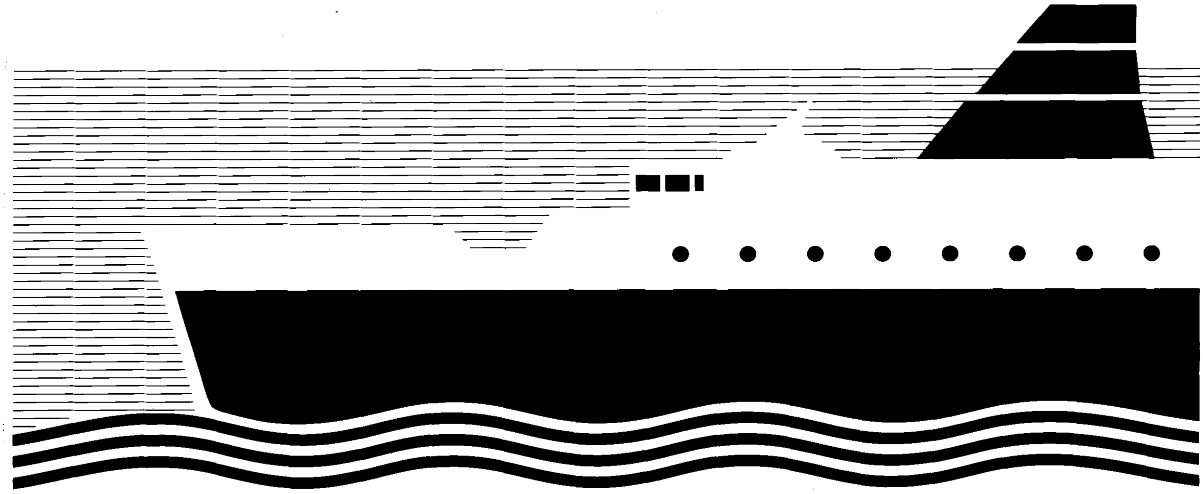
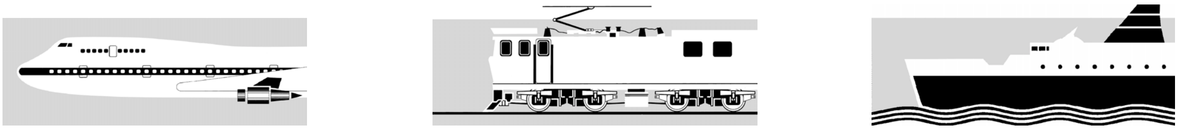


MARINE OCCURRENCE REPORT

05-206 **passenger freight ferry *Arahura*, loss of propulsion, Cook Strait** **24 April 2005**



TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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.

Report 05-206

passenger freight ferry
Arahura

loss of propulsion

Cook Strait

24 April 2005

Abstract

On Sunday 24 April 2005 at about 1150, the coastal passenger and freight ferry *Arahura* was approaching the entrance to Tory Channel while on passage between Wellington and Picton when it sustained a major loss of propulsion power. The Master was able to abort the entrance into Tory Channel and con the ship safely back into open water where the *Arahura* remained until power was restored. The Master then conned the ship to Picton, via the northern entrance to Queen Charlotte Sound, where repairs were effected to one of the diesel generators.

Safety issues identified included:

- engine room manning levels during critical phases of the voyage
- the adequacy of procedures covering the dissemination of information from the engine manufacturer.

Safety actions were taken by Interislander to cover one of these issues, and a safety recommendation was made to the General Manager, Interislander to cover the other issue.

