THE COMMONWEALTH OF THE BAHAMAS

M.V SEABOURN ENCORE
IMO NUMBER: 9731171
OFFICIAL NUMBER: 7000860

Report of the marine safety investigation into a collision with a bulk cement carrier on 12 February 2017 at Timaru, New Zealand

The Bahamas conducts marine safety or other investigations on ships flying the flag of the Commonwealth of the Bahamas in accordance with the obligations set forth in International Conventions to which The Bahamas is a Party. In accordance with the IMO Casualty Investigation Code, mandated by the International Convention for the Safety of Life at Sea (SOLAS) Regulation XI-1/6, investigations have the objective of preventing marine casualties and marine incidents in the future and do not seek to apportion blame or determine liability.

It should be noted that the Bahamas Merchant Shipping Act, Para 170 (2) requires officers of a ship involved in an accident to answer an Inspector's questions fully and truly. If the contents of a report were subsequently submitted as evidence in court proceedings relating to an accident this could offend the principle that individuals cannot be required to give evidence against themselves. The Bahamas Maritime Authority makes this report available to any interested individuals, organizations, agencies or States on the strict understanding that it will not be used as evidence in any legal proceedings anywhere in the world. You must re-use it accurately and not in a misleading context. Any material used must contain the title of the source publication and where we have identified any third-party copyright material you will need to obtain permission for the copyright holders concerned. This marine safety investigation was conducted by the Coastal State in accordance with the IMO Casualty Investigation Code MSC.255(84). The Bahamas Maritime Authority participated in the marine safety investigation and duly recognised as a substantially interested State. We would like to thank Transport Accident Investigation Commission (TAIC) for producing this report and for their continued cooperation.

The investigation report below can also be accessed through TAIC and is available via the following link:
https://taic.org.nz/inquiry/mo-2017-204

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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.

Final Report

Marine inquiry MO-2017-204

Passenger vessel *Seabourn Encore*

Breakaway from wharf and collision with bulk cement carrier at Timaru

12 February 2017

Approved for publication: February 2019

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

Ownership of report

Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1982 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

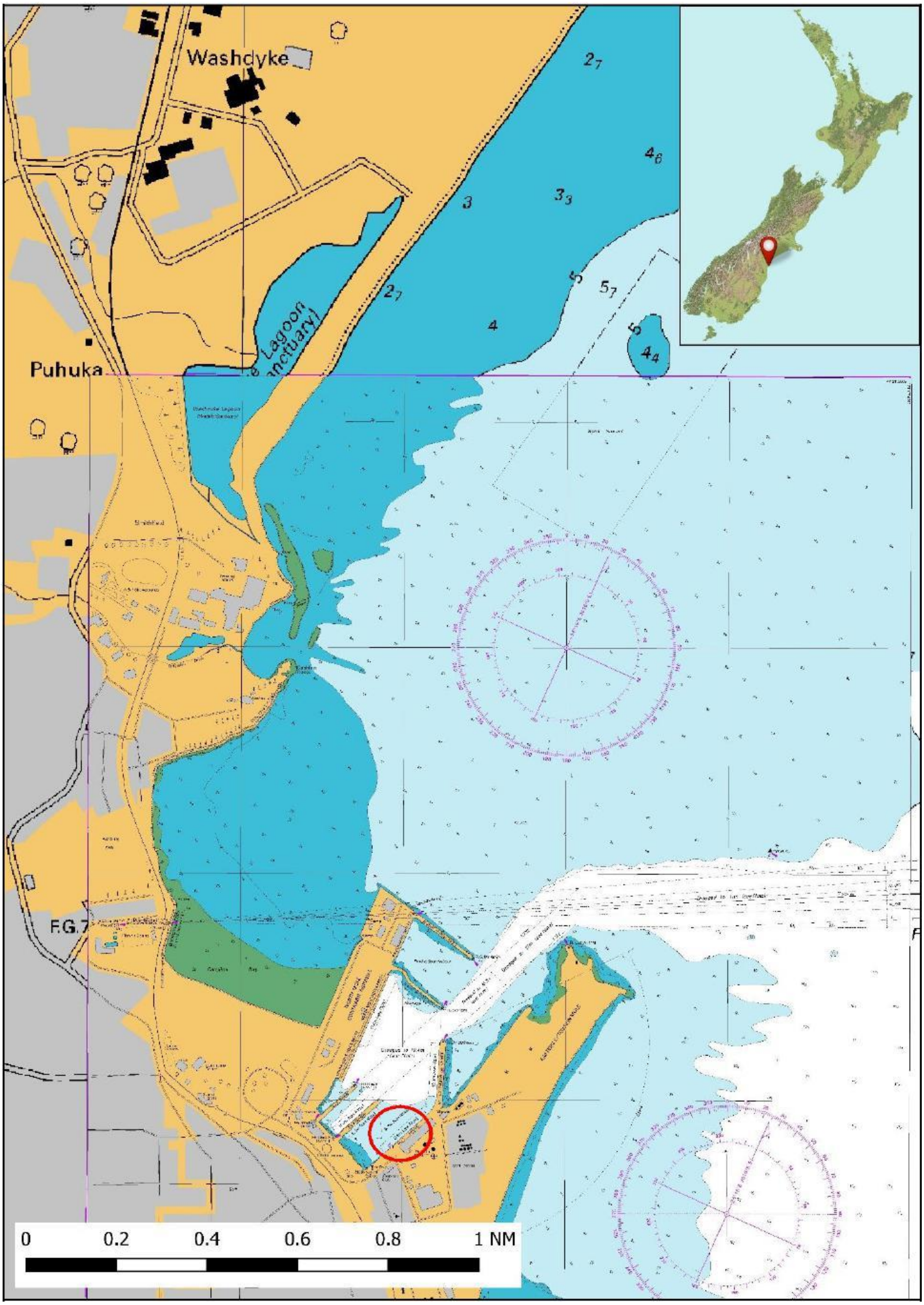
Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Verbal probability expressions

The expressions listed in the following table are used in this report to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis.

Terminology (Adopted from the Intergovernmental Panel on Climate Change)	Likelihood of the occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

The Seabourn Encore



Location of accident

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Abbreviations

°	degree(s)
CCTV	closed-circuit television
ISO	International Standards Organisation
kgf	kilogram-force
m	metre(s)
MBL	minimum breaking load
mm	millimetre(s)
OCIMF	Oil Companies International Marine Forum
Opus	Opus International Consultants Limited
SMS	safety management system

Glossary

bitts	paired vertical steel posts mounted on board a ship, used to secure mooring lines
bow or stern thruster	a transverse propulsion device mounted at the bow and/or stern to help make the vessel more manoeuvrable
classification society	a non-government organisation that establishes and maintains technical standards for the construction and operation of ships and offshore structures
fairlead	an opening at the forward and aft ends of a vessel used to guide a rope, usually to a tug or to the shore, keeping it clear of obstructions and preventing it cutting or chafing
head line	mooring rope leading forward from the bow and secured ashore
knot(s)	nautical mile(s) per hour
panama fairlead	a type of fairlead specifically designed for use when a vessel is being towed through the Panama Canal, but also used for routine mooring operations
port	the left hand side of the ship when looking forward
rendering load	a load applied to the mooring winch which, when the brake is applied, causes the drum to rotate in the direction opposite to the driving torque.
roller fairlead	a type of fairlead designed to reduce the amount of friction on a rope
quarter (port or starboard)	the part of a vessel's side towards the stern
spring	a mooring rope leading forward or aft to help reduce the movement of a vessel in a forward or aft direction
starboard	the right hand side of the ship when looking forward
stern line	a mooring rope leading aft from the stern and secured ashore
windage area	the exposed area of one side of a vessel above the waterline

Data summary

Vehicle particulars

Name:	*Seabourn Encore*
Type:	passenger ship
Class:	Class 1
Limits:	unlimited (SOLAS)
Classification:	Registro Italiano Navale
Length:	210.5 metres
Breadth:	28 metres
Gross tonnage:	41,865
Built:	November 2016
Propulsion:	two 6,000-kilowatt electric propulsion motors, each turning one propeller
Service speed:	15 knots
Registered owner:	Seabourn Cruise Line Limited, part of the Holland America Group
Port of registry:	Nassau, Bahamas
Crew:	428

Date and time 12 February 2017 at about 1515[1]

Location Number One Wharf – PrimePort Timaru

Injuries none

Damage the *Seabourn Encore* sustained minor indentation damage to the port quarter above the waterline

the *Milburn Carrier !!* sustained damage to the hull, causing a breach of watertight integrity on the starboard side midships in the vicinity of the waterline

PrimePort Timaru sustained damage to Numbers One and Two wharfs

[1] Times in this report are in New Zealand Standard Time (co-ordinated universal time + 12 hours) and are expressed in the 24-hour format.

1. Executive summary

1.1. On 12 February 2017, the passenger ship *Seabourn Encore* was berthed at Number One Wharf in PrimePort Timaru to facilitate passenger excursions ashore. The ship was secured to mooring bollards on the wharf using its own mooring lines.

1.2. During the day the weather changed rapidly and earlier than predicted. The wind increased in intensity and changed direction so as to push the ship away from the wharf. As a result, a number of mooring bollards on the wharf progressively failed by tearing from the wharf.

1.3. The resulting load on the remaining mooring lines caused them to break, and the stern of the ship swung across the harbour and collided with a bulk cement carrier that was in the process of berthing at an adjacent wharf. The *Seabourn Encore*'s crew were able to establish power to the ship's propulsion systems in time to lessen the impact and to maintain control of the ship until the wind abated enough to re-secure the ship to its berth with the aid of a harbour pilot and tugs.

1.4. As well as the damage to the wharf, the hull of the bulk cement carrier was holed near the waterline, but the damage occurred where a water ballast tank was located so did not materially affect the ship's stability. The *Seabourn Encore* sustained damage to its shell plating. Nobody was injured.

1.5. The Transport Accident Investigation Commission (Commission) found that the *Seabourn Encore*'s mooring lines and associated equipment were in good condition and were not factors contributing to the accident. However, the mooring bollards failed because the unique method with which each had been fastened to the wharf and/or the strength of the underlying wharf structure meant they were unable to withstand the forces imparted on them by the *Seabourn Encore*'s mooring lines.

1.6. The Commission also found that the port company had virtually no knowledge of the actual safe working loads of the various mooring bollards on the wharf and that the mooring procedures for the port were not strictly followed.

1.7. The Commission also found that the documented port company response to a predicted weather event was not strictly followed, which was a factor in neither the ship's crew nor the port company resources being fully prepared to respond to the predicted change in weather in a timely manner. However, the prompt actions taken by the ship's crew when the weather event occurred very likely reduced the consequences of the accident.

1.8. The Commission identified two safety issues:

- the safe working loads of the bollards on Number One Wharf were unknown and therefore it was not possible to determine whether the mooring plan for any ship was safe
- the mooring procedures contained in the port company's safety management system were not strictly adhered to and the procedure in the event of a high wind warning was ineffective.

1.9. The Commission made a recommendation to the port operator to address these safety issues.

1.10. The key lessons identified from the inquiry into this occurrence include:

- port companies must be aware of the safe working loads of their mooring infrastructure in order to produce safe and effective ship mooring plans
- procedures for monitoring and communicating weather conditions must be robust and strictly followed when harbouring ships that are prone to high winds.

