onto the seabed of the main entrance channel to the port. The master and crew of the tug, after advising Wellington Harbour Radio of the accident, towed the barge in its inverted state to Miramar wharf where salvage experts were able to right the barge on the 18 April 2007.

Safety issues identified included:

- the assignment of an inappropriate load line to the barge
- the need for stability standards for unmanned dumb barges in the Maritime Rules
- the poor standard of surveying and the apparent lack of understanding of Maritime Rules by safe ship management providers
- the minimal standard of stability knowledge required for the Inshore Launch Master certificate of competency
- the incorrect manning of the tug
- the difficulty and confusion surrounding the regulatory certificate, survey, load line, design and seagoing limit structure

Safety recommendations were made to the Director of Maritime New Zealand to address some of these issues.



The tug *Nautilus III* at Wellington



The barge *Kimihia* after righting at Wellington

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Abbreviations

CLM	commercial launch master
G	centre of gravity
GM	distance between the centre of gravity and the metacentre
GZ	righting lever
ILM	Inshore Launch Master
IMO	International Maritime Organization
KB	distance of the centre of buoyancy above keel
KG	distance of the centre of gravity above keel
KM	distance of the metacentre above keel
km	kilometre(s)
kW	kilowatt(s)
LLO	Local Launch Operator
m	metre(s)
Maritime NZ	Maritime New Zealand
MEC6	Marine Engineer Class 6
MetService	New Zealand Meteorological Service
mm	millimetre(s)
MSI	Maritime Safety Inspector
nm	nautical mile(s)
Nortel	Nortel (1998) Limited
NZOW	New Zealand Offshore Watchkeeper
RNZN	Royal New Zealand Navy
SSM	safe ship management
SOLAS	International Convention for the Safety of Life at Sea
t	tonne(s)
UTC	co-ordinated universal time

Glossary

block coefficient	the ratio of the underwater volume of a ship to the volume of a rectangular block having the length, breadth and draught of the ship
Class IX vessel	ships that do not proceed beyond restricted limits (not being passenger ships or ships of Class X (fishing vessels))
displacement	the weight of water displaced by a ship floating in a given condition; a measure of ship's size
free surface	adverse effect created by liquid shifting in a partially filled tank when afloat; when the liquid moves as the ship rolls and pitches, its centre of gravity changes and this affects the centre of gravity of the entire ship; a virtual reduction of the metacentric height follows, which reduces the ship's stability
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
lightship	the weight of a ship's hull, machinery, equipment and spares
metacentre	the theoretical point at which an imaginary vertical line through the centre of buoyancy intersects another imaginary vertical line through a new centre of buoyancy created when the body is displaced, or tipped, in the water, however little.
metacentric height	the distance from the centre of gravity of a ship to the metacentre; it is considered positive if the metacentre lies above the centre of gravity
port	left-hand side of a ship when looking forward
significant wave height	the height of the average of the highest $\frac{1}{3}$ of the waves
starboard	right-hand side of a ship when looking forward
Type A ship	a ship that carries only liquid cargoes in bulk
Type B ship	a ship other than a Type A ship

Data Summary

Vessel Particulars:

Name:	<i>Nautilus III</i>	<i>Kimihia</i>
Type:	tug	barge
Class:	non passenger ship	dumb barge
Limits:	New Zealand coastal limits	New Zealand coastal limits
Safe ship management system provider/surveyor:	SGS M&I	SGS M&I
Length:	14.146 m	27.60 m
Breadth:	5.27 m	8.55 m
Depth:	2.46 m	2.44 m
Gross tonnage:	36.38	150
Built:	1971, Carrington Slipway, Newcastle Australia	substantially re-built by Hartstone Engineering, Raglan in 1997
Propulsion:	2 x 8V71N Detroit diesels each driving a fixed-pitch propeller through a Twin Disc MG509 reversing gearbox	nil
Service speed:	towing 4.5 knots non-towing 9.0 knots	n/a
Owner/operator:	McManaway Tug and Barge Limited	McManaway Tug and Barge Limited
Home port:	Picton	Picton
Crew:	3	nil
Date and time:	14 April 2007 at about 0300 ¹	
Location:	Wellington Harbour entrance	
Persons on board:	crew: 3	nil
Injuries:	crew: nil	nil
Damage:	nil	Minor structural damage; extensive salt water damage to machinery and electrical systems
Investigator-in-charge:	Captain Iain Hill	

¹ Times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

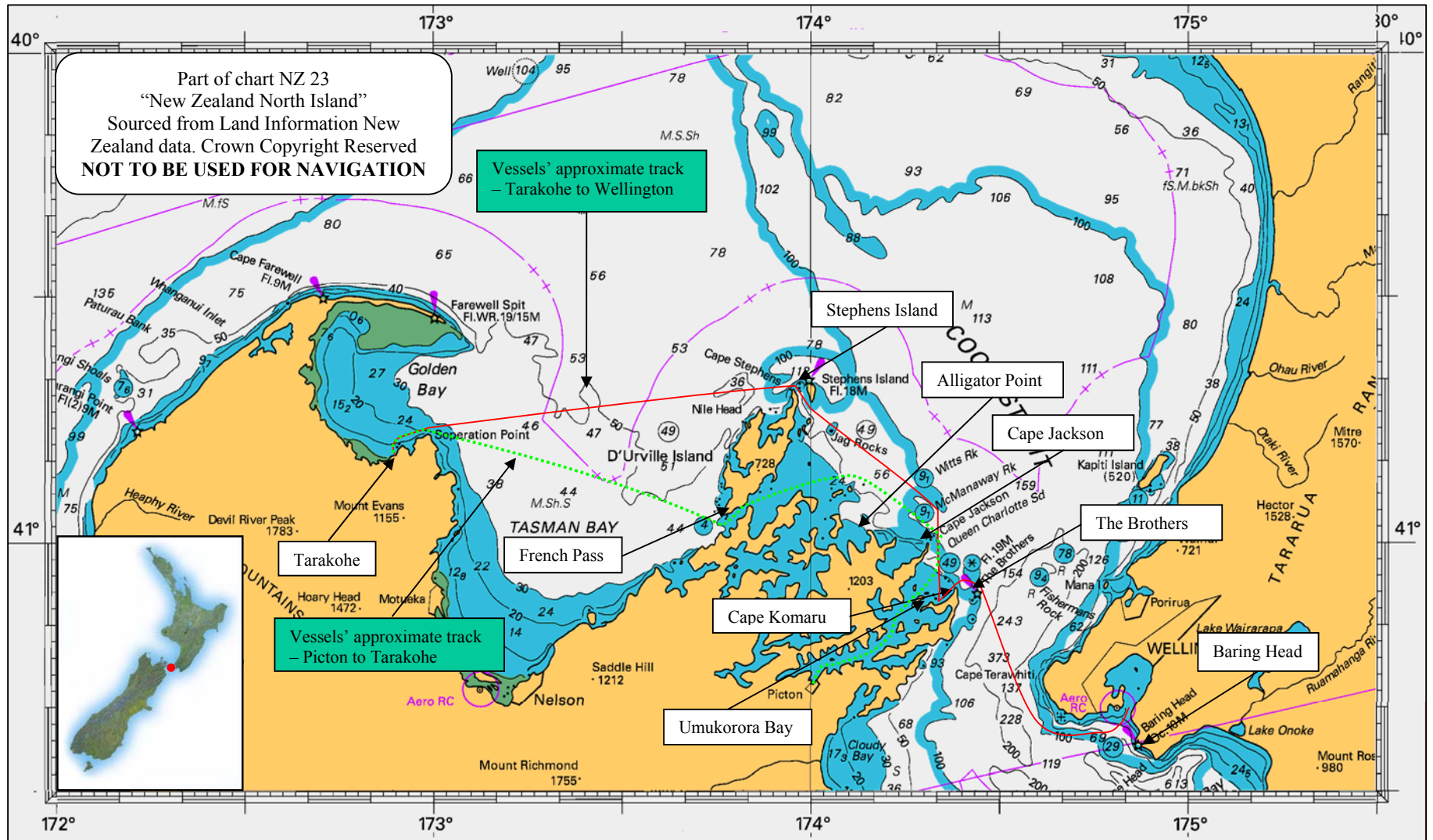


Figure 1
Chart of the general area

1 Factual Information

1.1 Narrative

- 1.1.1 On Wednesday 11 April 2007 at about 1700, the tug *Nautilus III* with a master and 2 crew on board left Picton Harbour with the barge *Kimihia* in tow bound for Tarakohe to load a cargo of rock (see Figure 1).
- 1.1.2 On Thursday 12 April 2007 at about 1000, the *Nautilus III* and *Kimihia* arrived at Tarakohe. The cargo of rock was then loaded by a mechanical digger, which placed the rocks into position on the deck rather than dropping them from a height. By about 1730, the cargo had been loaded. The master checked the freeboard of the barge to ensure the barge was not overloaded. The load line was above the waterline with the barge trimmed by the stern so the master considered that the barge was safely loaded. The crew inspected the inside of the barge for damage or water ingress; finding none, the barge was taken under tow and the *Nautilus III* left Tarakohe at about 1740.
- 1.1.3 The weather forecast for the start of the voyage to Wellington was good, but the master and crew were aware that the weather was expected to deteriorate through the voyage and that they may need to seek shelter from a forecast southerly gale.
- 1.1.4 At about 1900, the tug and barge passed Separation Point. On Friday 13 April 2007 at about 0440, as the weather was beginning to deteriorate, the *Nautilus III* and *Kimihia* passed through Stephens Passage and a course was set to pass off Cape Jackson. As the vessel was passing Alligator Head the wind was recorded in the log as being 25 to 30 knots from the south southeast and the master and crew observed a weather front approaching from the south.
- 1.1.5 The master and crew discussed the options available to them and, after a telephone call to the owner, decided to seek shelter behind Cape Koamaru until the frontal weather had passed. After passing Cape Jackson the tug's course was altered to enter Queen Charlotte Sound and at 1210 the tug and barge anchored in Umukorora Bay.
- 1.1.6 At about 1740, the worst of the frontal weather had passed, so the skipper and crew decided to continue on passage to Wellington. After checking the barge once again for water ingress they hauled anchor on the tug and barge, reconnected the barge to the tug with a long tow line and resumed the voyage to Wellington. At about 2205 the tug and barge passed Cape Terawhiti where the wind was recorded as being south easterly at 20 knots and above.
- 1.1.7 On Saturday 14 April at about 0005, the tug's crew member on watch contacted Wellington Harbour Radio (Beacon Hill) by very high frequency radio channel 14 and passed an estimated time of arrival of about 0200. Beacon Hill acknowledged the radio call and advised the *Nautilus III* that the wind was south-southwesterly 10 to 20 knots and there was a swell of between 6 and 7 metres (m).
- 1.1.8 At about 0145, the master of the *Nautilus III* advised Beacon Hill that the towline had parted so he was turning the tug around to recover it. The master later said that the swell was of such magnitude that he was losing sight of the shore lights on the Wellington coast when the tug was in the trough of a wave. The master also said that due to the length of the tow line the barge and tug were frequently on opposite sides of a wave requiring him to reduce the engine power to reduce the stress on the tow line.
- 1.1.9 At about 0200, the master reported to Beacon Hill that the *Nautilus III* had the *Kimihia* under tow again but the line was snagged underneath the barge and it was being towed slowly, stern first, into the harbour entrance. As the tug towed the barge stern first the master and crew observed the stern light slowly disappear and then the green starboard sidelight come into view as the barge slowly turned to starboard. By about 0226, the master and crew were able to see both sidelights and the master reported to Beacon Hill that the line had become free and the barge was being towed bow first again.