Photograph courtesy of Interislander

The *Arahura* under way in the Marlborough Sounds

Contents

Figures

Abbreviations

°	degrees
ARPA	automatic radar plotting aid
cm	centimetre(s)
DG	diesel generator
DNV	Det Norske Veritas
GPS	global positioning system
hp	horsepower
kn	knot(s)
kW	kilowatt(s)
m	metre(s)
mm	millimetre(s)
nm	nautical mile(s)
PM	propulsion motor
rpm	revolutions per minute
t	tonne(s)
UTC	Co-ordinated Universal Time
VHF	very high frequency

Glossary

abaft	on the after side of, further towards the stern
athwartship	transversely across a ship
beach marks	the progression marks appearing on a fatigue fracture surface indicating successive positions of an advancing crack front
bleed	allowing fluid or gas to escape from a closed system
bollard pull	a measure of the static pull a vessel can exert
bow thruster	a small athwartships propeller mounted in a tunnel at the forward part of a ship, used to manoeuvre a ship at slow speeds
con (conduct)	direct the course and speed of a ship
course	direction steered by a ship
Doppler log	a device that uses the Doppler effect to measure a ship's speed
ductile overload	a ductile part fails when it distorts and can no longer carry the needed load, like an overloaded steel coat hanger. However, some ductile parts break into 2 pieces and can be identified because there is a great deal of distortion around the fracture face
echo sounder	a device for measuring the depth of water below a ship's bottom
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
knot	one nautical mile per hour
neap tide	tidal undulation that has the highest low water, and lowest high water, in a series
perigee	the point in a body's orbit at which it is nearest the Earth
pitch (of propeller)	the angle that a propeller blade makes with the propeller shaft. It is this pitch that produces the propulsion to drive a ship ahead or astern
port	left hand side of a ship when looking forward
significant wave height	average height of the highest one third of the waves
spring tide	tidal undulation that has the lowest low water, and highest high water, in a series
starboard	right-hand side of a ship when looking forward
thermal capacity	the capacity, or ability, of a substance to receive and store heat; equals the specific heat of a substance multiplied by its mass
tidal stream	the horizontal movement of the water due to tide

Data Summary

Ship particulars:

Name:	*Arahura*
Type:	passenger freight ferry
Class:	II (coastal passenger)
Classification:	Det Norske Veritas ✠ 1A1, R2 (NZ coastal waters) Car and Train Ferry A
Length:	148.37 m
Breadth:	20.25 m
Gross tonnage:	13 621
Built:	1983, Aalborg Vaerft, Denmark
Propulsion:	four 3800 kW diesel generators driving 4 electric propulsion motors coupled in pairs to 2 shafts, each with a 4-bladed controllable-pitch propeller
Service speed:	19 kn
Owner:	Toll New Zealand Consolidated Limited
Operator:	Interislander
Port of registry:	Wellington
Minimum crewing requirement:	44
Maximum passenger capacity:	997

Date and time:	24 April 2005 at about 1150[1]	
Location:	Cook Strait	
Persons on board:	crew: passengers:	65 611
Injuries:	crew: passengers:	nil nil
Damage:	one cylinder head stud on No 1 diesel generator fractured	
Investigator-in-charge:	Captain Iain Hill	