2. Conduct of the inquiry

2.1. Maritime New Zealand notified the Transport Accident Investigation Commission (Commission) of the occurrence on 12 February 2017, the day of the occurrence. The Commission opened an inquiry under section 13(1)b of the Transport Accident Investigation Commission Act 1990 and appointed an investigator in charge.

2.2. On 13 February 2017 two investigators travelled to Akaroa where the *Seabourn Encore* was lying at anchor. They interviewed the master, obtained a download of the voyage data recorder, secured documentary evidence, and took photographs of the damage.

2.3. On 14 February 2017 contact was established with the Bahamas Flag State administration and agreement was reached that New Zealand would lead the investigation and conduct the investigation on behalf of the Bahamas. The flag state administration had requested that the operator of the *Seabourn Encore* conduct an internal investigation.

2.4. On 14 February 2017 investigators interviewed the Canterbury harbourmaster and the master of the *Milburn Carrier II*. Damaged bollards from the quay and parted mooring ropes from the *Seabourn Encore* were secured.

2.5. On 16 February 2017 communications were established with the *Seabourn Encore*'s operator.

2.6. On 24 February 2017 investigators travelled to Timaru and interviewed the port marine manager and the port infrastructure manager. Documentary evidence was obtained.

2.7. On 27 April 2017 investigators travelled to Timaru and conducted a second interview with the port infrastructure manager. Interviews were also conducted with the duty pilot on the day of the accident and the chief executive officer. PrimePort Timaru provided the Commission with a selection of sample bolts used for securing the shore bollards.

2.8. On 28 September 2017 an interview was conducted with the quay watchkeeper on duty at the time of the accident.

2.9. The Commission engaged Quest Integrity to conduct a metallurgy examination of the failed bollard securing bolts.

2.10. The operator engaged a naval architect to conduct a mooring load analysis using the Optimoor software. The Commission obtained a copy of the report and referred to it in its draft analysis of the facts

2.11. On 25 October 2018, the Commission approved the draft report to be circulated to interested persons for comment. The draft report was sent to 11 interested persons for comment.

2.12. The Commission received submissions from eight interested persons.

2.13. As a result of the submissions received, the Commission engaged another expert to conduct an independent Optimoor mooring analysis. The results of the second independent Optimoor mooring analysis were broadly consistent with the findings of the first Optimoor mooring analysis that had been commissioned by the operator.

2.14. Any changes as a result of the submissions have been included in the final report.

3. Factual information

3.1. Narrative

3.1.1. At 0655 on 12 February 2017, the Timaru pilot and an assistant pilot boarded the *Seabourn Encore* to assist the vessel to enter the harbour.

3.1.2. At 0711 the master-pilot exchange of information took place on the bridge. Based on the forecast that the wind was going to develop from the south at 15- to 20-knots[2] , it was agreed that the final moorings would consist of six head lines[3] and six stern lines[4], and two forward springs[5] and two aft springs.

3.1.3. At 0718 all pre-arrival checks had been completed and no deficiencies noted.

3.1.4. At 0758 the *Seabourn Encore* arrived alongside at Timaru and commenced securing starboard side alongside Number One Wharf. At 0809 the engine control room reduced to running one diesel generator.

3.1.5. At 0825 the vessel was all secure with six head and six stern lines and two forward and two aft springs. The line of the berth was 048/228˚ (degrees) (see Figure 1).

Figure 1
Mooring arrangement alongside Number One Wharf

3.1.6. At approximately 0825 the shore gangway was connected at 4 deck level, inspected and found safe to use. Passengers commenced disembarking to shore shortly afterwards.

3.1.7. The *Seabourn Encore's* bridge was permanently manned by bridge watchkeeping officers in port. In the same way that the officer of the watch assumed responsibility for the conduct of the vessel while at sea, the officer of the watch was also the master's representative

2 15-20 nautical miles per hour.
3 Mooring ropes leading forward from the bow and secured ashore.
4 Mooring ropes leading aft from the stern and secured ashore.
5 Mooring ropes leading forward or aft to help reduce the movement of a vessel in a forward or aft direction.

responsible for the bridge watch while the ship was in port. At 0900, the bridge logbook showed, the wind direction was 289°(degrees), speed 1.6 knots.

3.1.8. At 1200 the second officer was preparing to take over the bridge watch, and recorded in the deck logbook that the wind direction was 038° at a speed of 4.5 knots.

3.1.9. At approximately 1330 the duty pilot was monitoring the weather information from his home computer and noticed that the wind speed in Oamaru, 85 kilometres south of Timaru, had increased to 30 knots from the south about four hours earlier than predicted.

3.1.10. The pilot contacted the security staff stationed at the entrance to Number One Wharf and advised them that a southerly wind was due in about one hour.

3.1.11. A security guard noted the details on a piece of paper: "southerlies due half hour to one hour 2:30pm to 3:00pm, 30 knots Oamaru". The security guard then walked on board the *Seabourn Encore* and verbally passed on the message to the ship's staff at reception and asked them to inform the bridge. The receptionist telephoned the bridge and passed on the message regarding the approaching weather system. The message was not passed on to the master.

3.1.12. At 1400 the officer of the watch made an entry in the deck logbook and recorded that the wind direction was from 320° at a speed of 3.5 knots. An entry by the same officer of the watch at 1500 noted the wind direction as being from 231° at a speed of nine knots.

3.1.13. At 1500 the master visited the bridge to carry out some administrative paperwork.

3.1.14. Shortly before 1515 the master was standing at the port bridge wing watching the *Milburn Carrier !!* manoeuvre stern first into Number Two Wharf when he felt the vessel heel sharply to port. He walked across to the starboard bridge wing to investigate and noticed a significant change in the wind direction and strength. The wind direction had backed[6] to the south and it had increased in strength to 22-25 knots, which was pushing the vessel off the berth.

3.1.15. At 1516 the ship experienced the effects of a sudden heavy squall. The wind remained southerly, which was 135° relative to the ship's heading, gusting up to 45 knots and pushing the *Seabourn Encore* off the berth. From the bridge the master estimated that the stern was about four metres (m) away from the wharf. He took charge of the ship from the officer of the watch and ordered two diesel generators so that a bow and stern thruster could be used to try to bring the vessel back alongside. He also ordered all watertight doors to be closed.

Figure 2
Failure of bollard 26 with two mooring lines attached

6 A meteorological term meaning that the wind direction changed in an anti-clockwise direction.

3.1.16. Seconds later a shore mooring bollard holding a forward spring failed, rendering the mooring line ineffective. This was followed seconds later by the failure of an aft shore mooring bollard holding two stern lines (see Figure 2). Both lines became ineffective. Seconds later the bollard holding the second forward spring failed, rendering that line also ineffective.

3.1.17. At about 1520 three diesel generators were available and one bow thruster and one stern thruster became available for manoeuvring. The master then ordered four diesel generators in preparation for using the main propulsion. As they were being prepared, three of the remaining aft mooring lines broke and the stern drifted away from the berth towards Number Two Wharf. Only the shortest stern line remained intact. The additional weight caused it to surge on the mooring bitts[7] and allowed the *Seaborn Encore*'s stern to drift across the harbour.

3.1.18. At 1521 both stern thrusters were thrusting full to starboard. The wind was gusting to 45 knots when the *Seabourn Encore*'s port quarter[8] made contact with the starboard side, midships, of the *Milburn Carrier !!*, which was in the latter stages of berthing and already had mooring lines ashore (see Figure 3).

3.1.19. One minute later at 1522, both bow and stern thrusters were available and thrusting full to starboard and the main propulsion was available on bridge control.

3.1.20. The port quarter of the *Seabourn Encore* continued swinging around, cleared the *Milburn Carrier !!* and came to rest on the quay side of Number Two Wharf. The master used all four thrusters to keep the vessel wedged between Numbers One and Two Wharfs.

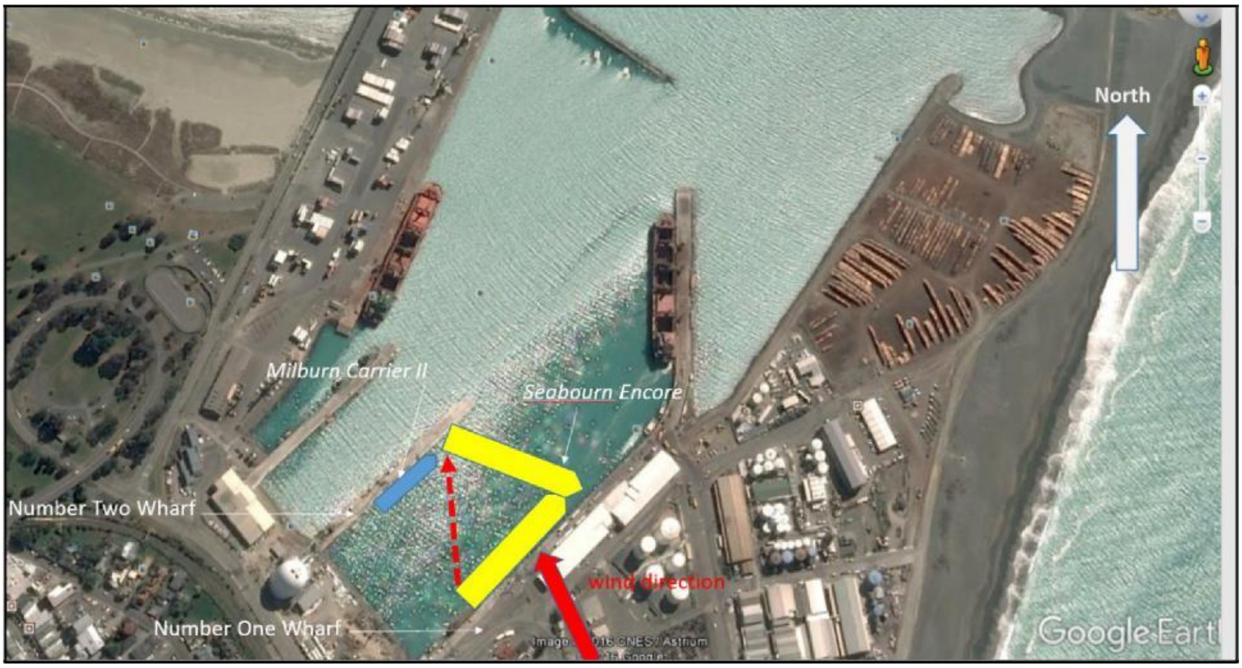

Figure 3
Movement of the *Seabourn Encore*'s stern after breaking away from Number One Wharf

3.1.21. Two head lines parted under the additional load and at about 1526 the starboard anchor was let go together with two shackles[9] of cable.

3.1.22. At 1528 the harbourmaster was contacted and briefed on the accident. Two tugs and a pilot were requested.

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7 Vertical steel posts mounted on board a ship and used to secure mooring lines.
8 The part of a vessel's side towards the stern, termed port or starboard quarter.
9 A nautical unit of measurement: one shackle equals 27 metres.

3.1.23. At 1531 the chief engineer confirmed that all four diesel generators were available and that the vessel's flooding sensors had not been activated. At 1532 an announcement was made to inform passengers about the circumstances of the accident.