- 1.1.10 As the master and crew observed the barge's sidelights from the tug's wheelhouse they noticed the barge develop a list to port. Over the next 20 to 30 minutes the master and crew noticed the list to port increase as the port sidelight got lower and lower in relation to the starboard sidelight, until at about 0258 the port sidelight disappeared from view and the crew observed the starboard sidelight describe an arc before it disappeared. The master informed Beacon Hill that he had a problem and he thought that the barge had rolled over. The master then ordered the tug's searchlight beam to be trained on the barge, where all that could be seen was the upturned bottom of the barge.
- 1.1.11 The master considered that due to the sea state it was unwise to attempt to go alongside the barge until daylight. The barge was able to be towed successfully upside down, so the *Nautilus III* continued to tow the *Kimihia* in this state clear of the normal shipping lanes until directed to a safe berth by the Harbourmaster.
- 1.1.12 Once alongside a safe berth, salvors were able to turn the barge the correct way up over the following few days. The Harbourmaster ordered a survey of the area where the barge capsized to determine the exact location of the barge's cargo (see Figure 2) and whether it posed a danger to navigation.

1.2 Vessel information

Nautilus III

- 1.2.1 The *Nautilus III* was a steel hulled tug built in 1971 by Carrington Slipway, Newcastle, Australia. The vessel had an overall length of 14.146 m, a beam of 5.27 m and a gross tonnage of 36.68. The vessel was powered by two, 171.6 kilowatt Detroit 8V71N diesel engines each driving a fixed-pitch propeller in a steering nozzle through a Twin Disc, MG 509, reversing reduction, gear-box.
- 1.2.2 The *Nautilus III* was owned and operated by McManaway Tug and Barge Limited. The vessel was under safe ship management (SSM) with SGS M&I² and had an SSM certificate to operate, when correctly manned, as a non-passenger ship in the coastal limits area. SGS M&I was an approved SSM provider recognised by Maritime New Zealand³ (Maritime NZ) and had supplied SSM services to the owners of the *Nautilus III* throughout the vessel's tenure in New Zealand.

Kimihia

- 1.2.3 The *Kimihia* was built by A&G Price of Auckland in 1957 as a non-propelled cutter suction dredge at Lake Kimihia near Huntley for the New Zealand Mines Department. The *Kimihia* (although un-named at this time) was used to create an opencast coal mine which it completed in 1962. In 1968 the barge was transported overland and launched into the Waikato River for use as a dredge there. After several years the barge lay idle on the river bank until it was bought by Winstone Aggregates in 1995. Winstone Aggregates the barge converted (re-built) to their requirements and American Bureau of Shipping standards. The barge was re-launched in 1997 and named *Kimihia* before being towed to the Kaipara Harbour, where it was used as a sand dredge.
- 1.2.4 In December 2006, McManaway Tug and Barge purchased the barge, on the basis that it could carry 300 tonnes (t) of cargo as stated in the ship-broker's advertisement. The barge was converted for use on its Cook Strait trade, which included removing all the dredging equipment.

² SGS M&I is the name of the company formed when SGS SA took over M&I in New Zealand. M&I (Marine and Industrial Safety Inspection Services Limited) was formed in 1994 to carry out the survey function of the Marine Department of the Ministry of Transport. The current name SGS M&I has been used throughout the report for consistency.

³ The Maritime Safety Authority's name changed on 1 July 2005 to Maritime New Zealand. The current name Maritime New Zealand and the abbreviation Maritime NZ have been used throughout the report for consistency.

- 1.2.5 The *Kimihia* was surveyed by SGS M&I between 29 January 2007 and 5 March 2007 and then issued with a fit-for-purpose certificate by SGS M&I and on that basis a barge safety certificate by Maritime NZ on 28 March 2007.
- 1.2.6 Some of the survey work carried out by the SSM company was done in Picton; however, the majority of the survey work was carried out in Nelson where the barge was slipped so that a survey of the underwater hull could be undertaken.



Figure 3
2 of the 3 wasted air pipes

- 1.2.7 Maritime Rules Part 40C Design, Construction and Equipment – Non-Passenger Ships that are not SOLAS Ships required the *Kimihia* to be fitted with air pipes for the under deck void spaces.
- 1.2.8 The surveyor who carried out the survey of the *Kimihia* in Nelson later said that he did not inspect the void space air pipes or their deck penetrations because the guard rail on the walkway on the sides of the barge was insecure and access to the deck from the slipway was by means of a portable ladder, which the surveyor considered unsafe.
- 1.2.9 During the post-accident investigation 3 of the metal air vent pipes on the port side were found to have corroded to the extent that 2 were severely holed. About 2 weeks after the occurrence the air pipes were removed by the owner and put into storage. The air pipes were further examined and photographed by the Commission 3 weeks after the occurrence, which was about 6 weeks after the survey was carried out in Nelson (see Figure 3). The holes were on the back of the air pipes close to and obscured by other parts of the barge's structure.

Cargo

- 1.2.10 The owner had been contracted to transport dolomite lime from Tarakohe, South Island, New Zealand to Wanganui, North Island, New Zealand and wooden fence posts for vineyards from Wanganui back to Tarakohe or Picton for about 3 years. The owner then entered into a contract to carry hard limestone from Tarakohe to Wellington for flood defence work. The *Nautilus III* with the *Kimihia* in tow had completed 11 such voyages as shown below:

Date of loading	Tonnage
08/02/2007	299.97
13/02/2007	299.00
16/02/2007	312.00
20/02/2007	305.50
23/02/2007	314.00
05/03/2007	252.00
19/03/2007	300.00
22/03/2007	300.00
26/03/2007	312.00
04/04/2007	300.00
05/04/2007	250.00
12/04/2007	310.00
Average load	296.23

The stone had a specific gravity of 2.6 and was shipped in varying sizes up to a maximum weight of about 1.5 t.



Figure 4
Kimihia loaded with rock at Tarakohe

1.3 Personnel information

- 1.3.1 The master of the *Nautilus III* had worked on tugs and barges for about 7 years. He had worked for McManaway Tug and Barge since about 2001 and had been master of the *Nautilus III* since 2004. He held an Inshore Launch Master (ILM) certificate of competency.
- 1.3.2 One of the crew members of the *Nautilus III* had been involved with small boats from an early age. In 2002 he started a full time career at sea and gained his ILM And Marine Engineer Class 6 (MEC6) certificate in 2002. He had worked 5 seasons tuna fishing out of New Zealand and Australia, acting as master during 3 of the seasons. He started work for McManaway Tug and Barge in 2006 as crew on board the *Nautilus III*.
- 1.3.3 The other crew member of the *Nautilus III* had first gone to sea with the Royal New Zealand Navy in 1968, and after leaving the navy had worked in the private and commercial shipping industry. He had worked for McManaway Tug and Barge since January 2006. He held a Commercial Launch Master (CLM) certificate of competency.
- 1.3.4 The managing director of McManaway Tug and Barge Limited (owner) started a boat building apprenticeship in 1965 and formed McManaway Tug and Barge as a boatyard in Picton in 1975, expanding into tug and barge ownership in about 1992. The company at the time of the accident owned and operated 4 tugs and 4 barges in addition to the boatyard business.

1.4 Climatic and environmental conditions

- 1.4.1 The accident happened in the Cook coastal waters forecast area. The New Zealand Meteorological Service (MetService) issued coastal waters forecasts at regular times.
- 1.4.2 MetService stated that coastal weather forecasts are valid within 60 nautical miles (nm) (about 100 Kilometres (km)) of the New Zealand coastline. Because most coastal forecast areas cover some thousands of square miles, the forecast describes in a general sense the weather conditions expected. Over small parts of the forecast area (for example, off a particular headland in a particular wind flow), weather conditions may be significantly different from those forecast.

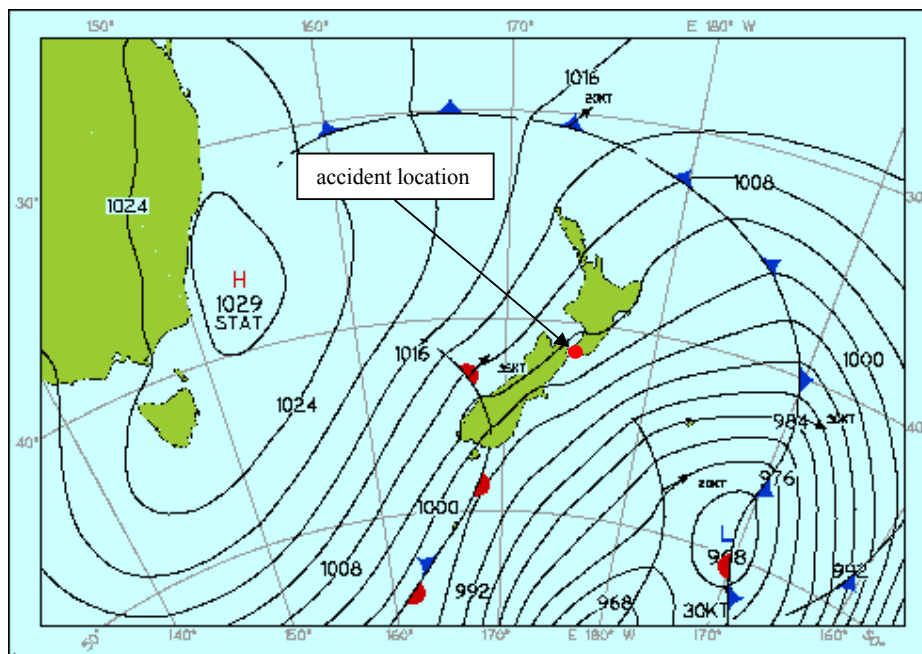


Figure 5
Mean sea level analysis for 1200 14 April 2007

- 1.4.3 The coastal waters' forecast for Cook sea area issued at 00:36 am, 14 April 2007 and valid to 2359 on 14 April 2007 was:

Forecast

Southerly 30 knots but 20 knots west of Cape Terawhiti, becoming northwest 20 knots everywhere this morning. A change to southerly 15 knots this afternoon, then becoming variable 10 knots this evening.
Rough sea in east easing. Southerly swell 4 metres easing..

Outlook

Variable 10 knots becoming Monday northwest 30 knots and rising early Tuesday to 40 knots with very rough sea. A change later Tuesday to southerly 30 knots. Moderate southerly swell easing Tuesday.

- 1.4.4 The National Institute of Water and Atmospheric Research maintained a wave rider buoy situated off Baring Head (see Figure 1). Data from the buoy was available to Beacon Hill. It was a summation of this data that the radio operator passed to the master of the *Nautilus III* when he called in on arrival at Wellington.