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

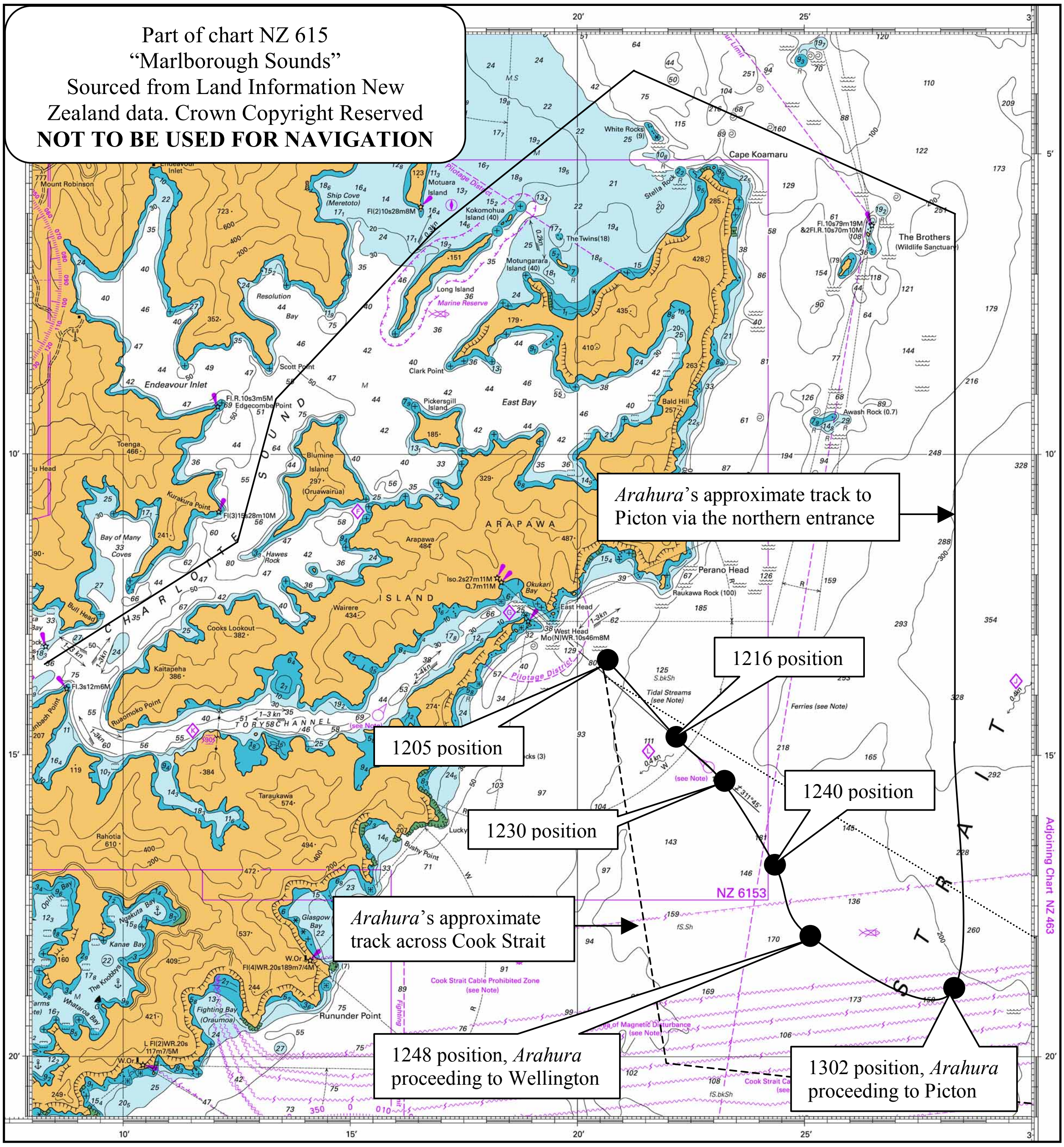


Figure 1
General area of the incident

1 Factual Information

1.1 History of the trip

1.1.1 On Sunday 24 April 2005 at about 0946, the *Arahura* departed from Wellington ferry terminal, with 611 passengers and 65 crew on board on its third crossing of Cook Strait that day. As the weather and sea state were known to be rough from the previous crossings, the Master implemented the operator's heavy weather procedures after leaving the berth (see Appendix 1).

1.1.2 The *Arahura* was using 3 of its 4 diesel generators to provide power to the propulsion motors as No.4 diesel generator in the aft engine room was out of service for planned maintenance and survey.

1.1.3 At about 1012, the *Arahura* cleared Wellington Harbour entrance and the Master decided to take a more southerly route than usual (see Figure 1), as was normal under such weather conditions. Such a course kept the swell on the port bow until the ship's course could be altered to make Tory Channel entrance with the swell abaft the beam.

1.1.4 The Master remained on the bridge for the majority of the crossing, conning the ship's course and speed to best suit the conditions. As the *Arahura* approached Tory Channel entrance the weather and sea moderated to what the Master estimated to be a 3 m swell and a 30 kn southerly wind.

1.1.5 At about 1142 the engine room watch changed. During the hand-over procedure, no irregularities were noted or commented on.

1.1.6 At about 1143, the navigating officer on duty made the required 10-minute call for entering Tory Channel on the very high frequency (VHF) radiotelephone. By about 1146, all the entry procedures for Tory Channel were completed and stand by was rung on the engine telegraphs.