3.1.24. At 1552 the duty pilot boarded the vessel and by 1601 the two harbour tugs were secure on the port quarter and the port bow.

3.1.25. At 1806 a bridge team briefing was held. The master and pilot agreed to postpone any attempt to manoeuvre back to Number One Wharf until the wind had abated to less than 20 knots.

3.1.26. At 1900 the wind strength was recorded as 11.9 knots and by about 1955 the *Seabourn Encore* had re-secured to Number One Wharf to allow all passengers to re-board the vessel.

3.1.27. The damage was inspected by a Maritime New Zealand maritime officer, the harbourmaster, a protection and indemnity[10] surveyor and the staff captain. It was decided to allow the vessel to sail to its next port. At 2356 the *Seabourn Encore* departed Timaru for Akaroa.

3.2. Sequence of mooring failure

3.2.1. Evidence provided by the port's closed-circuit television (CCTV) security camera showed that the failure of shore bollards and ropes occurred in the following sequence:

10 Liability insurance for practically all maritime liability risks associated with the operation of a vessel.

Time (hr.min.sec)	Bollard failure	Rope failure	Comment
15.15.43	Bollard 86 or 87	Forward spring	Shore bollard failed (Unclear from CCTV which bollard failed first, 86 or 87)
15.15.48	Bollard 26	Two stern lines	Shore bollard failed, and later recovered from the harbour
15.16.11	Bollard 86 or 87	Forward spring	Shore bollard failed and rope slipped off (Unclear from CCTV which bollard failed first, 86 or 87)
15.19.32		Stern line surging on mooring bitts	Rendered line ineffective
15.19.44		Longest stern line parted	
15.20.15		Second-longest stern line parted	
15.20.39		Third-longest stern line parted	
15.20.58	Bollard 46	Shortest aft spring	Bollard failed and line slipped off
15.21.28	Bollard 47	Longer aft spring parted	Bollard started to fail and line parted

Table 1
Sequence of mooring failure

3.3. Damage assessment

3.3.1. A classification society[11] survey by Registro Italiano Navale was carried out on board the *Seaborn Encore* in Melbourne, Australia on 3 March 2017. The survey found that the damage consisted of a side shell indentation on the port side between frames -11 and -13 inside the marina store. The damage extended 2-2.5 m above the waterline and was approximately 1.8 m in length and 1.6 m in height. The maximum indentation was 600 millimetres (mm). An approved temporary repair was carried out using four steel brackets connecting two side shell longitudinal frames and the indented hull plating.

3.3.2. The *Milburn Carrier II* suffered damage to the shell plating in way of the number three top wing saltwater ballast tank. The hull was penetrated and saltwater ballast was emptying into the harbour from below the waterline. The tank was pumped dry and the damage to the shell plating rose above the waterline (see Figure 4).

Figure 4
Damage sustained by the *Milburn Carrier II* (left) and the *Seabourn Encore* (right)

3.4. Environmental conditions

3.4.1. A weather forecast was produced by Weather Routing Incorporated for the *Seabourn Encore*'s visit to Timaru on 12 February 2017; the details are reproduced in Table 2. The wind pattern was being generated by an anticyclone (high pressure) 1,020 mb (millibars), situated 240 kilometres south-east of Timaru. The system was producing a predominantly north-westerly airstream for the duration of the *Seaborn Encore's* visit. The vessel was due to depart Timaru at 1800 that evening.

[11] A non-government organisation that establishes and maintains technical standards for the construction and operation of ships and offshore structures.

Local time Timaru	0700	1000	1300	1600	1900
True wind direction	North-east	North	West-north-west	West-north-west	West-north-west
Wind speed (knots)	11	6	9	15	14
Maximum wind gust (knots)	12	7	23	23	21

Table 2
Weather forecast obtained by the *Seabourn Encore*

3.4.2. The port company, PrimePort Timaru, contracted Blue Skies Weather and Climate Services Limited (Blue Skies) to produce weather forecasts for the harbour area. The forecast for 12 February 2017 is reproduced in Table 3; it was emailed to the *Seabourn Encore* by the senior pilot on 11 February 2017.

Period	**Morning**	**Afternoon**	**Evening**	**Night**
True wind direction	North	North-west	South (developing)	North-west
Wind speed (knots)	10	15	15-20	10

Table 3
PrimePort Timaru weather forecast provided to the *Seabourn Encore* on 11 February

3.4.3. Another Blue Skies Weather forecast for Timaru was printed at 1041 on 12 February 2017; it is reproduced in Table 4. There was no change from the previous day's forecast.

Period	**Morning**	**Afternoon**	**Evening**	**Night**
True wind direction	North	North-west	South (developing)	North-west
Wind speed (knots)	10	15	15-20	10

Table 4
PrimePort Timaru weather forecast, 12 February

3.4.4. The actual wind speed and direction for the duration of the *Seabourn Encore*'s visit to Timaru can be found in Appendix 3. The maximum wind speed was 36 knots and the maximum wind gust 45 knots from the south.

3.4.5. On 12 February, low-water Timaru occurred at 1113, height 0.5 m, and high water at 1724, height 2.4 m. At 1515, the time of the accident, the height of tide was 1.85 m.

3.5. Mooring arrangement alongside Number One Wharf

3.5.1. Figure 5 shows the mooring arrangements forward and aft on the *Seabourn Encore*. At the bow, six of the eight mooring lines were secured on dedicated split drum winches. The remaining two head lines were secured on mooring bitts. Seven of the eight lines were run through roller fairleads[12] and one head line was run through a panama fairlead.[13] Similarly, at the stern, six of the eight mooring lines were secured on split drum winches and the remaining two were secured to mooring bitts. Five of the eight mooring lines were run through roller fairleads and three were run through panama fairleads. All the mooring lines were fairly equally tensioned, and roller fairleads were later observed to be functioning correctly.

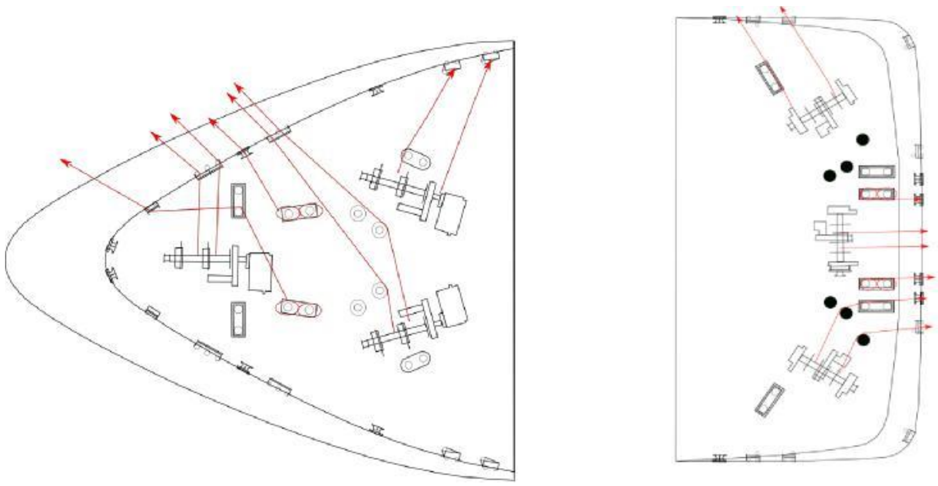

Figure 5
Bow (left) and stern (right) mooring and securing arrangements

3.5.2. Figure 5 shows, to scale, the mooring line configuration and the shore mooring bollards used to secure the lines. All the lines were run to separate shore bollards with the exception of two stern lines placed on bollard 26.

3.5.3. The mooring winches could be used in auto-tension mode or manual mode. On the day of the accident the winches were in manual mode and the mooring ropes were secured on the brake of the split drum winches (see Figure 6). Two additional lines forward and aft were secured to mooring bitts.

3.6. Mooring equipment on board the *Seabourn Encore*

3.6.1. The mooring equipment on the forward and aft mooring decks included winches, fairleads, rollers, bitts and associated electrical installations, which had been certified by the Registro Italiano Navale (RINA) classification society as having being tested and found to be in compliance with the requirements of RINA's rules.

12 A fairlead is an opening at the forward and aft ends of a vessel used to guide a rope, usually to a tug or to the shore, keeping it clear of obstructions and preventing it cutting or chafing. A roller fairlead is a type of fairlead designed to reduce the amount of friction on a rope.
13 A type of fairlead specifically designed for use when a vessel is being towed through the Panama Canal, but also used for routine mooring operations.

Figure 6
Split drum mooring winch used to secure mooring lines on board the *Seabourn Encore*

3.6.2. Each of the split drum mooring winches were designed for a synthetic rope 64mm in diameter with a minimum breaking load of 59 tonnes. The mooring winches were certified by RINA in August 2015 and commissioned in December 2016. All mooring winches supported a static pull on the brake of 48 tonnes, which was 76% of the design mooring rope minimum breaking load (MBL) fitted on the winches.

3.6.3. The mooring ropes supplied to the vessel were described as "12 Strand Eurodan ropes in standard white colour with blue T.Y. with 1.8 metre canvas covered eye splice at both ends". The mooring ropes had been supplied by Global Marine Supplies in Genoa, Italy (Appendix 1). They had been certified by classification society Det Norske Veritas – Germanischer Lloyd after witnessing breaking load testing on random samples that failed at 65,484 kilogram-force (kgf) (Appendix 2). The testing had complied with BS EN[14] ISO 2307:2010. Further tests had been carried out at the rope manufacturer's premises on 23 August 2016, witnessed and certified by the Lloyd's Register classification society.

3.6.4. Each rope had been manufactured from a mix of polypropylene and high-tenacity[15] polyethylene, and as such had an optimal balance between strength and ability to stretch under load. The ropes did not absorb water, floated, and had a melting point of 170°C. The ropes were reputed to have good abrasion, chemical and ultraviolet resistance. Each mooring rope was 60 mm in diameter and had a minimum required breaking strength of 63,000 kgf. Ropes had been supplied in two lengths, 200 m and 220 m, and were compatible with the mooring winch requirements.

3.7. Number One Wharf

3.7.1. Number One Wharf was constructed in 1878 and there had been a number of modifications, additions and repairs carried out since. With a length of 380 m and a width of 10 m, the wharf had been constructed using hardwood timber piles, timber beams and stringers, and more recently a 100 mm thick concrete deck had been laid over the wooden 'hit and miss[16]' deck (see Figure 7).

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14 A BS EN is the British adoption of a European (EN) standard.
15 High tenacity is force divided by linear density. High tenacity is generally preferred over mid tenacity. High strength from finer yarns creates a higher yield with optimum tensile performance.
16 The original timber deck had been constructed without proper planning or skill, so its quality varied.

Figure 7
Number One Wharf – 'hit and miss' decking under concrete

3.7.2. An engineering assessment of the wharf structure was commissioned by PrimePort Timaru in early 2016. It was carried out by Opus International Consultants Limited (Opus) between February 2016 and April 2016. The inspection report was completed on 9 May 2016. The purpose of the inspection was to allow the port company to have a better understanding of the condition of key elements of the structure and to better inform any future maintenance plan.