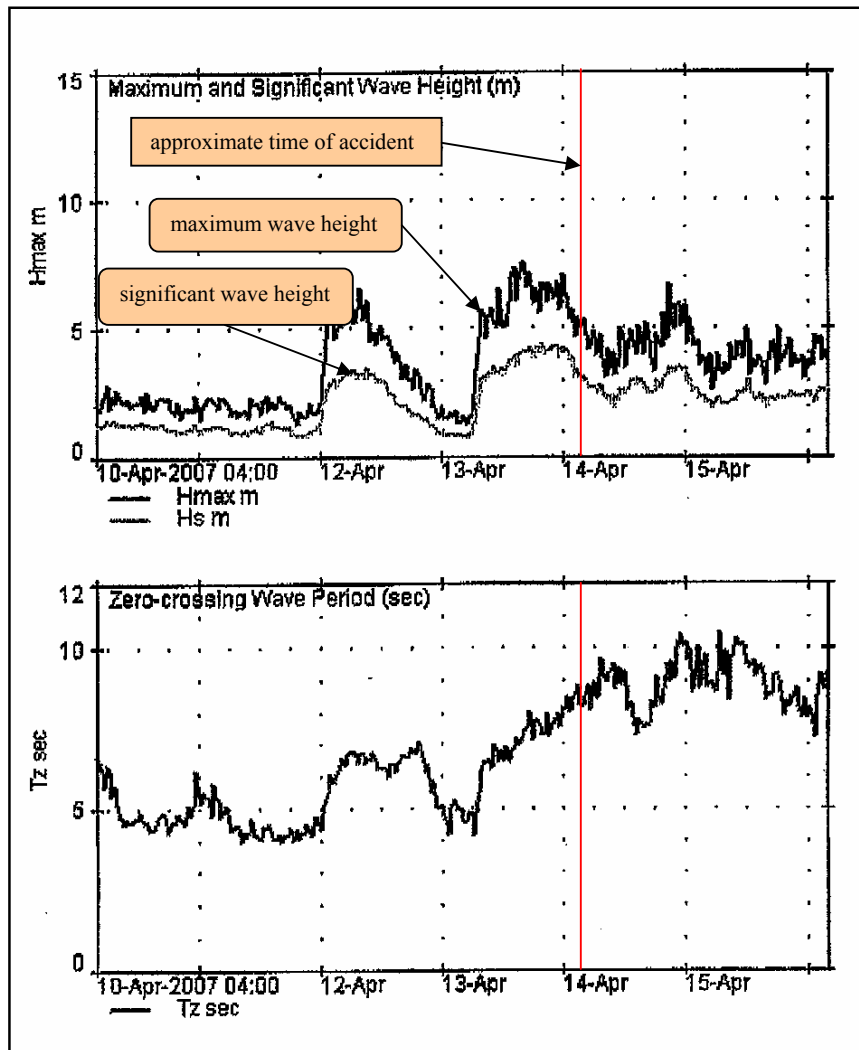


Figure 6
Significant wave height graph

1.4.5 The predicted tides for Wellington for 13 and 14 April 2007 were:

Wellington							
High water		Low water		High water		Low water	
Date - time	m	Date - time	m	Date - time	m	Date - time	m
13 – 1243	1.6	13 – 1847	0.6	14 – 0108	1.7	14 – 0724	0.6

1.4.6 The tidal range at the time of the incident was 1.1 m (a spring tide).

1.4.7 The accident occurred on a falling tide and thus the tide was running out of the harbour against the swell. When a tidal stream runs against a sea and swell, it causes the waves to become steeper and the wave period to decrease. Conversely, when a tidal stream runs with a sea and swell, it causes the sea to flatten and the wave period to increase.

1.4.8 Swell waves can travel for long distances in deep water without losing the energy they acquire from the wind. But as they travel into shallow water their shape and direction change. In shallow water, the waves slow down and change direction, the crests bend and their vertical profile becomes steeper. They eventually become so steep that they become unstable, breaking and losing most of their energy in the surf zone.

1.5 Damage

1.5.1 The *Nautilus III* sustained no damage during the accident.

1.5.2 The *Kimihia* sustained minor structural damage from the capsize, but sustained extensive damage to the on-board electrical and hydraulic systems, and the diesel engine to drive these systems.

1.6 Stability

1.6.1 Minimum stability criteria are laid down by maritime authorities to ensure the safety of the vessel and its crew, where crew are carried. In the case of internationally trading ships, these criteria are laid down by the International Maritime Organization (IMO). Other vessels that are not exposed to extreme sea and weather conditions are often allowed to comply with lesser standards set by the maritime authorities in the country of registration. However, the underlying principles of correctly loading a vessel to prevent it from capsizing and to maintain sufficient stability for the safety of the vessel, its crew, passengers and cargo remain the same. For a more detailed description of stability, refer to Appendix 1.

1.6.2 Barges could not comply with the stability criteria as laid down in the IMO Convention for the Safety of Life at Sea (SOLAS) unless stringent loading conditions were applied that made barges impracticable for their intended use. The barges' inability to comply with SOLAS was because SOLAS requirements were based on "ship shape" or rounded hull forms, whereas barges predominantly had flat bottoms and straight sides similar to a pontoon with a block coefficient of 0.9 or greater. Also, barges often loaded cargo on the upper weather deck at a relatively high centre of gravity (G), rather than down under deck like conventional ships. Different stability criteria for barges were introduced by the New Zealand Ministry of Transport in 1986; this requirement became known as MOT86.

1.6.3 On 1 August 1996, during the re-build of the *Kimihia*, SGS M&I wrote to the engineer in charge of the conversion, stating (in part):

Hull

1. The original structure and modifications of the barge has been assessed in accordance with the American Bureau of Shipping regulations for offshore service of steel barges. The structure has been found to be satisfactory for Class IX extended river limits. However, it is recommended by M&I to fit brackets of 150 x 150 x 7 mm at the top and the bottom of the pillars in line with deck and bottom girders.

2. The minimum freeboard at side above the deep waterline shall be in accordance with the New Zealand Loadline Certificate issued by Maritime Safety Authority.

Stability

1. Stability information will be required for this vessel and is to be passed to M&I Wellington for approval.

The Commission made enquiries about the original stability information to Maritime NZ, Nortel (1998) Limited (Nortel), SGS M&I, the present owner and the previous owner. None were able to produce, or had any recollection of seeing, any stability information pertaining to the barge.

- 1.6.4 After the accident an inclining experiment to determine the *Kimihia*'s stability was carried out by a surveyor from SGS M&I. The Commission along with an independent naval architect working on its behalf, attended the inclining.
- 1.6.5 The results obtained from the inclining experiment were used by the independent naval architect to calculate the statical stability of the barge. He calculated and commented as follows:

Displacement 127.8 t
VCG [vertical centre of gravity] 1.201 m
LCG [longitudinal centre of gravity] 13.90 m

The lightship VCG value is at 49% of the moulded draught of the barge. Given that the barge has the hopper sides, wheelhouse and various fittings above deck this may appear a little low. However note that the bottom structure of the barge is much heavier than the deck structure, and that there is machinery, pipe work, and some ballast fitted low in the barge.

From examination, the probably range of the VCG values is between 1.15 and 1.35 m, and errors or incorrect assumptions during the inclining may have caused discrepancies of up to +/- 75 mm in VCG.

Note also that while this may appear to be a very simple shape to analyse, the precise determination of VCG is more complicated than first appears. Both GM and KM values are very large, and so the value of the difference between these (i.e., the GM value) can be significantly affected by small errors. As an example, an error in GM of 5% will cause an error in VCG of over 40%. An error in the beam measurement of just 1% will lead to an error in VCG of about 20%.

1.9 Loaded Condition

With the reported 310 t of stone in the hopper. The VCG value for the stone is assumed to be 1.2 m above the deck, based on photographic evidence and witness reports. The summary of this condition is:

Displacement 437.8 t
VCG 2.999 m
LCG 13.667 m
Freeboard aft 485 mm
Freeboard fwd 533 mm

This result is in reasonable agreement with the reported freeboard of 540 mm in choppy conditions, assuming that it was the bow freeboard being measured. In this loaded condition the barge has stability characteristics as follows:

GM 1.213 m
GZ max 0.18 m
Angle GZ max 11 degrees (deg)
Stability range 23.6 deg
Area under GZ curve 2.62 deg m

There are no specific stability standards for this barge, and except for the GM the values noted are below the standard stability criteria applicable to most other vessels. However the stability should still be adequate for normal operations.

The barge was slightly overloaded prior to the capsizing event, when considered with respect to the Barge Stability Guidelines.



Figure 7
The *Kimihia* at Miramar wharf at commencement of righting



Figure 8
The *Kimihia* in the process of being righted

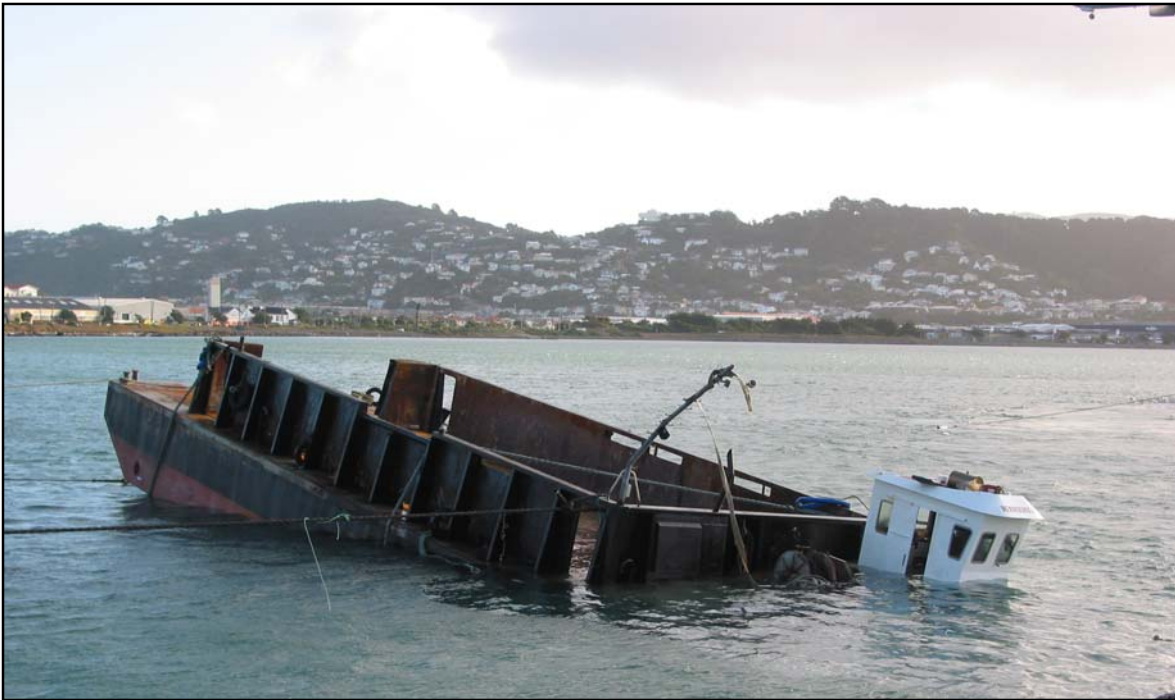


Figure 9
The *Kimihia* after righting

The capsizing was most probably initiated by the barge taking on a progressive list due to compartment flooding via defective air escapes in the prevailing swell conditions. With about 18 t of water on board the deck edge would be immersed, leading to a rapid increase in the flooding rate.

In this scenario the righting arm (GZ values) would be steadily decreasing, due to combination of the free surface effects and the deck edge immersion. As the stability deteriorated, the prevailing conditions with the occasional large swells would inevitably lead to a capsizing situation.