1.1.7 One or 2 minutes after the duty engineer had accepted the watch, and as he was about to fill in the engine room log, No.1 diesel generator in the forward engine room came into alarm and then rapidly went out of alarm. No.1 diesel generator continued to cycle rapidly into and out of alarm. The duty engineer saw that the alarm was for cooling water high temperature and checked on the engine room whiteboard that this alarm was not listed as faulty. He then called up No.1 diesel generator on the monitoring system in the control room. As he was doing this, one of the diesel generators' turbo charger exhaust high temperature alarmed, although later he was unable to recollect which diesel generator.

1.1.8 At 1146, the duty engineer received and accepted the stand by command from the navigating bridge. Knowing that the ship was approaching Tory Channel, the duty engineer later stated that he thought the ship was "pushing the tide", causing the high temperature alarms, so he slightly reduced the power settings on the engines. However, this seemed to have little effect and he continued to receive a succession of turbo charger high temperature exhaust alarms.

1.1.9 During stand by, the duty engineer was required to remain in the control room (see Figure 2) so he was unable to go to the forward engine room to inspect No.1 diesel generator. The duty engineer therefore telephoned the Chief Engineer and advised him of the problem. The Chief Engineer started to make his way to the engine room from the accommodation. The duty engineer then advised the navigating bridge team by telephone that he was experiencing problems in the engine room, and recommended that the ship not enter Tory Channel until the problems were resolved.

1.1.10 On the bridge the Master received the telephone call from the duty engineer at about 1150. Being unsure of the propulsion situation, the Master immediately placed the ship into hand steering with a helmsman at the wheel and ordered starboard helm to turn the ship away from the coast and advised the rest of the bridge team of the situation.