3.7.3. The inspection of the wharf was limited due to access, but it did include an examination of the timber stringers, beams and piles down to water level. It excluded bollards, piles below water level, and the outer edge of the wharf. The outer two stringers and the ends of some beams were not inspected.

3.7.4. The inspection found decay in many of the stringers and beams and identified that considerable restorative work was required as a high or urgent priority. Some areas of the wharf were not to be used until restorative work was completed. The report identified a methodology with which replacement or maintenance interventions could be undertaken and made several recommendations that included:

- broken piles are replaced or repaired
- excessive decayed beams and stringers are replaced or repaired
- an inspection regime is adopted and implemented to monitor further decay across all members
- a structured management plan to end of life is progressively developed and implemented to manage residual risk and maintenance requirements
- PrimePort Timaru and Opus discuss access/inspection process for the seaward stringer, row A piles and end of beams over row A piles for future maintenance management.

3.7.5. As a result of the inspection report the infrastructure manager commenced a risk-based approach to dealing with the repairs. By January 2017 the high-risk areas had been completed, approximately 35 piles and 40 structural beams had been replaced and parts of the wharf had been down-rated.

3.7.6. The engineering assessment carried out on the wharf structure in 2016 did not examine the bollard securing arrangement. However, as structural repairs on the wharf progressed the opportunity was taken to examine the tops of piles used for securing steel mooring bollards. Where the timber structure under a bollard had been repaired, the Pile Repair Progress Report showed that the port company had taken the opportunity to fit new securing bolts to some of the steel bollards (Figure 11). Some new steel bollards had also been fitted approximately 2 m back from the face of the wharf, where the supporting timber structure was considered to be in better condition. These were specifically to service cruise vessels.

3.7.7. There were no technical drawings or documentation available to assist the infrastructure manager to understand the safe working loads with which the bollards had originally been designed. The methodology for securing the new bollards and re-securing original bollards was on a 'like for like' basis.

3.7.8. To assist the shore mooring hands[17] to identify which bollards could be used, a green dot was painted adjacent to each bollard. Those that were not to be used had red dots painted adjacent to them.

3.8. PrimePort Timaru – port risk assessment

3.8.1. A port and harbour safety code navigational risk assessment was carried out by Marico Marine NZ Limited in 2006 on behalf of PrimePort Timaru. The resulting report was one of several documents from which the port developed a harbour safety management system (SMS).

3.8.2. In respect of Number One Wharf the risk assessment identified that the wharf was used for handling fishing vessels and as a base for the port's tug and pilot boat.

3.8.3. The assessment considered navigational, berthing and mooring issues, noting that PrimePort Timaru no longer maintained its own storm lines and recommending that vessels instead carried sufficient lines for their needs. It also identified that the failure of bollards was considered by stakeholders to be a significant risk within the port area:

> Wharf structures and mooring bollards are not surveyed for integrity beyond a monthly visual inspection by the marine manager. Bollards and piles used for mooring are considered to have breaking strains of around 24 tonnes while the mooring winches of containerships are capable of applying 40 tonnes.
>
> The marine manager reported a policy to place only one line on each bollard or pile...
>
> In practice, it is not always possible to achieve this policy without installing more bollards. It is understood that a programme of bollard installation is in place to achieve the policy.

3.8.4. The assessment also examined the effects of a beam wind on a 200 m passenger vessel. In conclusion it recommended that in the event of a mooring failure in high winds (40-50 knots), handling a vessel would not be possible and would "certainly require more than a second tug". In cost-benefit analysis terms it was considered that the strategy of increasing the available bollard disposition was a more prudent course of action.

3.8.5. In conclusion, the assessment report referred to the fact that the port's policy was to retain a vessel in the harbour during storm events and recommended "the ongoing introduction of mooring bollards to facilitate one line per bollard and a periodic structural inspection of its jetty facilities".

3.8.6. The 2006 port risk assessment was reviewed in 2011 and May 2013, and in May 2015 another port risk assessment report was published. It identified the risk of a bollard/wharf structure failure. Key control measures included; regulations and legislation, commercial vessel operations, berthing operations, and training. The risk rating fell within the "tolerable" risk definition and action required was "Risk within the ALARP [as low as reasonably practicable] area, procedures and controls to be reviewed".

3.8.7. A further risk review was carried out in 2015, and post the accident in 2017.

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[17] Port employees who handle mooring lines and place them over the shore bollards.

3.9. PrimePort Timaru – harbour safety management system

3.9.1. On 12 March 2015 the Director of Maritime New Zealand confirmed in writing that the SMS for PrimePort Timaru had been assessed and was confirmed as meeting the requirements of the New Zealand Port and Harbour Marine Safety Code. Developed jointly by Environment Canterbury and the port company, the code comprised both the council's and the port company's SMS.

3.9.2. Contained within the SMS were the instructions for vessel moorings. The instructions recommended that vessels longer than 135 m secure using four head and four stern lines and two springs at each end.

3.9.3. The instructions advised that in the event of a strong wind warning, the pilot should advise the master to take extra precautions such as running additional mooring lines.

3.9.4. The instructions made reference to bollards and stated that, "where possible steel bollards should be used when a choice is possible. Unless approved by the pilot the linesman should adhere to one line per bollard. It is possible to have two lines on certain steel bollards but this should be avoided where possible".

3.9.5. The SMS also included a procedure for the actions to be taken in the event of a high wind warning. The marine manager or duty pilot was to check the local weather forecast regularly, particularly when bad weather was expected. When winds in excess of steady north-westerly 35 knots were forecast, the vessel was expected to run extra moorings. The tug would be readied for sea and placed on 10 minutes' notice.

3.10. Previous accident

3.10.1. On 4 February 2015 the container vessel *E.R. New York* broke loose off the PrimePort Timaru North Mole berth when two timber bollards failed and a ship's line broke. The vessel was brought back safely alongside by two tugs within 35 minutes of its breaking loose. The vessel had berthed in an unusual position that did not facilitate the procedure of one line per bollard and the use of steel bollards.

3.10.2. On that occasion north-westerly winds had reached 41 knots. The lateral force imposed by the wind on the vessel meant that the stern bollards were experiencing a load of more than 25 tonnes at the time of the failure.

3.10.3. The causal factor was determined as "a lack of a mooring plan for this class of vessel at Timaru and a subsequent lack of contingency planning". Further contributory factors included:

- a lack of clear communication between pilots and mooring staff
- a lack of clear lines of responsibility
- procedural failures in training mooring staff
- a system failure in predicting strong winds locally.

3.10.4. The port's internal investigation into the accident made several recommendations, which included in part:

- undertake a full analysis of the strength of steel bollards and the lateral capacity of the wharf[18]
- establish a new vessel arrival plan for each new class of vessel arriving at the port
- analyse the safe working load of all steel bollards
- install new steel bollards (appropriately rated) at locations determined with pilots
- establish local weather forecasting

18 North Mole.

- set up clear communication and responsibility for mooring vessels
- ensure reiterating one line per bollard and proper communication between mooring hand and pilot/master in case of deviation.

3.11. Code of practice for the design of mooring systems

3.11.1. Part four of British Standard 6349:1994: Code of Practice for Design of Fendering and Mooring Systems provides a reference for calculating expected horizontal loads on shore mooring points (bollards). Section 10.2 of the code provides methods for calculating the expected loads on mooring points for vessels over 20,000 tonnes' displacement. In the event of insufficient data being available to carry out the calculations, the standard advises that for cargo vessels and bulk carriers between 20,000 and 50,000 tonnes' displacement (the *Seabourn Encore's displacement was* 24,397 tonnes) a mooring point should be rated to 80 tonnes. For locations with exceptional wind, the mooring point loads should be increased by 25%.

3.11.2. The code also advises that the design of the mooring point should be such that if it becomes overloaded the mooring equipment or its anchorage to the structure will fail before the overall structure is damaged.

3.11.3. Examples of various designs of mooring bollards are provided in the code, together with the standards of the materials required for manufacture. The code does not provide advice on the required arrangement for securing a bollard to a structure other than to say it should be robust, of simple design and designed to minimise maintenance. The design of a securing arrangement for a harbour mooring system is generally considered to be the function of a qualified structural engineer.

3.11.4. Table 9 of the code provides information on the sizes and breaking loads of synthetic mooring ropes normally carried by vessels. For a cruise vessel the size of the *Seabourn Encore*, the diameter is expected to be 64-72 mm and the breaking load 46.6-58.4 tonnes. The mooring ropes carried on board the *Seabourn Encore* had a breaking strength of 65 tonnes.

4. Analysis

4.1. General

4.1.1. A large cruise vessel such as the *Seabourn Encore* breaking away from its berth could have had serious consequences. Although the ship could have been better prepared for the weather event had the message from the pilot reached the master, once the weather event occurred, the prompt reaction by the ship's crew reduced the risk of harm to people and damage to property and the environment. Nevertheless, the *Milburn Carrier II*, the *Seabourn Encore* and Number One and Number Two Wharves still suffered damage, and there was a risk of injury to passengers and other personnel who could easily have been occupying the wharf at the time.

4.1.2. A similar event had occurred at the port in February 2015. The port's own investigation report on that accident had made several important recommendations that required addressing by the port company. This latest accident identified some similarities between the two events and showed that further progress is still required to ensure that large vessels, including cruise vessels, can remain safely alongside in adverse weather conditions.

4.1.3. The following analysis discusses why the *Seabourn Encore* broke away from its berth, and discusses two safety issues:

- the safe working loads of the bollards on Number One Wharf were unknown and therefore it was not possible to determine whether the mooring plan for any ship was safe
- the mooring procedures contained in the port's SMS were not strictly adhered to and the procedure in the event of a high wind warning was ineffective.

4.2. What happened

4.2.1. The *Seabourn Encore* was secured to Number One Wharf using six head lines, six stern lines and two forward and two aft springs. This exceeded the standard securing arrangement by using an additional two head lines and two additional stern lines. The decision was based on information in the weather forecast and an expectation that the wind speed would be no more than 20 knots from the south later that afternoon.

4.2.2. All the mooring ropes were in good condition; they followed good leads from the winches and passed through well maintained panama and roller fairleads.

4.2.3. At the time of the accident the tide was rising. CCTV footage showed that all the stern lines leading from winches were fairly equally tensioned with a small amount of slack on two lines that were turned up on sets of mooring bitts.

4.2.4. When the wind changed towards the south, the relative wind direction[19] was about 135° and pushing on to the vessel's starboard quarter. As the wind speed increased, the effects were that the vessel tried to move bodily forward and the stern tried to move off the berth. A warehouse on the wharf was affording the forward half of the vessel some protection from the wind.

4.2.5. The weight on the forward springs and stern lines increased significantly, with a consequent increase in the load being applied to the corresponding shore bollards. When the wind speed gusted to 45 knots, bollards 86 and 87, each holding a forward spring, and bollard 26 holding two stern lines all failed[20] within about 28 seconds.

4.2.6. This meant that four of the eight mooring ropes that were providing the majority of the holding power were rendered ineffective and the remaining mooring ropes and shore bollards were now required to take significantly more load.

[19] The wind direction relative to the ship's head measured clockwise from 000° through 180° at the stern, returning to 360° at the ship's head.
[20] The point at which the bollards could be considered unfit for purpose.