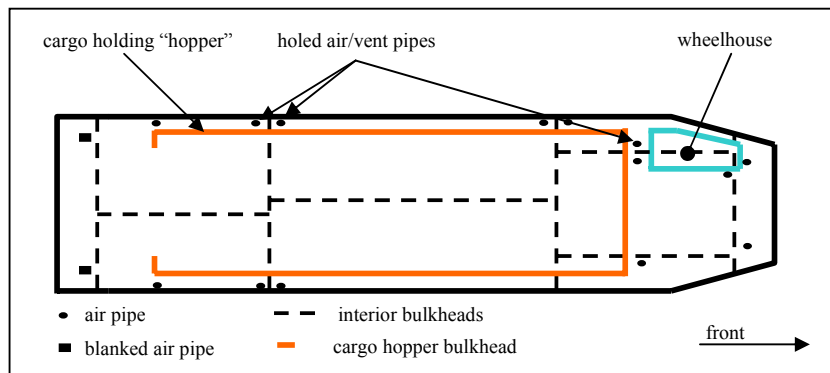


Figure 10
Plan of the *Kimihia*

1.7 Organisation and legislation

***Nautilus III* (operating limits and manning)**

- 1.7.1 The *Nautilus III* was brought into New Zealand from Australia in March 1996. At the beginning of May 1996 Maritime NZ issued the vessel with a New Zealand tonnage certificate and a certificate of survey as fit to ply as a non passenger ship within the “Nelson/Picton extended/extreme river limits”.

- 1.7.2 On 23 January 1998, the *Nautilus III* entered the SSM system with SGS M&I as an existing ship after being inspected and found to comply with Maritime Rule 21.13(2). The vessel was issued with an SSM certificate valid for restricted coastal limits.
- 1.7.3 In February 2002, McManaway Tug and Barge purchased the *Nautilus III* and a new SSM agreement was entered into between the new owner and SGS M&I. A fit for purpose certificate for restricted coastal limits within 20 nm off the coast, and an exemption SSM certificate were issued. On 29 July 2002, a full SSM certificate was issued for restricted coastal limits with the caveat that the vessel be manned by someone holding a CLM when within 12 nm of the coast or a New Zealand Offshore Watchkeeper (NZOW) certificate of competency when within 20 nm of the coast. The SSM certificate was valid until 30 April 2006.
- 1.7.4 In May 2006, a new fit-for-purpose certificate was issued for “Restricted Coastal Water Limits – restricted to within 30 nm of the coast of New Zealand”; subsequently, a new SSM certificate was issued for coastal limits valid until 30 April 2011.
- 1.7.5 Maritime Rule Part 20, which came into force on 1 February 1998, defined the various operating limits for vessels; those limits determined the standards that were applied to ships, their equipment, and the qualifications and number of persons crewing those ships.
- 1.7.6 Maritime Rule Part 20 stated in general that:

"Coastal" limits has been defined for the purposes of the rules which will allow suitable smaller ships to circumnavigate the North and South Island coasts without going too far offshore. Other maritime rules include requirements permitting ships which operate within restricted limits to make approved single voyages in coastal limits for such purposes as repairs, dry-docking and relocating. A surveyor may prescribe "restricted coastal" limits to a ship which would permit that ship to operate in a defined sector of the "coastal" limits, provided it met any maritime rule requirements made for restricted coastal ships. It is envisaged that the area prescribed for "coastal" limits will in due course have available national shore-based VHF radio coverage.

and in particular that:

20.5 Assigning Operating Limits

- (1) Subject to rule 20.5(3), the owner of any ship to which this rule applies must ensure that the ship has operating limits assigned to it by a surveyor.
 - (2) The operating limits assigned to a ship under rule 20.5(1) must be clearly recorded by the surveyor on—
 - (a) the certificate required by rule 21.13(2)(a); or
 - (b) the statement required by rule 21.13(4); or
 - (c) the certificate required by rule 21.13(19)(a); or
 - (d) the certificate required by rule 46.14; or
 - (e) the certificate issued under rule 46.24; or
 - (f) the certificate issued under rule 46.28;
 whichever is applicable.
 - (3) Any ship to which rule 21.13(2)(b) is applicable may maintain the survey limits shown on its certificate of survey at the time it enters an approved safe ship management system until 1 February 2000.
 - (4) Where a surveyor assigns inshore limits to a ship which include a defined section of the coastal limits not beyond the limit of the territorial sea of New Zealand, these limits must not allow the ship to undertake a voyage across Cook Strait.
 - (5) Any surveyor assigning limits to a ship must comply with any applicable restrictions and requirements for assigning limits to that type of ship specified in any maritime rule.
- 1.7.7 Maritime Rules Part 31B Crewing & Watchkeeping - Offshore, Coastal & Restricted (Non-Fishing Vessels) came into force on 1 February 2001. This Rule prescribed the minimum crew numbers and the qualifications required to be held by the master and crew of the *Nautilus III*.

- 1.7.8 To operate the *Nautilus III* in the Coastal limits area the master was required to hold an NZOW certificate of competency with a command endorsement. The mate was required to hold an ILM certificate of competency and either the mate or an engineer was required to hold an MEC6 certificate of competency. The minimum crewing requirement was 2 persons.
- 1.7.9 To operate the *Nautilus III* in the inshore limits area the master was required to hold an Local Launch Operator (LLO) certificate of competency and an engineer, who could be the master, was required to hold an MEC6 certificate of competency. The minimum crewing requirement was 1 person.
- 1.7.10 On 7 July 2005 a Rules Bulletin, which was designed to give assistance and explanation about the standards and requirements set out in the Rules, concerning Maritime Rules Part 20, and Part 31C Crewing and Watchkeeping - Fishing Vessels, was issued. The Rules Bulletin stated, in part:

Maritime rule part 20 uses the term “inshore” in a different manner. Inshore means defined section of the Territorial Sea of New Zealand set either, by the Ministry of Transport, or a surveyor, with the caveat that crossings of the Cook Strait are not permissible.

The use of the same term in the regulations and maritime rules, but with different meanings, has led to some confusion in the application of the requirements of maritime rule part 31C on fishing vessels not operating beyond the Territorial Sea of New Zealand.

Fishing vessels intending to operate in the Territorial Sea of New Zealand around the North, South and Stewart Islands must, on the vessel’s safe ship management certificate be described as “Restricted Coastal – restricted to the Territorial Sea of New Zealand”

Manning of a restricted coastal fishing ship restricted to the territorial sea must meet rule 31C.12, e.g. ILM of ships less than 20m in length or CLM of ships less than 15.24m in registered length.

Note: safety equipment levels set with maritime rule part 40D are identical for inshore and restricted coastal where restricted coastal is limited to the Territorial Sea.

This action of describing the fishing ship as restricted coastal enables craft under the old regulations described as “inshore” to continue what they were doing prior to the entry into force of the maritime rules without requiring upgrades of manning or equipment.

- 1.7.11 Both the LLO and the ILM certificates included an oral examination based on the syllabi as prescribed in Maritime Rules Part 31B. Part of these syllabi covered the basic requirements of stability as shown below:

11 Stability

- 11.1 Understands what is meant by good stability and poor stability and recognises the warning signs of poor stability
- 11.2 Describe the effect on stability of:
- a) Raising and lowering weights
 - b) Freely suspended weights
 - c) Free fluid surface
 - d) Low freeboard
 - e) Obstructed freeing ports

The LLO and ILM certificates once issued remained valid for the remainder of the seafarer’s life. There was no requirement for revalidation.

- 1.7.12 The owner had elected to increase the number of crew on board the *Nautilus III* to 3 persons, including the master, to allow for adequate rest and the ability to handle the tow safely.

- 1.7.13 The owner stated that in an attempt to work out the manning requirements he had contacted the local Maritime NZ, Maritime Safety Inspector (MSI) to clarify the situation. He further stated that the MSI had advised him that instead of following the 12 nm inshore limit, the tug and barge should take a more direct route even though it was outside the inshore limit but was less than 30 nm from a safe haven at any point. The MSI stated later, that although the taking of a more direct route was discussed the MSI thought they were discussing a different motorised barge which would require the barge to comply with the regulations for a ship.

Kimihia

A timeline of events is contained in Appendix 2.

- 1.7.14 On 17 November 1994 the Maritime Transport Act 1994 came into force. Parts X, XI, and XII of this Act, covered interim measures on construction, survey, equipment, load lines and safety at sea which were to be in force for 3 years from the time of enactment to allow for suitable Maritime Rules and Regulations to be put in place. Parts X, XI and XII contained sections from the 1952 Shipping and Seamen Act, and the *Kimihia* was re-built under these sections. In due course these 3 sections were repealed, on 2 February 1998.

- 1.7.15 The sections referred to the assignation of load lines as was covered by the 1952 Shipping and Seamen Act as amended. Details concerning the survey of barges for submersion lines were contained in the Ministry of Transport circular 1987/55. This circular made particular reference to stability as below:

4. Stability

The assistant Chief Surveyor is to be satisfied that the vessel has adequate stability at the freeboard assigned. Stability calculations should be submitted for approval before freeboards are assigned to deck barges having a beam to draft ratio of less than 6.

- 1.7.16 On 20 September 1996, the *Kimihia* was issued with a submersion line certificate valid until 20 September 2001 for extended river limits with a freeboard of 240 millimetres (mm) under the 1994 Maritime Transport Act. On 25 September, the barge was issued with a completion certificate which contained details of the submersion line, gross and net tonnages. No record of the stability calculations ever having been done could be found.

- 1.7.17 Maritime NZ considered that, as the *Kimihia* carried 2 persons on board while working, it was to be surveyed as a Class IX vessel. An exemption for the requirement to carry 2 fire pumps was issued and the vessel was issued with a certificate of completion by SGS M&I.

- 1.7.18 On 1 February 1998, Maritime Rules Part 46, Surveys, Certification and Maintenance came into force. Section 2 applied to ships which did not proceed beyond restricted limits, fishing ships, and ships of less than 45 m in length that were not required to comply with section 1. This section applied to the *Kimihia* when it was being operated by Winstone Aggregates. Section 3 applied to barges that did not carry any persons on board during a voyage. This section applied to the *Kimihia* while it was being operated by McManaway Tug and Barge. Section 2 required the vessel to be under SSM and required the issuance of appropriate fit for purpose and SSM certificates. Section 3 required the issuance of a New Zealand barge safety certificate, which replaced the former barge completion certificate, at the next 5-yearly survey after the Rule came into force. .

- 1.7.19 Also on 1 February 1998, Maritime Rules Part 47, Load Lines came into force. The intent of which was stated in the Rule as shown below:

Part 47 is divided into three sections. Section 1 applies to commercial ships of more than 24 metres in length, other than fishing ships, and barges of 24 metres in length or more which operate outside the coastal limit. Section 2 applies to smaller ships which carry cargo and section 3 applies to barges of 24 metres in length or more which do not go beyond the coastal limit.