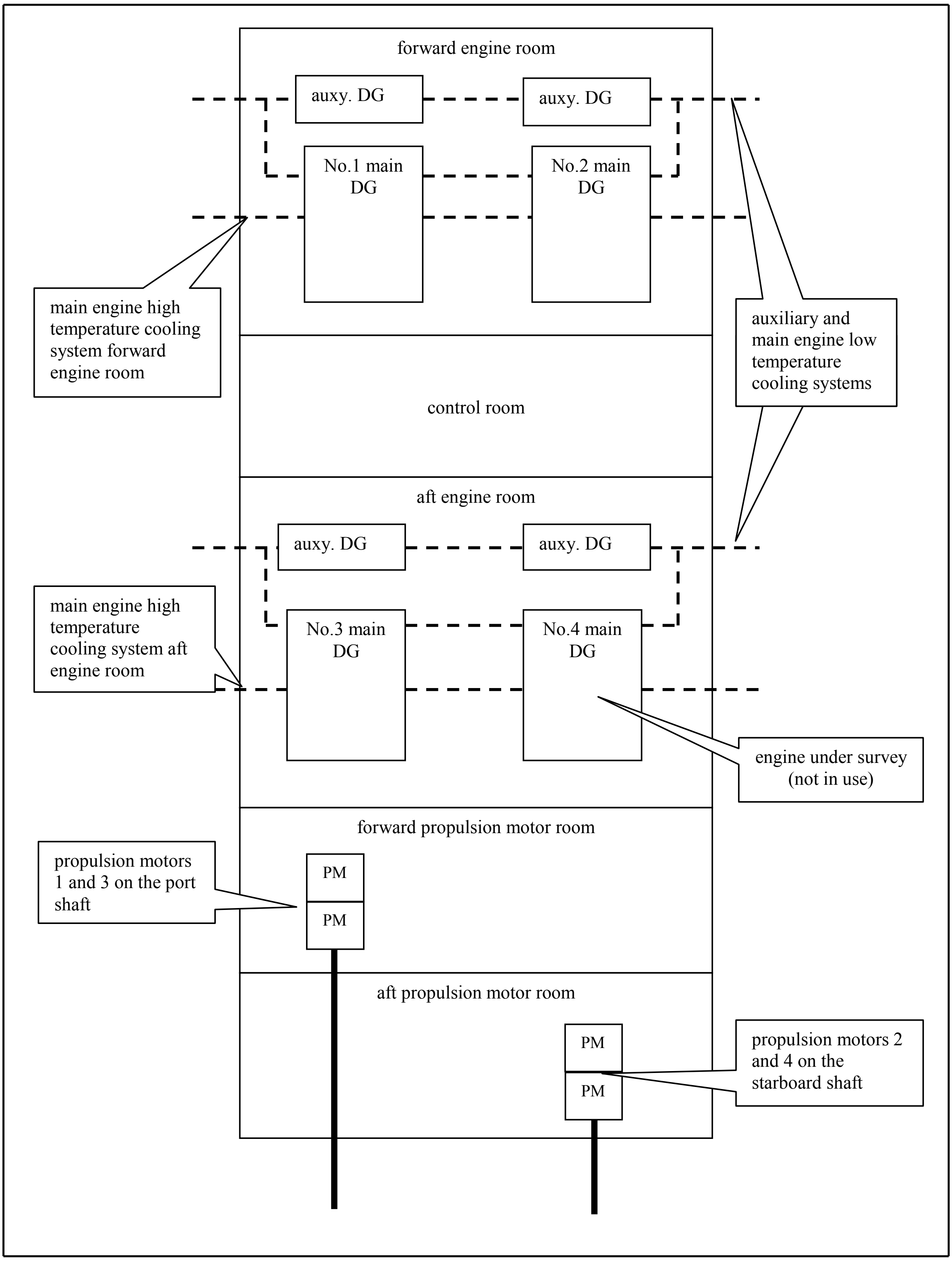


Figure 2
Diagram of the *Arahura*'s machinery space layout (not to scale)

1.2 Events in the engine room and ancillary spaces

1.2.1 To summon more help, the duty engineer set off the all-engineers call alarm. As he did so No.1 diesel generator stopped. Anticipating more help arriving, he then made his way to the forward engine room to see why No.1 diesel generator had stopped. As he made his way forward No.2 diesel generator stopped. One diesel generator (No.3) in the aft engine room continued to run. However, at about 1152, the 4 propulsion motors stopped.

1.2.2 As the duty engineer entered the forward engine room, he saw that there was water raining down all over the engine room. He realised that the diesel generator cooling water system had become pressurised so he went to the system header tanks and opened the valve to allow water to fill the header tanks. He then made his way back to the control room to inform the other engineers of what had happened.

1.2.3 The Chief Engineer entered the control room and quickly assimilated the situation before telephoning the navigating bridge and updating the bridge team. The Chief Engineer then sent the Electrician, who had responded to the all-engineers call along with the other engineers on board, to reset the propulsion motors and to override the safety interlocks to allow a propulsion motor to be started with only one diesel generator running.

1.2.4 After the electrician had reset the propulsion motors, the Chief Engineer attempted to start one from the control room. He was unable to do this so he ordered the Electrician to change over to local control and start one of the propulsion motors from the propulsion motor room. The Electrician was successful in starting one of the propulsion motors on the starboard shaft, however when he tried to start one on the port shaft, the one on the starboard shaft stopped. The Electrician restarted one propulsion motor on the starboard shaft and advised the Chief Engineer of the problem with starting the others.

1.2.5 The Chief Engineer telephoned the navigating bridge and advised the Master that it would be best to clear the coast on the one available propulsion motor before attempting to restart the others.

1.2.6 On arriving in the engine room the First Engineer took charge of the other engineers and proceeded to isolate No.1 diesel generator, fill the header tank and bleed the cooling system on No.2 diesel generator prior to restarting No.2 diesel generator at about 1215. However, No.2 diesel generator was not connected to the electrical switchboard until the ship was in safer waters.

1.2.7 At about 1245, the Chief Engineer advised the Master that No.2 diesel generator was running in the forward engine room in addition to No.3 diesel generator in the aft engine room that had continued to run, all 4 propulsion motors were available for use, and that the ship could proceed with a pitch setting of up to a maximum of 8 on each shaft.