4.2.7. As the load on the remaining mooring lines increased, the stern started to move further off the berth. The bridge team had already observed events on the wharf and progressively ordered power for thrusters and main propulsion with a view to manoeuvring the vessel and holding it alongside.

4.2.8. About five minutes after bollard 26 failed, all the remaining stern lines parted or slipped off damaged shore bollards, with the exception of one of the stern lines that was surging on a set of mooring bitts. As the stern started to drift off the berth, additional load came onto the two aft spring lines and within one minute one of the spring lines had parted and the second had slipped off a bollard that had failed. The stern was now free to drift across the harbour towards Number Two Wharf.

4.2.9. As the bow and stern thrusters became available, an attempt was made to stop arrest the stern swinging down onto the *Milburn Carrier !!* and subsequently Number Two Wharf. By design the vessel was only capable of moving sideways into a prevailing wind (from the same relative direction) of approximately 35 knots (see the polar diagram in Figure 8). This required all thrusters and main propellers to be available. At best it may have been possible to arrest the swing but it was more likely to have reduced the rate of drift towards Number Two Wharf.

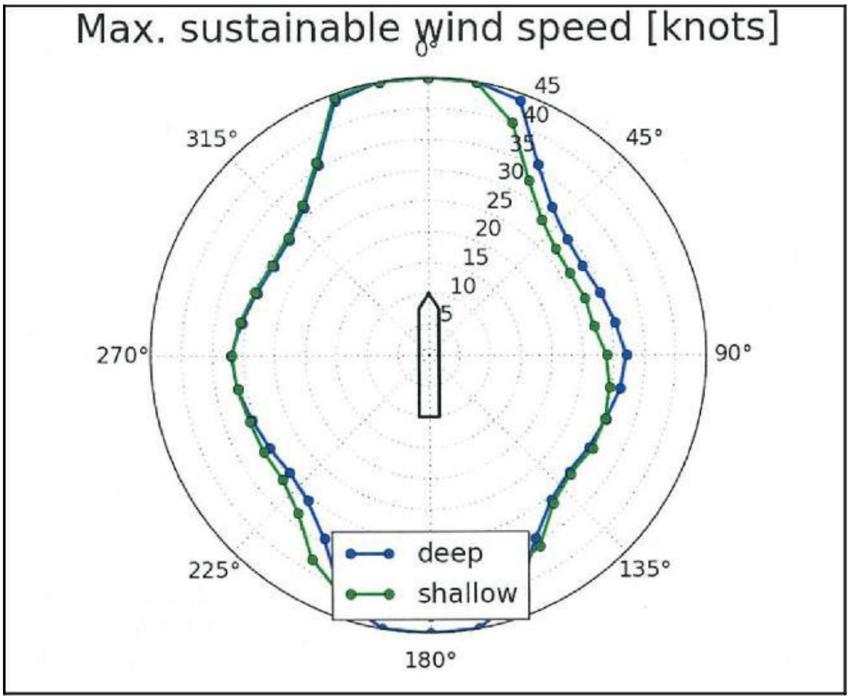

Figure 8
Polar plot showing the crabbing capability – quay on port side shallow water

4.2.10. There were only six minutes between bollard 26 failing and contact being made with the *Milburn Carrier !!*. An attempt was made, via very-high-frequency radio, to alert the *Milburn Carrier !!* to the events quickly unfolding. It could not be established what channel was used and the *Milburn Carrier !!*'s bridge team could not recall receiving the call. They became aware of the situation when they felt the impact of the *Seabourn Encore* amidships on the starboard side, while they were in the latter stages of berthing and already had mooring lines ashore.

4.2.11. Once the *Seabourn Encore*'s stern came to rest, the master decided to keep it pinned against Number Two Wharf using the propulsion that was available. The remaining head lines and the starboard anchor were used to hold the bow close to Number One Wharf. In doing so the vessel was kept relatively secure until the weather conditions improved, tugs and a pilot became available, and it was considered safe to manoeuvre back to Number One Wharf.

4.2.12. This accident showed how quickly events unfolded and the importance of maintaining an awareness of environmental surroundings. The master was unaware of the predicted change

in weather pattern. However, having the bridge and engine room permanently manned while the vessel was alongside Number One Wharf improved the reaction time of the crew. Once the seriousness of the situation was recognised the crew's actions were timely and effective given the speed with which events unfolded.

4.2.13. Although the duty pilot had passed on a message, through the port security guard, advising the vessel of the approaching southerly wind, the warning had failed to trigger any direct response from the port and effectively left the ship to its own devices. This is discussed later in the report.

4.3. Why did some of the shore bollards and mooring ropes fail?

Forces exerted on the vessel's mooring ropes and shore bollards

4.3.1. An analysis of the mooring arrangement at the time of the accident[21] examined the loads imparted on individual mooring ropes and shore bollards at a point in time when the wind had changed to the south and was gusting up to 45 knots. The analysis assumed a pretension on the lines of 5 tonnes and the minimum breaking load reduced to 52 tonnes to allow for the bending of mooring ropes around fairleads. The results of the analysis at around the time of failure (see Table 5) show the approximate forces imparted on bollards and ropes:

Position of mooring rope	Load on the mooring rope (tonnes)	Bollard number (as allocated by the port operator)	Total horizontal force (tonnes) on mooring rope and bollard	Percentage strength of reduced minimum breaking load of mooring rope
Forward spring	27.8	86	24.6	53
Forward spring	23.0	87	20.4	44
Stern line 1 (Connected to same bollard as stern line 2)	29.7	26	29.7 (total 59.5 tonnes when combined with stern line 2)	57
Stern line 2	29.8	26	29.8	57

Table 5
Calculated loads on mooring ropes and bollards

4.3.2. Appendix 4 shows that at about the time shore bollards 86, 87 and 26 failed, the mooring ropes had not reached their minimum breaking load and were capable of absorbing considerably more load. In respect of the four remaining intact stern lines, further analysis showed that the load on each rope increased until there was a sequential failure of the three longest lines. The shortest stern line remained intact, but as the load increased it started surging on the mooring bitts.

21 By Stronach & Co Limited, Rev G 01, November 2017.

4.3.3. Theoretically, after bollard 26 failed the remaining stern lines that were leading out from winches should have rendered[22] before they broke. At least one of these stern lines was seen to render, but eventually broke soon after.

4.3.4. Industry good practice in respect of safe mooring practices can be found in the Oil Companies International Marine Forum (OCIMF) publication Mooring Equipment Guidelines (4th Edition).

4.3.5. The OCIMF publication explains that 'the primary brake secures the drum, and thus the mooring line, at the shipboard end when the ship is moored. The primary brake is designed to render before the loads become excessive to reduce the risk of mooring lines breaking'. New winch brakes are normally designed to hold about 80%, of the mooring line minimum breaking load (MBL). In the case of *Seabourn Encore* the winches were designed to support a static pull of 48 tonnes before rendering, which is 76% of the mooring lines minimum breaking load.

4.3.6. The OCIMF publication advises setting the brake in service to hold 60% of the mooring rope minimum braking load. However, the International Standards Organisation (ISO) 3730 recommends that the brake holding capacity for new equipment should be initially left at 80% of the MBL. The ISO recommendation makes an allowance for wear and tear of the winch brake in service and so it is recommended that new equipment be set up to hold 80% of the design MBL with a capability of adjusting the holding load down to 60% if required.

4.3.7. The *Seabourn Encore*'s mooring systems were almost new, having only been commissioned to service three months before the accident. It could not be established with certainty what the winches were set to render at when commissioned, but it is about as likely as not that it would have been at the 48-tonnes maximum (76% of the mooring rope minimum breaking load). One explanation for why the mooring ropes broke, rather than the winch rendering is the typical reduction in the rope's minimum breaking load caused by the change in direction as the rope passes around mooring leads and fairleads at the ship's side.

Bollard securing arrangement

4.3.8. The Commission recovered three of the four bolts that had been used to secure bollard 26, which had recently undergone refurbishment (Figure 9). Two securing bolts recovered had been passed through the concrete section of the wharf, and the remaining one had been passed through the wooden fendering at the face of the wharf. The bolts underwent metallurgical examination to identify the failure mode and assess their suitability.[23]

4.3.9. The subsequent examination report concluded that:

- the bolts failed in shear at the weld between the head plate and the bolt (Figure 10)
- because of the design of the welded bolt head arrangement, it was estimated that the bolts had an effective strength of one-half to one-third of a normal 32 mm-diameter bolt
- a comparison to contemporary bollard designs suggested that the use of only four such welded head plate bolts to fix bollards would result in significantly diminished bollard capacity, well below the loading applied to the bollards on the day of the accident.

4.3.10. The bollard bolt heads failed as a result of shear overload in the weld between the bolt shank and the head plate. The total shear area of all four bolts was 400 square millimetres, which equates to about 27 tonnes force if the load was equally distributed under the bolt head. If the loading was uneven the load could have been as low as 18 tonnes force. As shown in Table 5, any one of the two mooring ropes attached to bollard 26 would have likely exceeded the holding capability of bollard 26. The two mooring ropes together caused a total load on the bollard of approximately 60 tonnes, meaning failure of the bollard was virtually certain at the time of the weather event.

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22 A load applied to the mooring winch which, when the brake is applied, causes the drum to rotate in the direction opposite to the driving torque.

23 Quest Integrity 111352.01, dated 14 November 2017.

Figure 9
Bollard 26 after the failure, showing the direction of mooring lines to the ship

Figure 10
The top (left) and bottom (right) welded bolt head plates, same design used to secure bollard 26

4.3.11. The metallurgical analysis confirmed that there was no significant loss of section due to corrosion, but that the shearing had occurred at the weld material, which had a total area of about half the cross-sectional area of the bolt shank. The welded head had therefore become the weakest point in the securing arrangement (Figure 10).

4.3.12. The mooring ropes had an elevation of approximately 30° to the horizontal and therefore had a vertical component creating an uneven distribution of load. It is likely that the loads being applied to the bolt heads on bollard 26 were not equal. As a result, it is likely that the shearing force required to cause failure was less than that envisaged at design.

Figure 11
Decaying timber and corroded bolts supporting bollards 47 (left) and 46 (centre and right)

4.3.13. A vessel the size of the *Seabourn Encore* has a windage area[24] of about 5,800 square metres, which can impart significant loads on mooring lines in strong wind conditions. On the day of

24 The exposed area of one side of a vessel above the waterline.

the accident the loads generated by the wind on the ship and imparted by the mooring ropes exceeded the holding power of some shore bollards. The reasons for this are discussed below.

4.3.14. The design used for attaching the heads of the securing bolts was a key component in providing strength to the bollards. The method used to weld the heads of the bolts to the shafts effectively reduced the cross-sectional areas of the bolts by at least 50%. This introduced a weak point to the securing arrangements. Had the bolt heads been attached to withstand the same load as a 32 mm-diameter bolt, they would have failed at approximately 57 tonnes force, nearly three times the apparent failure load.

4.3.15. Another factor was that some bollards were secured through decaying timber at the face of the wharf (Figure 11), which was the weakest point in the securing arrangement. The load on the mooring ropes was transferred to the bollard securing bolts that passed through the supporting timber structure. The timber was unable to withstand the loads being applied and gave way, causing the bollards to fail.