- 1.7.20 This preamble indicated that section 3 applied to the *Kimihia*. However, in the application of section 1, paragraph (c) stated that section one applied to:
- i every New Zealand barge of 24 metres or more in length that intends –
 - ii to operate outside the coastal limits; or
 - iii carries any person on board during a voyage
- So, section 1 applied to the *Kimihia* when it was being operated by Winstone Aggregates because they carried persons on board during a voyage, and section 3 applied to the *Kimihia* when it was being operated by McManaway Tug and Barge because they did not.
- 1.7.21 Maritime Rules Part 47 Load Lines was introduced so that New Zealand continued to comply with the International Convention on Load Lines 1996 as amended, and ensured that the freeboard assigned to the vessel took into consideration the:
- structural strength
 - compartmentalisation and reserve buoyancy
 - deck height
 - transverse stability
 - hull form and underwater shape of the hull
 - vessel length
 - type of vessel, its cargo and the weather conditions in the area in which the vessel was operating.
- 1.7.22 There was no specific stability requirement contained in Maritime Rules Part 46 or Part 47 for the *Kimihia* when being used as an unmanned barge. However, there was a specific stability requirement for the *Kimihia* in these Rules when it was originally surveyed and continued to operate with 2 persons on board. There was also a specific stability requirement for the *Kimihia* prior to the coming into force of Parts 46 and 47 under the 1952 Shipping and Seamen Act as amended.
- 1.7.23 As part of new legislation, Maritime Rules Part 21 Safe Ship Management Systems came into force in 1997. The SSM system was based on the established International Safety Management system, but was modified for domestic commercial ships. Part 21 was supported by an included New Zealand Safe Ship Management Code, which outlined how an SSM system should be implemented. Since 2001, Maritime NZ had been working on a revised Part 21, which was released for industry consultation in September 2007. In 2005, it produced a Safe Ship Management Code of Practice, which set down requirements and responsibilities of participants in the system.
- 1.7.24 The philosophy of the SSM system was for owners and operators to take responsibility for their own safety and to develop their own safety management system in conjunction with their chosen SSM provider. At the time of writing there were 7 general SSM companies and one company that administered its own in-house SSM system. Part 21 provided a broad standard format of what was required of the industry.
- 1.7.25 As a barge that carried persons on board, the *Kimihia* was required to be in SSM while it was being operated by Winstone Aggregates. There was nothing found on record relating to SSM or subsequent annual surveys for the *Kimihia* from September 1996 to April 2001.
- 1.7.26 On 10 April 2001, Nortel, an SSM company entered into an agreement with Winstone Aggregates to supply SSM services for the *Kimihia*. A fit-for-purpose certificate and an SSM certificate were subsequently issued on 17 April 2001. These certificates covered the *Kimihia* to operate in Kaipara Harbour enclosed limits with 2 persons on board until 17 April 2005. Still no stability data was available for the *Kimihia* in spite of the requirements of Maritime Rule Part 47 for stability to be measured and documented.

- 1.7.27 On 20 September 2001 the *Kimihia*'s submersion line certificate expired; the submersion line certificate should have been replaced with a load line certificate following the appropriate surveys and inspections. This was not done.
- 1.7.28 On 7 November 2002, 7 January 2003 and 4 February 2004, Nortel carried out SSM audits on board the *Kimihia*. On 17 April 2005 Nortel issued a new SSM certificate for the *Kimihia* valid until 17 April 2009. On 6 May 2005 Nortel carried out an SSM profile and audit on board the *Kimihia*, after which it advised Winstone Aggregates that a load line certificate was required. This was not done.
- 1.7.29 At sometime during early 2006 Winstone Aggregates decided to dispose of the *Kimihia*, so it engaged the services of a marine broker who on 25 May 2006 produced a valuation report before listing the barge on the market.
- 1.7.30 In the latter part of 2006 McManaway Tug and Barge expressed an interest in the barge, but was concerned about the lack of stability information and in particular a load line certificate. Through the marine broker Nortel was requested and agreed to provide a load line certificate.
- 1.7.31 Nortel engaged the services of an independent naval architect to calculate the load line for the *Kimihia*. Winstone Aggregates operated the *Kimihia* as a Type B vessel so the naval architect initially calculated the load line for the barge as a Type B vessel under Section 1 of Maritime Rules Part 47, Load Lines. However, the naval architect later stated that when he queried this he was informed that this was not correct and he should calculate the load line as an un-manned barge for use in enclosed waters.
- 1.7.32 The naval architect wrote a letter to Nortel advising that he had computed a provisional load line assignment for the *Kimihia* with a minimum inshore freeboard of 221 mm, a minimum bow height of 600 mm and "no persons to be carried on board whilst in transit". He also noted that "the figures are provisional and may need to be adjusted depending on the final outcome of any stability analysis".
- 1.7.33 On 19 October 2006 Nortel issued an invoice for a load line calculation and subsequently on 16 November 2006, Nortel through the naval architect requested Maritime NZ to issue a load line Certificate for the *Kimihia*. The stability analysis was never made. The form that the naval architect used for the application had been compiled by Nortel under its quality assurance system as at the time there was no prescribed Maritime NZ form in use. However, the Nortel form did not allow for application for any load line other than a Type A or Type B ship. A Type "A" ship being a ship designed to carry liquid cargoes in bulk, and a Type "B" ship is any other ship that does not come within the provisions of the Rule regarding Type "A" ships. As an unmanned barge, *Kimihia* was neither a Type A nor a Type B vessel. On 16 November 2006, Maritime NZ issued a load line certificate for the *Kimihia* for a Type B ship with a freeboard of 221 mm valid until 16 November 2011, the 221 mm freeboard being on the assumption that the barge was going to be operated in enclosed water limits.
- 1.7.34 After McManaway Tug and Barge Limited purchased the *Kimihia* it requested SGS M&I to bring the barge into survey. SGS M&I made an out of water survey of the hull and applied to Maritime NZ for a New Zealand barge safety certificate as a New Zealand coastal limit dumb barge. SGS M&I assigned coastal limits to the *Kimihia* based on the load line certificate being for a "Type B" vessel, valid until 5 November 2011, and a fit-for-purpose certificate complying with Maritime Rules Part 47, section 2, valid until 5 March 2012.
- 1.7.35 The Commission requested information on the number of barges listed in Maritime NZ's vessel database. The results showed 26 barges over 24 m in length and 3 barges with no length specified. The Commission contacted several New Zealand barge owners to ascertain the number of dumb barge's under 24 m in length in New Zealand, which gave a very conservative estimate of 20 or more barges. Anecdotal evidence received by the Commission indicated that there were barges being constructed just under the 24 m length so as not to have to comply with the regulatory framework.

1.8 Related occurrences

1.8.1 On 19 August 2005, a barge, the *Mac III*, owned and operated by McManaway Tug and Barge was being loaded with 2 concrete trucks and a concrete pumping vehicle when the *Mac III* listed heavily and the 2 concrete trucks slid to the starboard side and toppled into the water. Both truck drivers died before they could be rescued.

1.8.2 The *Mac III* was a dumb barge which did not carry any persons on board during the voyage and was constructed with an overall length of 22 m and a breadth of 5.8 m. Due to the *Mac III's* length, the absence of a crane of over 1 t capacity and restricted operating limits having no persons on board during the voyage then:

- a load line certificate was not required
- no intact stability requirements needed to be met
- it was not required to comply with any other design, construction or equipment requirements as laid down in Maritime Rules Part 40C
- it was not required to be surveyed or issued with a New Zealand barge safety certificate
- it was not required to be issued with a tonnage certificate.

Thus the operator of the *Mac III* was not required to operate within any specific regulatory framework.

1.8.3 As a result of the Maritime NZ investigation into this accident, Maritime NZ issued “Barge Stability Guidelines” in August 2006. The purpose of these guidelines was:

to provide insight into the basic stability concepts relevant to loading and to loaded pontoon barges.

The guidelines required the barge owner/operator and skipper to know:

- the lightship displacement of the barge
- the lightship centre of gravity of the barge
- the weight and centre of gravity of the cargo
- how to calculate the combined centre of gravity of the barge

and be aware of:

- the block coefficient of the barge
- the initial metacentric height and how to calculate it for the loaded barge
- the limiting centre of gravity (KG) curve for the loaded barge.

1.8.4 The majority of the information required to have been known in order to calculate the stability of the barge *Kimihia* was unavailable to the master of the *Nautilus III*.

- 1.8.5 After the tragic accident involving the *Mac III* a coronial hearing was held. The Coroner in his findings dated 22 February 2007 stated:

Concerns about the loading process

81 Ordinarily, in an operation, one would expect that those responsible for the transportation of the goods in question would have some basic systems and some basic understandings in place to enable the transportation of the goods to be safely achieved. A starting point would seem to be to determine how much weight was to be carried. In this case McManaway did not know the weight of the load it was being asked to carry. Moreover, it had no system in place for determining in a systematic way on each occasion what weight was to be carried. Another basic question for a transport operator must surely be the weight carrying capacity and the stability capacity of the vehicle or vessel in question. In this case McManaway had some understanding of the outer limits of weight carrying capacity but it had not addressed, in any systematic way, the inter-relationship between weight, load position, loading dynamics, and stability.

- 1.8.6 On 19 October 2007, a dumb barge of less than 24 m in length, with a 26 t mechanical digger chained to it, sank at its mooring in Tauranga Harbour. Neither the Commission nor Maritime NZ opened investigations into this incident as it was not reported, presumably because the barge was not thought to be subject to the Maritime Transport Act. In conversation with local authorities they said the proximate cause of the sinking was the ingress of water into the barge through open manholes on the deck when the barge became trapped under a set of concrete steps the digger was demolishing, as the tide came in. The incident occurred overnight while no work was in progress, so there were no persons on board at the time. The reason the watertight manhole covers had been left off was not ascertained but may have been for easy access to inspect the inside of the barge, constructed in 1920, for the ingress of water.
- 1.8.7 As the barge was less than 24 m in length and outside the regulatory framework this incident was not reported through the normal channels and was only anecdotally brought to the attention of the Commission.

2 Analysis

- 2.1 The cause of the *Kimihia* capsizing was loss of stability caused by sea-water entering the barge via the holes corroded in the vent pipes. The following analysis looks at the stability of the barge, the way it was loaded, the weather conditions at the time, and the broader issue of survey and maritime legislation.

The voyage

- 2.2 The decision of the master of the tug to take a more sheltered route on the voyage between Picton and Tarakohe was reasonable in the forecast weather conditions. Although the bad weather did not eventuate, the choice showed that the master and crew were aware of the possible conditions and suitable action to take to mitigate the situation.
- 2.3 The method of loading the rock onto the barge minimised the amount of damage that occurred to the deck of the barge and also allowed for the master and crew to ensure that the cargo was placed in the best position.
- 2.4 From all accounts the barge was well stowed and at a good trim for the intended voyage. Trimmed by the stern, this would have made the barge easier to tow and would also have given a greater bow height and help stop waves breaking over the bow during the tow. Any water that did get into the cargo area would have drained either out of the freeing ports at the side or through the open after end of the bin.

- 2.5 The master of the tug organised the crew of the tug to do an internal inspection of the under deck spaces of the barge at the completion of loading to ascertain if any major damage had occurred to the barge during loading, especially the deck plating. From the crew's report and the post-accident inspection there was no other major source of water ingress other than the holes found in the air pipes on deck.
- 2.6 The voyage from Tarakohe was uneventful. The master and crew knew they were going to encounter bad weather so they took the reasonable action of sheltering from the worst of the weather behind Cape Koamaru in Umukorora Bay.
- 2.7 Once near the south coast off Wellington the crew realised that the weather they were encountering was worse than they had anticipated; however, they continued with the voyage because trying to turn the tug and tow in the conditions could have been hazardous.
- 2.8 The master and crew thought, as they drew close to the entrance of Wellington Harbour that the swell appeared to increase to such an extent that they were losing sight of the barge. From the significant wave height graph (see Figure 6) it can be seen that by the time they arrived off the port the swell as recorded at Baring Head had peaked and was starting to diminish. However, the shallowing of the water and the outgoing tide from the harbour would have made the swell heap up and the swell would have appeared to increase. Around the south coast and entering Wellington Harbour in southerly conditions would have been the most hazardous part of the journey, and would have been where progressive down flooding of the *Kimihia's* voids probably started.
- 2.9 The extra strain put on the tow rope caused by the tug being on the opposite side of a wave from the barge was enough to cause the tow rope to fail. The master had tried to mitigate the situation by adjusting the speed of the tug, thus reducing the strain on the tow rope. Once the tow rope had failed, the barge was likely to naturally take up a heading side on to the waves, possibly accelerating the amount of down flooding through the badly corroded air pipes.
- 2.10 Due to the momentum of the barge when the tow-line broke, the barge overran the tow line, leaving the end of the towline floating astern.
- 2.11 Once the tug had recovered the tow-line and started towing the barge stern first, the barge would initially have put its port side broadside to the sea allowing a greater amount of water to be taken on deck. Towing the barge stern first with its lower stern freeboard would also have allowed more water to be taken on deck.
- 2.12 When the tow-line freed itself and the barge turned the correct way around, this would again have exposed the port side to the sea with possibly more water entering the voids through the wasted air pipes. It is highly likely that the stability of the barge had been eroded by the free surface of water in the voids before the attempt to enter Wellington Harbour.