1.2.8 Subsequent to the incident the engineers found that when No.2 diesel generator stopped, the reverse current trips and the load-limiter equipment did not operate correctly. This equipment was overhauled and the faults rectified by the ship's engineers after the incident.

1.3 Events on the navigating bridge

1.3.1 At about 1152, the bridge team noted that the propulsion motors had stopped. The Master ordered that the anchors be cleared ready for use and, using the remaining headway, continued to con the ship away from the coast.

1.3.2 At about 1155 (see Figure 3), the Master informed Interislander's Operations Manager and the Interislander ferry *Aratere,* which was in the vicinity, of the situation. At about 1157, after reassessing the situation, the Master issued an urgency message on VHF radio channel 16. This message was received by Maritime Radio and relayed to the Rescue Co-ordination Centre. The *Aratere* was asked to stand by to render assistance if necessary.

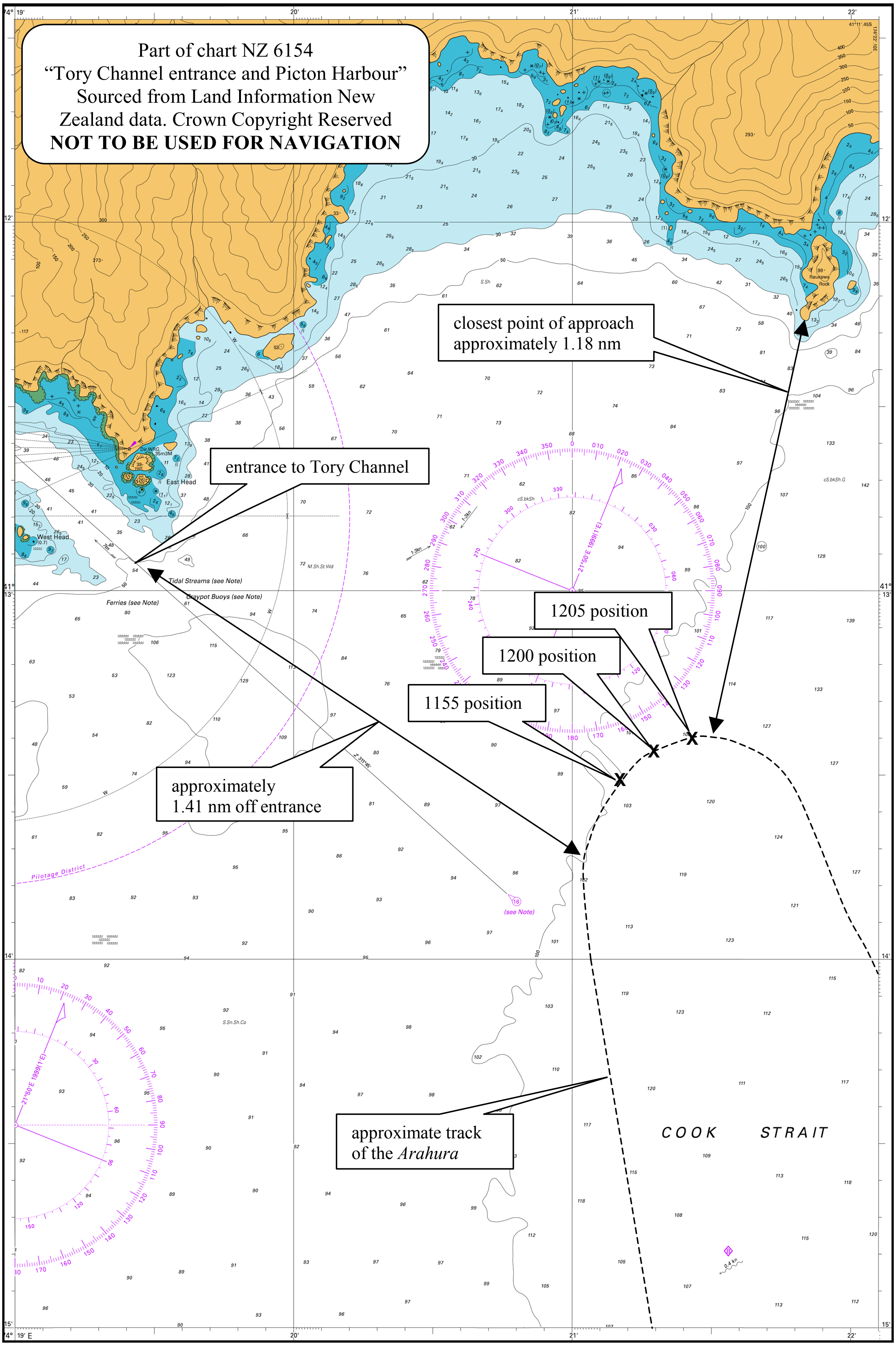


Figure 3
The *Arahura*'s track and closest point of approach during the incident

1.3.3 At about 1205, the chief engineer advised the Master by telephone that one propulsion motor on one shaft was available for propulsion. The Master proceeded to con the *Arahura* away from the coast out into Cook Strait. When it was about 5 nm off the land, the Master and the remainder of the bridge team agreed that they were in safe waters and stood by awaiting updates from the chief engineer.

1.3.4 At about 1245, the Chief Engineer advised the Master by telephone that 2 diesel generators, one in each engine room, were providing power to the electrical distribution board and were available to power all of the propulsion motors. The remaining 3 propulsion motors that had stalled had been started and a maximum pitch setting of 8 could be used on each of the propellers.

1.3.5 At about 1247, after receiving a weather update and considering his options, the Master with the rest of the bridge team decided not to proceed to Picton because of the wind direction and strength and the poor holding ground if he was required to anchor. Instead he decided to return to Wellington with its better harbour entrance, good tugs and a berth that was easier in the weather conditions prevailing at the time.

1.3.6 At about 1251, the Master cancelled his urgency message on the VHF radio and informed the passengers of the situation. He also contacted the relevant harbour authorities, managers and the Rescue Coordination Centre to advise them of his decision.