4.3.16. Another factor was the inconsistency in how bollards were secured. There were a number of different bollard designs and securing methods in use. No bollard contained the maximum possible number of securing bolts and the bolt head design for securing them was inconsistent (Figure 12). As a consequence, the bollards were not secured in a way consistent to achieve their designed safe working load, making it virtually impossible to establish a known safe working load for each.

Figure 12
Underutilisation of the bollard securing arrangement

4.4. Integrity of the bollard securing arrangement

Safety issue – The safe working loads of the bollards on Number One Wharf were unknown and therefore it was not possible to determine whether the mooring plan for any ship was safe.

Structural condition of the wharf

4.4.1. The 2016 engineering assessment of Number One Wharf, commissioned by PrimePort Timaru and carried out by Opus, identified deficiencies in the condition of the supporting timber structure. As a result of the findings PrimePort Timaru commenced a long-term, risk-based programme of replacing decaying timber.

4.4.2. The engineering assessment did not examine bollards or the outer edge of the wharf, but as part of the work in progress for meeting the needs of cruise vessels PrimePort Timaru commenced a programme of installing some new bollards (Figure 13) and replacing some original bollard securing bolts.

4.4.3. The new bollards were set further back from the face of the wharf and had a safe working load of 80 tonnes stamped on their bases. The replaced bollard securing bolts were of the same design as those described earlier in this report.

Figure 13
Newly installed steel bollard

4.4.4. The lack of any historical records held by PrimePort Timaru in respect of bollard design and securing arrangements meant that the safe working loads or capacity of the bollards were unknown. The various bollard designs and securing methods meant that each bollard was likely to have its own safe working load.

4.4.5. There had never been a programme of work to load-test bollards and establish their safe working loads. As part of the risk-based approach to the restoration and repair work being undertaken it would have been appropriate for PrimePort Timaru to identify the safe working load or capacity of each bollard, including the new bollards that had been recently fitted.

4.4.6. Three of the *Seabourn Encore*'s head lines were each secured to one of the new bollards. Although the mooring analysis showed that the loads on these bollards were less than those at the stern, the bollards were secured using the same type of securing bolt as bollard 26. Given the earlier explanation of the bolts' failure it is highly likely that the new bollards as installed would not have met their designed 80-tonne capacity.

4.4.7. Some large, modern types of vessel, such as passenger and container vessels, have large windage areas. These vessels can impart significant forces on a wharf structure and mooring bollards when the ships are exposed to high winds from the direction of the wharf. The overall force that wind can impart on a ship can be calculated, and from that the force that the ship's mooring lines impart on the wharf bollards can be calculated. These calculations can then be compared to the safe working loads of the mooring bollards (if known) to which the mooring lines are attached.

4.4.8. Only when these parameters have been established can it be determined whether a berth is suitable for a vessel to lie safely alongside. Such parameters help to identify operational limits and provide guidance as to what additional control measures may be required for different environmental conditions.

4.4.9. Although PrimePort Timaru had tried to mitigate some anticipated risks of berthing cruise vessels, the arrival of the *Seabourn Encore* for the first time at Number One Wharf should have prompted both the port and the ship operator to satisfy themselves that the allocated berth and the planned mooring arrangement were fit for purpose.

4.4.10. Other Seabourn Cruise Line vessels had visited Timaru previously, but this was the *Seabourn Encore*'s first visit. On this occasion the company had relied on its appointed commercial agent to determine berth suitability. However, the agent's assessment had primarily focused on the commercial activities of the vessel during its stay in Timaru.

4.4.11. Regarding berth suitability, the New Zealand Port and Harbour Marine Safety Code, a voluntary national standard, advises a port operator in part to:

> ensure that all wharves, including structures, decking, berthing facilities and bollards are suitable for the ships that use them.

Notwithstanding the need for a port operator to ensure that a wharf is suitable, there is also a need for ship operators to establish with the port operator the suitability of the wharf, preferably through an exchange of information prior to the ship visit.

4.4.12. The most recent document identifying risks within the harbour at the time of the accident was the 2015 Timaru pilotage area risk assessment. Prepared in accordance with the New Zealand Port and Harbour Marine Safety Code, the assessment identified seven risks having significant consequences requiring further scrutiny and attention to mitigations and controls. Pertinent to this accident the risks included wind and wind gusts, vessel mooring line parting and bollard/wharf structural failure.

4.4.13. In relation to these three risks the assessment made reference to the 2015 accident involving the *E.R. New York* breaking away from the North Mole, an accident after which the port had made several recommendations. Had all of the recommendations from the 2015 accident been implemented throughout the port, including Number One Wharf, it is likely that this accident could have been avoided. Unfortunately, some measures were still being reviewed and others were only considered relevant to the North Mole.

4.4.14. The steady growth in the number of vessels with large windage areas visiting New Zealand has predominantly reflected growth in the cruise and container sectors. Port operators have to be cognisant of the fact that some New Zealand ports were never designed and constructed to accept vessels capable of imparting considerable loads on wharves and bollards.

4.4.15. Notwithstanding the advice contained in the New Zealand Port and Harbour Marine Safety Code, port operators should also consider the integrity of their port infrastructure in relation to the types of load that can be expected when vessels with large windage areas are exposed to strong winds.

4.4.16. To ensure that all New Zealand port operators are aware of the potential implications of securing vessels with large windage areas in their ports, the Commission has made a recommendation to the Chief Executive of Maritime New Zealand to promulgate through the Secretariat of the Port and Harbour Marine Safety Code Steering Group the findings of this report, in particular the potential dangers associated with securing vessels that may be capable of generating loads in excess of those that the infrastructure can withstand.

4.4.17. Whilst the risks had been identified and kept under review, they had not been made 'as low as reasonably practicable' for the *Seabourn Encore* alongside Number One Wharf. Previous lessons learnt had not been implemented and therefore the control measures in place at the time of the accident were not effective.

4.4.18. The Commission would have made a recommendation to PrimePort Timaru to undertake a thorough assessment of the port's mooring capabilities to establish the suitability of wharf structures and bollard securing arrangements for vessels approved to enter the port. Part of that assessment would have been to determine the maximum loading capacity of all bollards within the port and their suitability in respect of the guidance laid out in the Code of Practice for Design of Fendering and Mooring Systems. However, this work is currently underway and is detailed in section 7 of this report.

4.4.19. Until this programme of work is complete the Commission has made a recommendation to PrimePort Timaru to undertake a type-specific ship-to-berth risk assessment for all vessels visiting the port. The assessment should confirm that allocated berths are safe for the vessels, define any operational limits or restrictions, and identify any additional control measures that may be required.

4.5. Adherence to the port's procedures for mooring and high wind warnings

Safety issue – The mooring procedures contained in the port company's SMS were not strictly adhered to and the procedure in the event of a high wind warning was ineffective.

4.5.1. Mooring procedures contained in the port's Quality System Document had been updated to reflect lessons learnt from the breakaway of *E.R. New York* from the North Mole. The risk of a vessel breaking away from its berth had been considered and two key procedures had been developed as an outcome: high wind warning and advice on moorings.

4.5.2. In the event of a high wind warning, the procedure in part required:

- the marine manager and/or duty pilot to check the local weather forecast
- when winds in excess of 35 knots were forecast, the marine manager or duty pilot to advise the ship's agent to inform the vessel to put out extra moorings
- a tug to be made ready for sea and placed on 10 minutes' notice.[25] If a vessel required assistance the tug was to assist by pushing up alongside.

4.5.3. The above procedures only applied to vessels berthed at the North Mole. A strong wind event is relative to the size of the vessel and where it is berthed. Every vessel must be considered according to its unique characteristics, which is why ship-specific parameters are essential so that any response can be measured and effective. Likewise, a wind warning procedure must consider all berths and ensure that the response is appropriate.

4.5.4. On this occasion the duty pilot was monitoring the weather information and attempted to alert the master with advance warning of the predicted increase in wind strength. However, the ship's staff did not act on the information or pass on the message to the master. Had they done so the master would undoubtedly have been better placed to prepare the ship for the worsening weather.

4.5.5. Although the ship could have been better prepared, on these sorts of occasion it is likely that a ship's master will also need assistance from the port. The port's own response to the high wind warning was rudimentary and did not automatically trigger the type of support and resources the master may have required, particularly if it had been decided to run additional mooring lines (to the correct bollards) or if a pilot and/or tugs were required at short notice.

4.5.6. There were two other options for the duty pilot. One would have been to inform the vessel's commercial agent in accordance with the instructions contained in the high wind warning procedure for the North Mole, and the second would have been to contact the vessel directly and discuss with the master the implications of the new weather information and jointly agree what action needed to be taken.

4.5.7. Had the master and the pilot discussed the situation then measures could have been taken earlier, including running additional mooring lines, preparing propulsion systems, and ordering tugs. Collectively these measures could have reduced the weight on the mooring ropes and in turn the load on the shore bollards. It is feasible that the reduction in load may have prevented the bollard failure.

4.5.8. As part of the port's risk control measures, shore bollards had been colour coded to identify those that were suitable for use. The mooring procedure required no more than one mooring line to be placed over a bollard, and where possible steel bollards were to be used in preference to timber bollards. Any change in the procedure required approval from the duty pilot.

4.5.9. Although the mooring hands had been trained in the required mooring procedures, one stern line had been placed over a timber bollard, and two stern lines had been placed over steel

---

25 Placing tugs on stand-by when large-windage vessels are on the North Mole and a high north-westerly wind is forecast.

bollard 26, a refurbished bollard used for servicing cruise vessels. It was a departure from the procedure and one that had not been approved by the duty pilot.

4.5.10. Placing two stern lines on bollard 26 significantly increased the load and highly likely contributed to its failure. Notwithstanding that, results showed that had only one line been placed on bollard 26 the load being imparted by that one line could have been sufficient to cause failure anyway.

4.5.11. As previously discussed, there were similarities between this accident and the previous 2015 accident. Although control measures had been implemented and incorporated as a result of the previous accident, this accident shows that further work is still required. A robust port response to a high wind event, the ability to promulgate weather information effectively, and tan assessment of each ship and its mooring arrangement for a proposed berth would improve the safety of vessels berthed at PrimePort Timaru.

5. Findings

5.1. The *Seabourn Encore* broke away from its berth during a weather event. The breakaway was caused by the progressive failure of the wharf mooring bollards to which the ship's mooring lines were attached.

5.2. The weather event could not have been considered extreme or unusual for the port.

5.3. The mooring bollards failed because the unique method with which each had been fastened to the wharf and/or the strength of the underlying wharf structure meant they were unable to withstand the forces imparted on them by the *Seabourn Encore*'s mooring lines.

5.4. The mooring procedures for the port were not strictly followed, which increased the vulnerability of the mooring arrangement.

5.5. The *Seabourn Encore*'s mooring lines and associated equipment were in good condition and were not factors contributing to the accident.

5.6. Knowing the safe working loads of the various mooring bollards in a port is critical to safe ship operations. The port company had virtually no knowledge of the actual safe working loads of the various mooring bollards on the wharf.

5.7. The documented port company response to a predicted weather event was not strictly followed, which resulted in neither the ship's crew nor the port company resources being fully prepared to respond in a timely manner.