Stability and load line

- 2.13 On completion of loading the master of the tug checked the freeboard of the barge; this to him suggested that the barge was not overloaded. From the basics of stability he had been taught when completing his ILM certificate he assumed that the stability of the barge was not compromised because:
- the cargo was not loaded any higher than usual (so he had not raised or lowered any weights)
 - the cargo was tightly stowed (so he had no freely suspended weights)
 - the cargo was a solid and there was minimal free water on the inside of the barge (so there was no free surface effect)
 - the freeboard was about 300 mm greater than the minimum assigned freeboard (so he did not have a low freeboard)
 - the freeing ports were open.

However, the content of the stability syllabus included in the ILM certificate was not enough for the master to properly understand the need for adequate stability to ensure the safety of the cargo and barge.

- 2.14 For the master of a tug towing a barge to be able to calculate its stability they would be required to have knowledge of the general principles of stability and the basic stability formulae. These basic formulae were not included in the syllabus for the ILM certificate that the tug master held.
- 2.15 Another method of determining the stability of the barge was contained in the Barge Stability Guidelines. This method would have required only a few simple mathematical calculations to be made and the ability to use the answers obtained to interpolate the vessel's KG from a graph. These calculations should be within the capabilities of a person who has obtained an ILM certificate, and sufficiently familiarised with the tug and barge they are operating
- 2.16 To calculate this simplified, or indeed the basic, stability then the lightship displacement, centre of gravity, block coefficient and initial metacentric height would be required to be known. This information would also be required for the compilation of the limiting KG curve. For these parameters to be known, the barge's stability would have to have been calculated when the barge was designed and built, and an inclining experiment would have had to have been carried out.
- 2.17 These stability calculations were supposed to have been made for the *Kimihia* at several times in the past, but for various reasons discussed later in this report it was not done.
- 2.18 The owner had provided a copy of the Barge Stability Guidelines to the tug crew, but the master was unable to calculate the stability of the barge as he did not know the basic stability information for the barge as the data was not available to him. When asked to show how to calculate the stability of the barge the master did not understand how to do the calculations required, because he had never been shown how, or instructed in the theory behind it.
- 2.19 This incident had some similarities to the capsizing of the barge *Mac III* in Picton with the loss of 2 lives. Neither master had the means or the knowledge to assess the stability of their barges, nor were they required to.
- 2.20 The saviour in the case of the *Kimihia* was that the skipper did know by weight how much he was loading, and it was a regular cargo that had been carried 11 times before. It would, however, have been easy for him to be misguided by the incorrect or at least contested load line that had been assigned to the barge. Had he loaded the barge down to that load line, it is possible it would have capsized in the sea conditions experienced without taking on water through the air pipes.
- 2.21 As it turned out, the stability of the *Kimihia* as loaded was adequate for the intended voyage, provided the watertight integrity of the barge had been maintained.
- 2.22 The amount of water flooding over the deck during the voyage, would have had little effect on a watertight barge; however, with 3 of the air pipes extensively holed, large amounts of water would have drained down into the barge's interior.
- 2.23 Although the position of the holes formed by corrosion wastage of the metal of the air pipes was hidden from view, this is a typical place for such wastage to occur and should be carefully examined during any survey concerned with the watertight integrity of a vessel by a surveyor.
- 2.24 The wastage due to corrosion on the air pipes was of such an extent that this wastage would have been present when the load line survey should have been conducted by Nortel, thus an opportunity was missed for discovery and remedial repairs to be made to the air pipes. A further opportunity was missed during the out-of-water survey conducted by the new owner's SSM company when the surveyor deemed it unsafe to use a ladder to inspect the air pipes.

- 2.25 The amount of water that entered the interior would have had a detrimental effect on the stability of the *Kimihia* through free surface effect. Once the barge started to list, the freeboard on the lower side would diminish allowing more water onto the deck and down the holed air pipes. After a time the list would have increased to a point where the deck edge of the barge would become immersed. At that point the *Kimihia* would have been close to reaching its point of vanishing stability and prone to total capsize. A short time after this the sea level would reach the holed air pipes, and down flooding would occur and the barge would capsize.
- 2.26 The barge's last remaining reserves of stability were probably lost due to loss of buoyancy in a seaway.
- 2.27 This would explain why the master and crew first noticed a slight list that slowly increased followed by a greater rate of increase in listing, until finally the barge appeared to quickly roll over.
- 2.28 There was a legal requirement for the barge to have stability data when it was certified for use with 2 persons on board; however, when McManaway Tug and Barge purchased the barge and converted it to a dumb barge with no persons on board there was no legal requirement for the barge to have any stability data. It was therefore difficult for a surveyor to insist that an owner went to the extra expense of having an inclining experiment carried out to determine the stability when the owner was not legally obliged to do so. A new inclining experiment would also be difficult to enforce when the owner was aware that the barge had been issued with a load line certificate but he may or may not have been aware that the load line certificate was for a Type "B" ship, for which a stability assessment should have been made.
- 2.29 When the barge was re-built in 1995-1997 and its intended use still included having 2 persons on board, the barge's stability information was required to be calculated. This stability information was mentioned in the letter from SGS M&I to the engineer in charge of the conversion. However, as no stability information could be found and none of the parties asked could recollect having seen any stability information, it is possible that this information was either never calculated or never made available.
- 2.30 Prior to the rebuild, stability calculations were required for the *Kimihia* to demonstrate to the Assistant Chief Surveyor that the *Kimihia* had adequate stability at the freeboard assigned under the Ministry of Transport circular 1987/55. The circular was still being used under the Maritime Transport Act 1994 until the relevant Maritime Rules came into force in February 1998. When the Maritime Rules came into force the *Kimihia* would still have been required to meet certain stability requirements as the barge was still certified to carry 2 persons on board. This did not happen either.
- 2.31 When the load line calculation took place, the calculation was completed by a naval architect engaged by Nortel. This naval architect was remote from the Nortel office and from the location of the barge; therefore, he could only work from the information supplied to him in hard copy or by telephone by Nortel. The naval architect's calculation was, as he stated to Nortel, dependent upon any stability analysis. He was not told if a stability analysis had been carried out, neither was he told if a survey had been completed; however, he applied to Maritime NZ for the issuance of a load line certificate for an incorrect Type B existing ship on Nortel's behalf signifying that a survey had been carried out. Due to the design of the Nortel form he was restricted to a Type A or B ship application, however, he could have annotated the form to apply for a load line for a barge.
- 2.32 The regulator issued a load line certificate for a Type B ship without checking the veracity of the application, as it would have been highly unlikely that a Type B ship with the principal dimensions of the *Kimihia* would have a freeboard as low as that assigned to the *Kimihia*. The fact that the *Kimihia* had been incorrectly assessed as a Type B ship and that its load line was incorrectly assigned indicates a lack of process surrounding the application of Maritime Rules.

- 2.33 Statistics show that the number of dumb barges in use around the coast of New Zealand is growing. From the evidence received by the Commission it would appear that dumb barges are possibly being constructed at lengths just under the 24 m threshold to circumvent the need to enter the regulatory framework.
- 2.34 While gathering the information the Commission became aware of a barge in use, with a pile driver operating on board, on one of New Zealand's lakes that was 27 m long and 12 m wide. However, this barge was made up of 12 smaller barges of 9 m in length and 3 m in width joined together. The operator said that it had been informed by the regulator that the barge did not need to be certificated or in survey but stability issues should be considered. The operator had since completed its own stability calculations for the barge and had the barge surveyed by its own staff for its own piece of mind. This raises the question as to which Maritime Rules should be applied to modular barges in this case?
- 2.35 For whatever reason, the stability requirements for unmanned dumb barges were excluded from the Maritime Rules. In light of the lessons learned from the accident involving the *Mac III* and this incident, a review of the current Rules is needed. Given the time traditionally taken to amend Rules, some urgent measures need to be taken to mandate the requirement for stability for dumb barges and the means for the crew to understand and be able to calculate the stability. This would go some way to ensuring the safety of the environment and persons associated with the loading and unloading of dumb barges.

Safe ship management

- 2.36 Nortel entered into an agreement with the owner in April 2001 to supply SSM services for the *Kimihia* indicating that the barge was still carrying 2 persons on board. The number of allowable persons on board was confirmed when a fit-for-purpose certificate was issued on 17 April 2001. To issue a fit-for-purpose certificate the SSM company should have at least sighted the stability calculations because a fit-for-purpose certificate means that, among other things, the *Kimihia* complied with the relevant rules. The SSM company would also have been required to sight the submersion line certificate. It may have done this but did not comment that this certificate only had 5 months before expiring. Nortel continued to provide SSM services for the *Kimihia*, carrying out 3 audits, 2 SSM profiles and the issuance of a new SSM certificate in the next 3 years 9 months, before advising the owner that a load line certificate was required in June 2005. However, the load line calculation and issuance of a load line certificate did not take place until October 2006 and, even then, without the required stability having been assessed.
- 2.37 The owner of the *Kimihia* had the responsibility of ensuring that the vessel complied with all relevant regulations and was responsible for presenting the vessel ready for audits, surveys and entry into the SSM system. In this context the owner, the SSM company and the regulator responsible for monitoring the performance of the SSM company all had a joint responsibility to ensure that the vessel was fit for purpose.
- 2.38 A reasonable expectation would be that any initial survey for a new, or a new to the system, vessel would be thorough, would test the ship for total compliance with the Rules, and would pick up any unsafe engineering and operational practices.
- 2.39 The owner could reasonably have expected recognised surveyors from an SSM company to have sufficient expertise and knowledge of the requirements to highlight most major deficiencies. Conversely it was reasonable for the SSM company to expect the owner to have an understanding of the regulations and to have ensured that its vessel was compliant before presenting the vessel for survey. Yet the ship operated in the system for nearly 4 years, without identification of a major non-conformance with the Maritime Rules.

- 2.40 In the Commission's Marine Occurrence Report 06-208, fishing vessel *Santa Maria II*, engine room fire, 105 nm west-southwest L'Esperance Rock, Kermadec Islands, 10 December 2006, the Commission commented on the standard of surveying within the SSM system. The Commission recommended (recommendation 042/07) to the Director of Maritime NZ that she:

By the most appropriate means ensure that all marine surveyors employed by safe ship management companies' are fully aware of their obligations under Maritime Rules Part 21 Safe Ship Management Systems to carry out work with due care and diligence in accordance with the requirements of the Maritime Rules.

On 24 July 2007, the Director of Maritime NZ replied:

Recommendation 042/07

This recommendation is acceptable to Maritime NZ which is expected to be completed in the 2008 year.

Safety recommendation 042/07 is considered to be equally applicable in this case, so although the recommendation is not reiterated here the Commission still concludes that this recommendation is of high importance, and will remain open.

Manning

- 2.41 The *Nautilus III* was certified to operate as a non-passenger ship in the coastal area when correctly manned. When operating in the inshore area the requirements for manning were reduced, and at the time of the occurrence the *Nautilus III* was correctly manned for operation in the inshore area. The inshore area can be up to 12 nm off the coast of New Zealand and as such the *Nautilus III* could have completed the voyage from Tarakohe to Wellington without going more than 12 nm off the coast of North or South Island as the 12 nm limits surrounding the 2 islands overlap in Cook Strait. However, Maritime NZ considered Cook Strait to be a coastal area because Maritime Rule 20.5 stated that:

Where a surveyor assigns inshore limits to a ship which include a defined section of the coastal limits not beyond the limit of the territorial sea of New Zealand, these limits must not allow the ship to undertake a voyage across Cook Strait.

The *Nautilus III* had been surveyed and the design, construction and equipment found to be suitable for use in coastal limits and so, had been assigned coastal limits. The *Nautilus III* could therefore cross Cook Strait provided the master held an NZOW certificate of competency. The master only held an ILM certificate of competency so was not qualified to perform the voyage according to the Rules, but, a master of a non-passenger-carrying fishing ship of less than 20 m in length holding an ILM certificate of competency could have performed the voyage according to the Rules. This inconsistency probably led to a degree of confusion with the operator as to what qualifications his employees required to perform his trade.

- 2.42 In the Commission's Marine Occurrence Report 04-212, fishing vessel *Iron Maiden*, foundering, off Pandora Bank, 16 August 2004, the Commission commented on the lack of clarity regarding the manning of fishing vessels and the confusion about the extent of certain limits. The Commission recommended (recommendation 028/05) to the Director of Maritime NZ that he:

in order to reduce confusion and the possibility of misinterpretation, develop a policy to rationalise and simplify the current maritime rules concerning the crewing and watchkeeping requirements for non-SOLAS vessels, and the limits in which they operate.

The Director of Maritime NZ replied at the time that:

Maritime Rules 31B and C are currently being amended. MSA is prepared to accept this recommendation, provided suitable funding is obtained in its 06/07 rules bid to extend this work.

Unfortunately, funding was not available to extend the work at that time. Information available from Maritime NZ at the time of writing was that draft amendments to Maritime Rules Parts 31A and 31B for crewing and watchkeeping on vessels other than fishing vessels had been made available for comment as part of the formal consultation process. Safety recommendation 028/05 is considered to be equally applicable in this case, so although the recommendation is not reiterated here the Commission still concludes that this recommendation is of high importance, and will remain open.

Summary

- 2.43 The Maritime Rules concerning load line, survey, design and construction, and certification were contained in Parts 40C, 46, and 47. These Parts were further subdivided into sections pertaining to various types and sizes of vessels, some of which referred to other sections contained within the same Part or within other Parts of the Maritime Rules. The wording in the Rules within each section was not easy to follow.
- 2.44 It would have been easy to become confused when reading and trying to follow the sometimes extended chain of reasoning through the Rules. There appeared to be little logic in where to look for the information required. For example, Maritime Rules Parts 31B and 31C are about crewing and watchkeeping within restricted limits and on board fishing vessels, yet the paragraph concerning the crossing of Cook Strait is contained in Maritime Rules Part 20.
- 2.45 There were several Maritime Rules that covered the requirements for vessels engaged in various businesses in the designated areas and the associated manning levels and certificates required. This made the regulations complex and difficult to follow, especially when certain caveats had been “grandfathered” in from previous regulations so as not to disadvantage anyone.
- 2.46 There were several dates through the history of the *Kimihia* where it was mandatory under the then current legislation for the barge to have undergone a stability assessment. There were several opportunities to have recognized and acted on that requirement; they were:
- when the *Kimihia* was built in 1957
 - when the barge was purchased and converted by Winstone Aggregates in 1995
 - when the conversion was completed in 1997 and the *Kimihia* should have been entered into SSM, but was not
 - when the *Kimihia* entered safe ship management with Nortel in 2001
 - during several audits conducted by Nortel between 2001 and 2005 (when it was finally realised the *Kimihia* had neither a submersion line nor load line certificate)
- 2.47 Ironically, the first time in the *Kimihia*’s history that it did not require stability assessment (when it was converted to a dumb barge) it was erroneously issued with a load line certificate for a Type B ship that was supposed to be subject to a stability assessment, but even then one was not done.
- 2.48 The *Kimihia*’s history did span a period of changing legislation, including periods of transition between Acts and Rules. By careful scrutiny of the legislation the requirements for the *Kimihia* could be found, but the task was difficult and required the interpretation between several Acts and Rules.
- 2.49 What is clear is that the successive statutory maritime authorities responsible for overseeing and enforcing compliance with the Rules have themselves struggled to follow the complex Rules and Acts and how to apply them to the *Kimihia*, or they simply have not enforced them.
- 2.50 Maritime NZ has identified the need for clear processes, and has developed and put into use new procedures and certificate templates (supported by advisory notes) for its own staff, SSM companies and surveyors, ship owners and ship operators to aid in understanding and applying the legislative requirements. Some of these have been included in Appendix 3.

3 Findings

Findings are listed in order of development, not in order of priority.

- 3.1 The *Kimihia* capsized when its stability reserves were eroded by the free surface effect of water in its void spaces caused by the progressive down flooding through holes corroded in vent pipes servicing those void spaces.
- 3.2 The *Kimihia* was loaded and trimmed in a way that should have survived the sea conditions encountered if the watertight integrity of the barge had not been compromised.
- 3.3 The air pipe vents to the voids were critical to the watertight integrity and stability of the barge; the condition they were in during the incident voyage and at the time of the *Kimihia*'s last survey meant the barge was not fit for purpose. (see previous safety recommendation 042/07 regarding safe ship management)
- 3.4 Under Maritime Rules there was no requirement for any unmanned dumb barge of less than 24 meters in length (such as the *Mac III*) to:
 - have a load line assigned
 - be measured for tonnage
 - have a barge safety certificate
 - comply with any design, construction or equipment criteria
 - meet any stability test or have basic stability documentation.
- 3.5 Under Maritime Rules there was no requirement for unmanned dumb barges over 24 meters in length (such as the *Kimihia*) to meet any stability test, or have basic stability documentation.
- 3.6 The essentially unregulated regime that dumb barges operated in meant that the persons involved in the loading, unloading and manoeuvring of such barges were potentially not offered the same level of safety as with other types of commercial marine craft (see safety recommendation 001/08 below).
- 3.7 The qualifications held by the *Nautilus III*'s master and crew did not meet the levels required by Maritime Rules, a situation that arose out of poor understanding of complex and in some cases incompatible Maritime Rules for ship operating limits and crew qualifications (see previous safety recommendation 028/05 regarding operating limits and qualifications).
- 3.8 The *Kimihia* was erroneously assigned a Type B ship load line without undergoing the required stability assessment, and the barge was operating outside the enclosed limits the load line had been assigned for. The load line could have misguided a crew, who typically had limited knowledge of stability commensurate with their level of qualification, into overloading the *Kimihia* to a point of marginal stability (see safety recommendation 002/08 below).
- 3.9 The various owners, operators, surveyors and staff from the maritime authority in its various forms, either did not have adequate understanding of, or elected not to apply, the various rules and regulations to the *Kimihia* for most of its 50-year life. In more recent years at least, this poor standard of rule following resulted from a lack of formal documented procedures to ensure the correct standards were applied (see safety on next page).

4 Safety Actions

4.1 After the accident Maritime NZ:

- was in the process of implementing a large project review and upgrade of the whole SSM system
- completed a third party review of barge certification
- reviewed barge-related Maritime Rules
- reviewed and updated SSM barge certification procedures
- reviewed Maritime Rule part 21 section 2 (regarding SSM)
- developed and put into use new barge certificate templates
- implemented improved practices within the Maritime NZ SSM team
- implemented a series of mandatory surveyor training seminars at which written assessment papers were to be completed as part of surveyors' re-recognition process.
- brought to the attention of SSM companies, and discussed, recent barge incidents
- created barge stability guidelines
- commenced developing a code of practice for barge operations

Copies of Maritime NZ advisory notes to aid safe ship management companies, surveyors, owners and operators in decisions for Load line, certification requirements are contained in Appendix 3.

5 Safety Recommendations

Safety recommendations are listed in order of development, not in order of priority.

5.1 On 20 March 2008 the Commission recommended to the Director of Maritime New Zealand that she:

- 001/08 take the steps necessary to ensure that all dumb barges with no persons on board that are used commercially for the carriage of cargo are brought within the safety framework of the Maritime Rules with regard to the issuance of load lines and the provision of stability information.
- 002/08 take the steps necessary to ensure masters of tugs, barges and other craft where stability is critical to their operation are provided with sufficient training in how to apply the provided stability information to ensure their vessels remain compliant with appropriate stability criteria.

5.2 On 28 March 2008, the director of Maritime New Zealand replied:

- 001/08 Policy work will be carried out during the 08/09 year to assess whether this recommendation meets the threshold for acceptance by the Ministry of Transport onto the Rule development programme.
- 002/08 As part of the 40D review, it is proposed to create a training course on vessel stability. The course being developed will be such that it can be presented to not only the fishing industry, but also to masters of non-passenger and passenger vessels.
- MNZ is proposing to utilise a course developed by SNMAE (Society of Naval Architects and marine Engineers) called *Fishing Vessel Stability Training Course*. The course teaches, over the space of 1-2 hours, the basics of stability, from which many scenarios can be discussed.

Approved on 20 March 2008 for publication

Hon W P Jeffries
Chief Commissioner

Appendix 1

The transverse stability of a vessel determines, among other things, its roll period. A ship with a high transverse stability is said to be “stiff” and has a short, quick roll period, whereas a ship with a low transverse stability is said to be “tender” and has a longer, slow roll period. Decreasing the stability too far would make a ship unstable and unsafe.

The figure below illustrates a basic explanation of stability and the terms and definitions associated with it, showing a ship’s hull at an angle of heel to the waterline **WL** of θ (theta) degrees.

When the hull is immersed in water, the buoyant force from the water pressure acts through a point **B**, the centre of buoyancy. This force is equal and opposite to the displacement Δ of the vessel which acts downward through the centre of gravity **G**.

B is initially on the centreplane, but when the vessel is rolled to an angle θ , the change in immersed underwater shape causes it to move to a point **B¹**. At this angle the lines of action of the forces of buoyancy and displacement are separated by the horizontal distance from **G** to **Z**.

The distance **GZ** is the righting lever, and is an important indication of a ship’s stability at angles of heel over about 10° . Large values of **GZ** mean that the forces have a longer lever arm and the ship will return to the upright position more rapidly. Negative values of **GZ** mean that the ship will capsize.

At the intersection of the vertical line through **B¹** and the centreplane of the vessel is the metacentre **M**. The height of **M** above **G** is the metacentric height **GM** and is a useful measure of stability at angles of heel up to around 10° . Large values imply that a vessel is stiff, small values imply that it is tender and negative values imply that it is unstable. **GZ** is related to **GM** by the equation: $\mathbf{GZ} = \mathbf{GM}(\sin \theta)$.

Point **K** is a reference point on the keel of the ship. Point **N** is a point level with **K** on the vertical line through **B¹**. The distance **KN** is used for analytical purposes and is represented in **KN** tables.