5.8. The ship could have been better prepared for the weather event had the message from the duty pilot been passed to the master. However, the prompt actions taken by the ship's crew when the weather event occurred very likely reduced the consequences of the accident.

6. Safety issues

6.1. The safe working loads of the bollards on Number One Wharf were unknown and therefore it was not possible to determine whether the mooring plan for any ship was safe.

6.2. The mooring procedures contained in the port's SMS were not strictly adhered to and the procedure in the event of a high wind warning was ineffective.

7. Safety actions

General

7.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

Safety actions addressing safety issues identified during an inquiry

7.2. Since the accident PrimePort Timaru has reported that:

- it has been decided not to allow cruise liners to berth at Timaru in 2019
- the mooring procedures have been updated to include mooring plans for each class of vessel. The policy of 'one line one bollard' has been reemphasised (and trained for) in that it is only permitted on explicit approval by the pilot in charge
- additional training of moorings staff, particularly the Charge Hands (crew Foreman) on procedures for mooring has been completed
- remote wind sensors were investigated extensively. MetService consultants conducted a site visit and we have determined that, generally, remote wind sensors were not required, with the exception of a new wind sensor to be installed on the eastern breakwater
- a new prediction model 'Predict Wind' is now being used and MetService remote weather stations are monitored when "Predict wind flags strong winds likely"
- high wind procedures have been updated in our pilotage procedure guide and PrimePort Timaru emergency cards
- shore bollards are currently being installed on the North Mole to protect container ships from prevailing norwest winds. The capex cost is approx. $150k
- shore bollards for the No1 wharf have been approved by the board and are going through the final engineering design. These bollards are intended for use by cruise ships should there be any threat of high winds. The capex cost is estimated at $600k and works are planned for completion by the 2019/20 cruise season
- while underway before the Seabourn accident, extensive bollard strengthening work continues around the port (as below report from our Infrastructure Manager):
    - completed a bollard condition inspection (including bolt systems' assessment) of all bollards on all wharves. Inspection sheets have been completed for every bollard on each wharf
    - a jacket system has been introduced whereby Bollards identified as "NOT to be used" have a "DO NOT USE" jacket installed over them
    - we have removed a few more decayed timber bollards ID through the Condition Inspection process
    - since June 2017:
        - 7 new 80T Bollards have been installed on North Mole
        - 3 new 80T Bollards have been installed on number one wharf
        - 3 new 80T Bollards have been installed on number one wharf X
    - 20 new 80T Trelleborg Bollards are due to arrive in the next week or so to enable this programme to continue
    - the long-term plan is to ensure all bollards used by large bulk vessels and container vessels:

- are of a known strength (e.g. 80 tonne Trelleborg bollards). Many of the existing steel bollards in the port have no recorded “load capacity or rating”
- bollard bolts with welded heads are eliminated and replaced with 32mm (min) threaded rods
- all Bollard bolts are in place and “tight”
- fastening systems are tied to the wharf in a consistent (“engineered” manner
- we have begun replacing all sub strength bollard systems using a risk approach to prioritise replacement. The priority wharf is North Mole – most (if not all) of the regularly used bollards were replaced earlier this year.

7.3. Holland America Group has reported that:

- an internal investigation report on this accident was concluded in 2017
- in future at all New Zealand ports that are visited by our fleet, the ship’s agent is to obtain written confirmation from the port operator that the bollard capacity meets recognised industry standards and is suitable in all respects for a cruise ship of the size that is being booked. The agent should request and have copies available of the test certificates confirming the SWL (safe working load) of bollards at the assigned berth(s)
- when in port, any wind or weather advisory, or warning, that is received by the officer of the watch is to be entered in the ship’s log.

8. Recommendations

General

8.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to PrimePort Timaru and Maritime New Zealand.

8.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or accidents occurring in the future.

Recommendation

To PrimePort Timaru

8.3. The responsibility for the safety and security of a vessel moored alongside a harbour wharf lies with both the vessel and the port operator. Notwithstanding that joint responsibility it remains an important function of a port to ensure that the wharf structure and mooring system is adequate for any vessel that intends to use it.

Section 7 of this report draws attention to the work that PrimePort Timaru is currently undertaking, and the work it is planning to undertake, to improve the condition and reliability of its wharves, associated mooring systems and mooring procedures.

Until all of the improvement work has been completed, it is important that the port ensures that the infrastructure and procedures in place at any given time are suitable for any vessel intending to use the port.

On 21 February 2019 the Commission recommended to the Chief Executive of PrimePort Timaru that, until all the planned improvement work is completed, a ship-to-berth risk assessment be undertaken for all vessels intending to use the port. The assessment should identify whether a berth is safe for a vessel to remain alongside, define any operational limits or restrictions and identify any additional control measures that may be required. This information should be passed to the ship prior to arrival. (003/19)

On 8 March 2019, PrimePort Timaru replied:

> PrimePort Timaru can confirm that recommendation 003/19 has been fully implemented from February 2018.
>
> As TAIC will be aware, the Harbour Master is an appointee of the regional council, who is under a duty to ensure the maritime safety of ports in that region. The Harbour Master regularly makes extensive enquiries of the Port and is provided with the Port Engineer's six monthly assessment of berths. The Harbour Master issues Directions from time to time which, for example, determine the operating requirements and limitations that apply to vessels using the Port and to the Port itself.
>
> Under these Directions, vessels must ask the Port for a berth at least 24 hours in advance. The Port must receive a declaration as to the particulars of the vessel. The Port will then determine if the Master holds the relevant Pilot Exemption Certificate (PEC) issued by Maritime New Zealand under Part 90 of the Maritime Rules. A PEC will not normally be issued for any vessel above 120m LOA.
>
> Where a PEC is held, the vessel will be directed to a berth with prior approval for that vessel type from the Harbour Master under his powers contained in Part 3A of the Maritime Transport Act 1994. Monthly meetings are conducted with the Harbourmaster and Maritime New Zealand. Infrastructure is a topic on the agenda. The Harbour Master will have regard to prior use of the berth and the port engineer's assessment in determining the grant of approval.

If a PEC is not held by the Master, then a Port Assessment will be jointly completed between the ship and the Port prior to arrival. Further pre-arrival information will also be passed onto the Master via the vessel's shipping agents.

The Port Assessment considers relevant factors such as wind conditions, the dimensions (LOA, draft) of the largest vessel to have called at the port, and the official restrictions of the Port and berths imposed by the Harbour Master and navigation safety bylaws.

Pilots work to a pilot procedure guide agreed by all the pilots, applying the Harbour Master's Directions and navigation safety bylaws. The guide details matters relevant to assessing risks such as standard mooring guides for use at Timaru, high wind procedures for each wharf and operating criteria in different environmental conditions. Pilots must receive from Masters a 'Pilot Information Card' as set out in the pilots' pre-movement checklist. Pilots work with Masters using the mooring guide and passage plan to determine safe piloting of the vessel to an appropriate berth, with Masters having the final say as to the manner in which the vessel is made and declared fast.

The Port will also respond to specific requests for information or audits from vessel operators such as Coastal Oil Logistics Ltd or cruise liners, using forms such as the Marine Terminal Criteria & Assessment Questionnaire. Audits cover matters such as jetty or berth structure, and the systems and operations used.

To the Chief Executive of Maritime New Zealand

8.4. The port company should ensure that a berth allocated to a visiting vessel is suitable. A prerequisite for achieving that is port companies having an understanding of the loads capable of being generated by vessels with large windage areas and whether the port infrastructure is capable of withstanding them.

On 21 February 2019 the Commission recommended that the Chief Executive of Maritime New Zealand promulgate, through the Secretariat of the Port and Harbour Marine Safety Code Steering Group, the findings of this report, in particular the potential dangers associated with securing vessels that may be capable of generating loads in excess of those that the port infrastructure can withstand. Port companies should have a thorough appreciation of the loads involved for various ship types as well as the load limitations of the port infrastructure. (004/19)

On 8 March 2019, Maritime New Zealand replied:

The Port and Harbour Marine Safety Code Steering Group is a partnership between Maritime NZ, regional councils and port companies. Its primary responsibility is to implement the New Zealand Port and Harbour Marine Safety Code. Maritime NZ will work with the Secretariat of the Steering Group to promulgate the findings of the report in that context.

As noted in my letter to the Commission on 6 December 2018 I agree that the issues highlighted in this report will be of importance to port companies and consider that a direct promulgation of these issues to port companies would also be appropriate in the circumstances. Accordingly, we will also engage directly with port companies and those who work on the ports through their associations and representatives. This will enable Maritime NZ as the regulator to make its expectations clear as to the actions that port companies should be taking as a result of the findings and ensure that they comply with their maritime safety obligations.

I believe that WorkSafe New Zealand will also have an interest in the findings of the final report. Maritime NZ and WorkSafe are co-regulators for health and safety matters in port operations, and we work closely together on all port safety matters. We will share these findings with Worksafe.

Once the Commission has released the final report we will undertake the actions described above. I will advise you after this has been done.

9. Key lessons

9.1. Port companies must be aware of the safe working loads of their mooring infrastructure in order to produce safe and effective ship mooring plans.

9.2. Procedures for monitoring and communicating weather conditions must be robust and strictly followed when harbouring ships that are prone to high winds.

Appendix 1: Mooring rope particulars

Certificateno: BUS 1610825/10 Page 1 of 1

Project GLOBAL MARINE SUPPLIES SPA

Client: DONG YANG ROPE MFG. CO., LTD.

Office: Busan Port

Client's Order Number: 007/2016

Date: 23 August 2016

Order Status: Complete

Inspection Dates

First: 23 August 2016

Final: 23 August 2016

Thisceilificatemissuedto Messrs. Dong Yang Rope Mfg. Co.. Ltd., Busan, Korea, to certify that the undersigned surveyor did at their request, attend at their works on the above dates far the purpose of inspecting & testing the undermentioned item stated to be intended for the above project.

Description	: EURODAN 12—STRAND ROPE (100% high tenacity Polyolefin made of HTPP & HDPE mixed)
End	: 1.8m PVC protected eyes at both ends (5 tucks)
Color	: White
Lay	: Regular
Etc.	: UV stabilized

Number of coil	: 1 Coil
Specified Diameter	: 60 m
Specified Length	: 200 m
Specified Net Weight per coil	: 326 Kg
Test Length	: 1500 mm
Rate of Straining	: 90 mm/min
Specified MBL(Minimum Breaking Load)	: 63.00 Tonnes
Actual Applied Load	: 65.00 Tonnes

Testing of a production sample was witnessed by undersigned surveyor according to ISO 2307 & Manufacturer's specification IM-101.

For the purpose of identification, the bale was marked as follows

Lloyd's Register Asia
S. M. Kang
Busan Port Office

IDENTIFICATION : EURODAN ROPE
60 MM
200 M
Kong
12—STRAND
BALE NO.10
LR BUS 1610825/10
MANUFACTURED DATE : 22/08/2016

S. M.

Surveyor to Lloyd's Register Asia

a member of the Lloyds Register group.

Form 1123 (2015.08)

Appendix 2: Mooring rope test certificate

DNV•GL

Certificate No. GLIS/16/RR/504/04-11

Test Certificate

This is to certify that, at the request of M/S. GLOBAL MARINE SUPPLIES, the undersigned surveyor to this company attended their Approved works, on 01.03.2016 for the purpose of inspection of the below mentioned items.