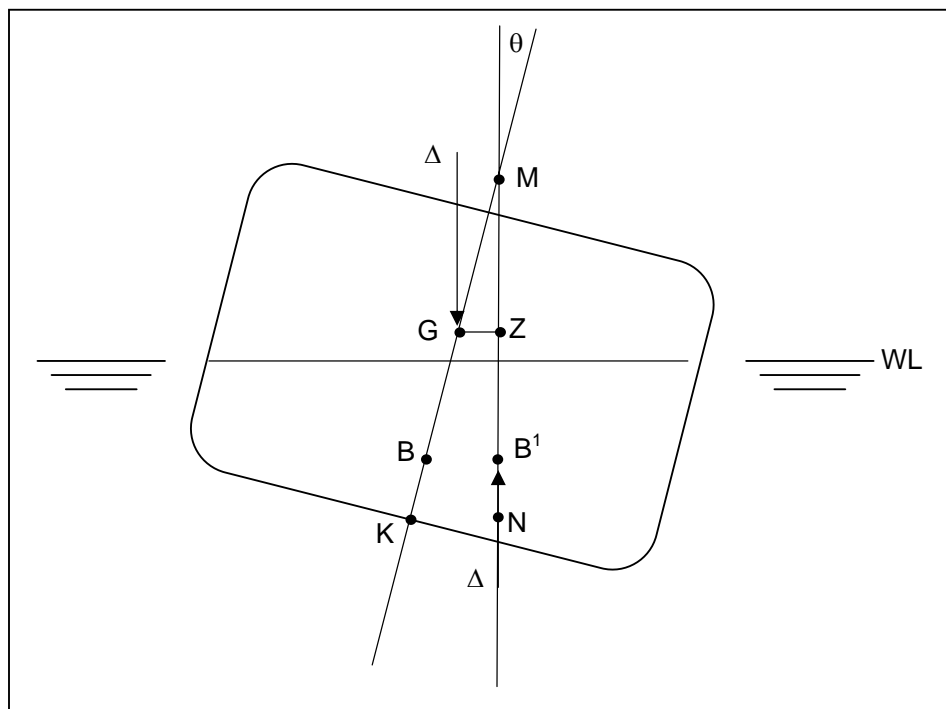


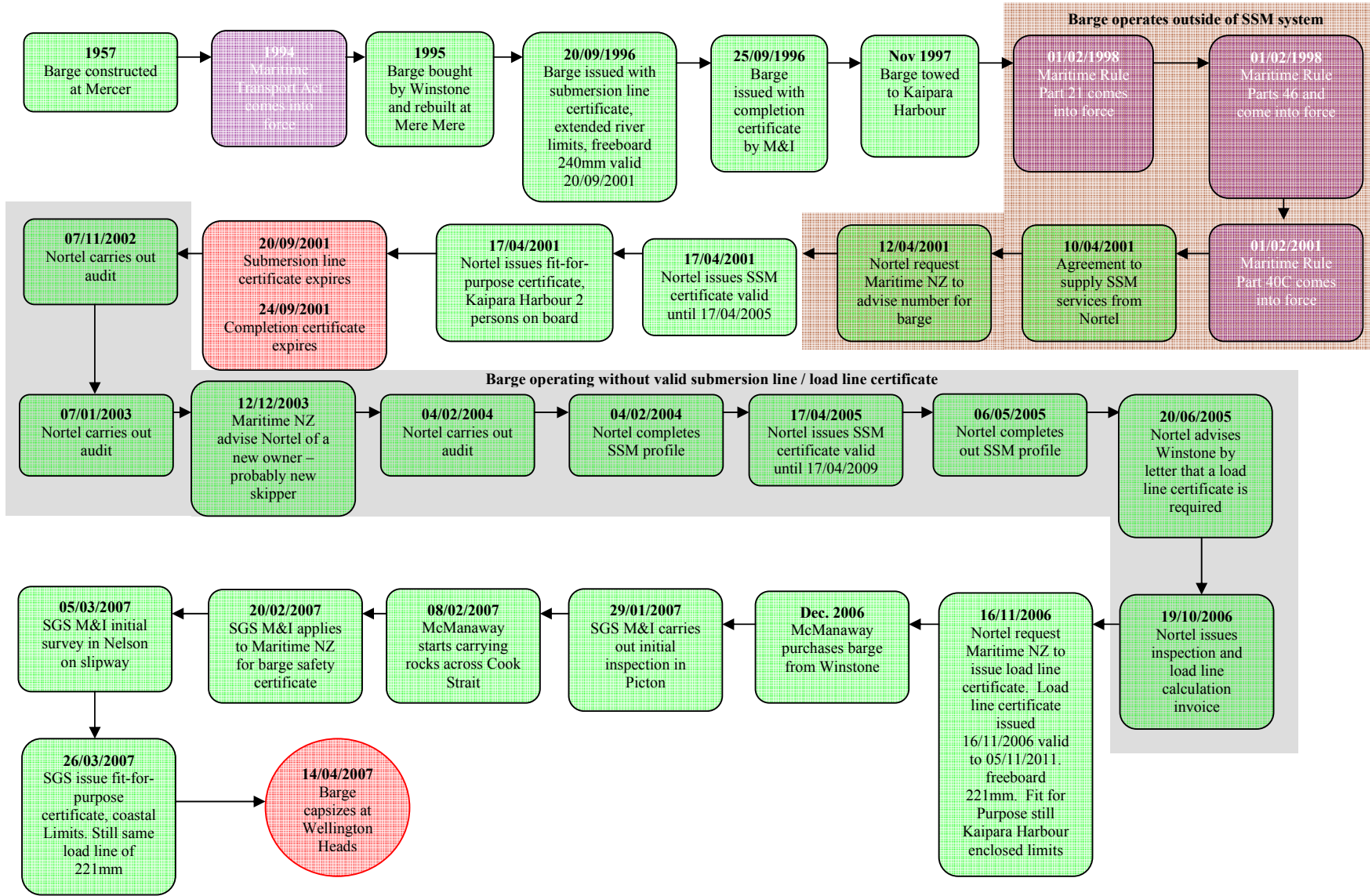
Figure 11
Basic stability diagram

A simplified method of determining a vessel's stability when carrying cargo was to use a limiting **KG** curve graph. This graph plotted the displacement of the vessel and cargo against the homogenous **KG** (the distance **K** and **G** of the vessel and cargo combined) and showed a curve of recommended maximum **KG** against displacement.

As cargo was loaded on the deck, in this case, of the barge, the homogenous centre of gravity **G** would rise and thus the **KG** would increase. As the cargo was loaded the vessel would sink in the water to a draught that reflects the combined weight of the vessel and cargo and thus **B** would rise and the **KB** would increase although not by as much as the increase in **KG**. As the **KG** increased the **GZ** would decrease.

A factor that could adversely affect the stability of a vessel was free surface. As a ship floods there was a loss of stability due to free surface effect as the flooding water accumulated within the hull in tanks and spaces and these spaces became partially filled. As the vessel inclined the surface of the liquid stayed level, this resulted in a displacement of the centre of gravity of the tank or space. The effect is similar to that of carrying a large flat tray of water. When an edge is tipped, the water rushes to that side which exacerbates the tip even further and can cause a vessel to capsize.

Appendix 2



Advisory Notes

Application for a Load Line or Barge Certificate

Code: MO/04 R/00

Issue Date: March 2008

Owned by: Manager Safety Management Systems

Review Date: March 2009

Authorised by: General Manager Maritime Operations

1 General Items

- 1.1 The following shall be noted when completing any draft Load Line Certificate:
- a) Length is defined in 47.2;
 - b) Type A refers (broadly) to Oil Tankers and Type B is any other type of ship (see ICLL 2004 Regulation 27 for details);
 - c) The ship Owner can apply for increased or decreased freeboard provided this is according to Maritime Rule 47 or the International Convention on Load Lines and justification is supplied in the application;
 - d) Barges cannot have increased or decreased freeboards;

2 Specific Procedure (International Load Line Certificates)

- 2.1 International Load Line Certificates may only be issued to ships of 24m or more in length that are:
- e) New Zealand ships; or
 - f) Foreign ships in New Zealand waters.
- For more details on inclusion and exclusion see MR47.6;
- 2.2 International Load Line Certificates will usually be issued by one of the MNZ recognised Classification Societies .

3 Specific Procedure (International Load Line Exemption Certificates)

- 3.1 International Load Line Exemption Certificates may only be issued to:
- 3.2 Ships with special features of a "novel" kind; or
- 3.3 Ships that are not normally engaged on an international voyage but under exceptional circumstances are undertaking a single international voyage.
- 3.4 When a International Load Line Exemption Certificate is applied for, in addition to the completed application form the following documentary evidence shall be provided by the Owner as to:

- 3.5 The novel features of the ship that does not allow it to comply with Maritime Rule 47 Section 1; and
- 3.6 Measures taken to achieve an equivalent level of safety which are satisfactory for it's intended service; or
- 3.7 Confirmation that the international voyage is a single voyage and the reasons for that voyage; and
- 3.8 Evidence that the ship is safe for it's intended voyage.
- 3.9 When a International Load Line Exemption Certificate is issued the IMO shall be notified as to the ship particulars and the reasons for the granting of the exemption. This shall be done by the Nautical Advisor SMS

4 Specific Procedure (New Zealand Load Line Certificates)

- 4.1 New Zealand Load Line Certificates may only be issued to a New Zealand Ship that does not proceed on a international voyage (MR47.61).
- 4.2 New Zealand Load Line Certificates are only issued to "decked" ships <24m that (MR47.54(3)).:
 - a) Are New Zealand ships that carry cargo; or
 - b) Are foreign ships operating on the New Zealand coast; or
 - c) Are barges carrying persons during the voyage.

5 Specific Procedure (New Zealand Load Line Exemption Certificates)

- 5.1 A New Zealand Load Line Exemption Certificate may be issued:
- 5.2 Against a specific prescribed requirement of Maritime Rule 47 Section 2 if an alternative, which provides an effective equivalent (as shown in trials), to the prescribed requirement; or
- 5.3 The novel features of the ship that does not allow it to comply with Maritime Rule 47 Section 1; and
- 5.4 Measures taken to achieve an equivalent level of safety which are satisfactory for it's intended service; or

6 Specific Procedure (Barge Safety Certificates)

- 6.1 It is important to note that a Barge Safety Certificate are only issued to New Zealand Barges that are 24 m or more in length that carry, for hire or reward, any cargo, wastes, dredgings or other materials.

A Barge Safety Certificate does not apply to any barge that carries persons during the course of the voyage.

A Barge Safety Certificate assigns freeboard to a barge.

- 6.2 The Data Administrator will receive applications for a Barge Safety Certificate from the Owner. The application must include:
 - a) Identification of the barge and confirmation that maritime rule 46 section 3 applies;

- b) Written notification from the appropriate surveyor stating that the barge safety survey has been successfully completed an initial survey as required by maritime rule 46.23(2) or renewal survey as required by 46.23(3);
 - c) Evidence that freeboard has been assigned; and
 - d) If the barge has a crane of 1 tonne or greater, evidence that the stability has been approved as required by maritime rule 46.23(2)(b)(ii).
- 6.3 The Nautical Advisor SMS will review each application to confirm the following:
- a) That maritime rule 46 section 3 applies in this case i.e. 24 m or more in length that carries for hire or reward, any cargo, wastes, dredgings or other materials and does not carry persons;
 - b) Application is complete and accurate – paying special attention to barge details, ship type and correct application of rules;
 - c) Freeboard has been assigned;
 - d) Evidence that structure, machinery, boilers, pressure vessels, anchors, navigational lights etc referred to on the barge safety certificate have been surveyed (where evidence is not provided of structure/ equipment not being surveyed those sections shall be deleted from the draft certificate);
 - e) All survey findings have been closed;
 - f) If a crane of 1t or greater is onboard then stability must be approved by a approved naval architect;
 - g) Survey has been completed by surveyor approved for this scope of work.
- 6.4 Once the Nautical Advisor SMS has signed off the Action Sheet that the items in Section 10.3 are correct the file shall be passed to the Data Administrator, who will use the information in the file to draft the appropriate Barge Safety Certificate. A controlled certificate template shall be used. The Action Sheet shall be signed off.



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