GUIS order No. : 0860-15-1 1146-403

Place of Inspection : At, Boisar, Maharashtra.

Materials / **Items** : **12 — STRAND EURODAN ROPES IN STANDARD WHITE COLOUR WITH BLUE T.Y.WITH 1.8 METERS CANVAS COVERED EYES SPLICE AT BOTH ENDS.**

oft. Item Inspected:

Size	No. of Coils	Coil Bale No	Length (as co nfirmed by manufacturer)	Minimum required Breaking Strength (in Kgf.)	Breaking strength of samples (in Kgf)
DIA 60 MM	01	8965	220 Mtrs.	63000	65382

Inspection / Verification Performed. Selection of random samples. Witnessing Breaking Load Testing.

Identification : By Name of the Item / Bale No / Size - DIA MM / Length. and has been hard stamped on Lead seal As " CW." .

Results : The test gave no reason for objection, it is confirmed that the ropes comply with the Minimum Guaranteed breaking strength requirement of M/S. GLOBAL MARINE SUPPLIES,

Note : Testing performed as per BS EN ISO 2307: 2010. Certificate issued based on test results of randomly drawn sample nos. 8958 from Coil Bale nos. 8955 & 8962 for 200 Mtrs. & 8963 & 8966 For 220 Mtrs.

The inspection performed and certificate issued without prejudice to whomsoever it may concern.

SAFEGUARDING LIFE, PROPERTY AND THE ENVIRONMENT 18 64 DNV·GL 52 - 027

Date:
02.03.2016

PRAVIN WADEKAR
For Germanischer Lloyd
Industrial Services GmbH

Equinox Busniess Park, 6" Floor,Tower 3, L.B.S Marg. Off. Bandra Kuda Complex, Kurla VV) Mumbai - 4000 070

DNV GL Headquarters, Veritasveien 1, P.O.Box 300, 1322 Hevik, Norway. Tel: +47 67 57 99 00. www.dnvgl.com

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Appendix 3: Actual wind speeds and direction

istered to Prime Port Timm

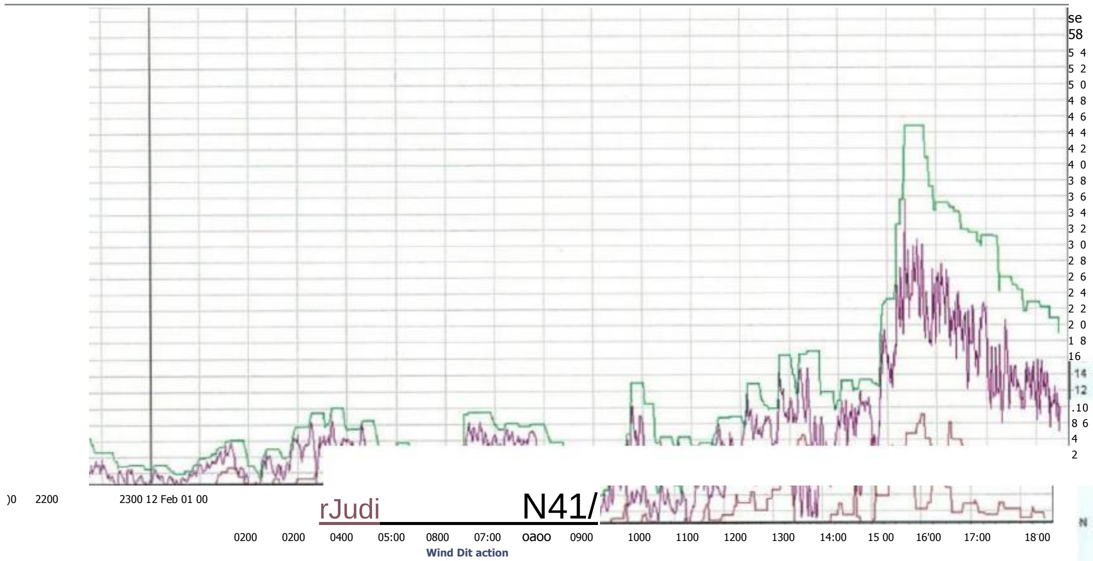
El 1=1 g IEI E rd 5k 4D

e WW1 Wed I Wind & Pressure I Tide I Waverider Location I Waverider Wave P1 ; Weverider *Wave* P2I Wevesider Spectra I Wayeridei Battery I Alarm Loci

North Mole Wind

Wind Speed

Max Gust



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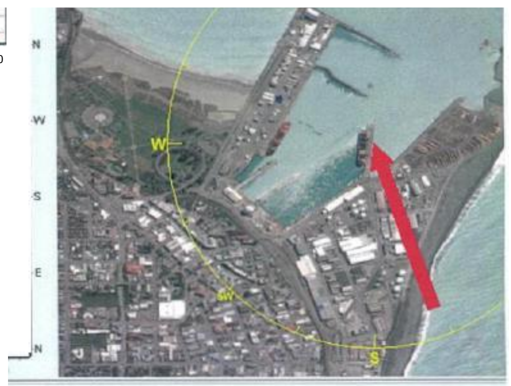

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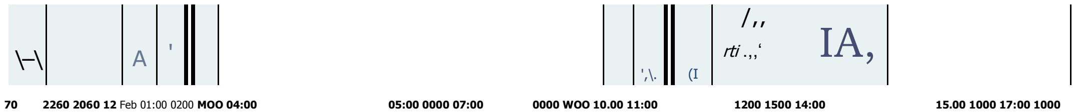
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3:30 DT

1U

Situation B3-Southerly Wind 45 kts

Allfinesareintaaandtheywind hasgeeredto135 deg ielative to the ship (180 deg true), and incxeasedspeed:o45 kts. The loads in the mooring system are as follows:

wind Speed 45 kts wind Directiot 180 deg true

Total End-On windage Area: 1044 Total Side windage Area: 5874

	Longitudinal	Transverse	Yaw moment/LBP
Other Force:	-69.7	149.5	-28.3
Total Force:	-69.7	149.5	-28.3

vessel moves(at Target): 0.2 fwd -5.9 out 0.0' stbd 0.3 up

Line to Bollard	Pull -in	Tot.Line Length	in-Line winch suction Slippage	/ncl n. Down	Line Tension	Percent Strength
1-n	1.17	54.3				5%
2-a	4_6	46_2		10*	11.0	21%
3-C	4.1	41.4		1?	12.8	25%
4-0	0.90	41.5		12'	2.4	518
5-E	4.0	40.8		14'	11.6	22%
6-F	3.9	39.4		1'	12.5	24%
1-6	1.91	10.9		18	27.8	5P6
8-H	2.03	22.2		28'	23.0	44X
0-I	4.0	41.0		2	7.0	5.4s
10-3	3.8	38.9		2'	7.2	14%
11-K	0.17	21.2		4'	30.5	59:8
11-L	2.44	7K0			29.4	51%
13-m	2.71	29.4		3s '	29	57%
14-N	0.83	84.0			8.1	16a
13-0	3.7	39.5		2'	19.6	38%
16-P	3.9	42.3		2'	17.3	33%

Hook/ Bollard	Force x-	Force Y-	Other x-Load	Other v-Load	Total Horiz Force	Direction in Plan	uplift
A	2.1	1.1	2.3			62'	0.4
rt	9.8	4.6	10.9			65'	1.9
C	11.0	5.9	12.5			62'	2.4
0	2.1	0.9	2.3			67'	0.5
E	10.1	4.9	11.3			64'	2.8
F	10.6	5.6	12.0			62'	3.3
G	-19.1	15.4	24.6			-51'	13.0
H	-16.6	11.8	20.4			-55'	10.7
I	6.9	1.5	7.0			78'	0.3
3	7.0	1.5	7.2			78'	0.3
K	-17.2	25.1	30.4			-34'	1.9
L	-21.3	20.7	29.7			-46'	1.4
M	-20.9	21.2	29.8			-45'	1.4
N	-6.0	5.5	8.1			-47'	0.3
o	-14.8	12.9	19.6			-49'	0.7
P	-13.6	10.7	17.3			-52'	0.6

Approximate natural periods Surge; 64 5%dy; 38 sets

CwiwiP'0

al,///://9rLtze-t7 4../Zatez4,42/ ".,<Pid /•• 1/

Comment: Simi ar to Situation B2. vessel (at midships) has moved 5.9 m out from the wharf, and line loads increase with bow springs at 44-53% strength, and stern lines L/h/ at 57% strength. Mooring arrangenent is secure provided bollards hold.

Recent Marine Occurrence Reports published by the Transport Accident Investigation Commission

MO-2017-203 Burst nitrogen cylinder causing fatality, passenger cruise ship Emerald Princess, 9 February 2017

MO-2017-205 Multipurpose container vessel *Kokopo Chief*, cargo hold fire, 23 September 2017

MO-2017-202 Passenger vessel *L'Austral*, grounding, Milford Sound, Fiordland, 9 February 2017

MO-2016-206 Capsize and foundering of the charter fishing vessel *Francie*, with the loss of eight lives, Kaipara Harbour bar, 26 November 2016

MO-2016-202 Passenger ship, *Azamara Quest*, contact with Wheki Rock, Tory Channel, 27 January 2016

MO-2017-201 Passenger vessel *L'Austral* contact with rock Snares Islands, 9 January 2017 MO-

2016-201 Restricted-limits passenger vessel the *PeeJay V*, Fire and sinking , 18 January 2016

MO-2016-204 Bulk carrier, *Molly Manx*, grounding, Otago Harbour, 19 August 2016 MO-2016-

205 Fatal fall from height on bulk carrier, *New Legend Pearl*, 3 November 2016 MO-2015-201

Passenger ferry *Kea*, collision with Victoria Wharf, Devonport, 17 February 2015

Interim Report Burst nitrogen cylinder causing fatality on board the passenger cruise ship *Emerald* MO-2017-203 *Princess*, 9 February 2017

MO-2012-203 Fire on board *Amaltal Columbia*, 12 September 2012

MO-2016-203 Bulk log carrier Mount Hikurangi, Crew fatality, during cargo securing operation, 27 February 2016

MO-2014-203 Fatal injury, Purse seine fishing vessel, *Captain M. J. Souza*, 24 August 2014

MO-2015-202 Containership *Madinah*, loss of person overboard, Lyttelton Harbour entrance, 2 July 2015

MO-2016-202 Urgent recommendation: Cruise ship *Azamara Quest*, contact with Wheki Rock, Tory Channel, 27 January 2016

MO-2011-202 Roll-on-roll-off passenger ferry *Monte Stello*, contact with rock, Tory Channel, Marlborough Sounds, 4 May 2011

MO-2014-201 *Dream Weaver*, flooding due to structural failure of the hull, Hauraki Gulf, 23 February 2014

MO-2010-206 Coastal container ship *Spirit of Resolution*, grounding on Manukau Bar, Auckland, 18 September 2010

MO-2014-202 Lifting sling failure on freefall lifeboat, general cargo ship *Da Dan Xia*, Wellington, 14 April 2014

11-204 Container ship MV *Rena* grounding, on Astrolabe Reef, 5 October 2011

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