1.3.7 At about 1257, the Chief Engineer contacted the Master and advised him that the reliability of the propulsion was then almost 100% with the affected unit totally isolated, and that the propulsion system was operating in a mode in which the vessel frequently operated when ahead of time with 2 diesel generators and 4 propulsion motors running. The Master and bridge team re-evaluated their destination decision and decided to head for Picton via the northern entrance to Queen Charlotte Sound.

1.3.8 After the Master advised all parties of the revised decision, the *Arahura* continued on passage to Picton without further incident, berthing in Picton at about 1551 with a tug standing by to assist if required.

1.4 Ship information

1.4.1 The *Arahura* was a purpose built Roll on-Roll off passenger and freight ferry, which plied the waters between Wellington and Picton. It was built in Denmark for New Zealand Railways[2] in 1983. The ship operated on a scheduled 24-hour service across Cook Strait, and was certified to carry a total of 997 passengers. The ship was registered in New Zealand and had valid certificates issued by or on behalf of that Government and Det Norske Veritas classification society and was certified to operate in New Zealand coastal waters.

1.4.2 The *Arahura* was 148.4 m in length and 20.5 m extreme breadth. The navigating bridge was situated about 20 m from the bow. The ship was powered by a diesel electric system, comprising four 5565 horsepower (hp) [4194 kW] diesel engines each driving a 3800 kW generator. These supplied power to 4 electric propulsion motors, 2 on each of the 2 shafts, each of which drove an inward turning controllable-pitch propeller at a constant speed of 214 rpm.

1.4.3 Power was produced by as many of the 4 diesel generators as was required, and could be interswitched between the propulsion motors, allowing for different combinations of generators and motors to be used. The *Arahura* often ran on fewer than all 4 generators allowing one to be isolated for maintenance and survey.

[2] New Zealand Railways underwent several changes of standing as a company after 1987, as did the rail ferry division. The current names, Toll Consolidated New Zealand for the company and Interislander for the rail ferry division, have been used throughout this report for consistency.

1.4.4 The diesel generators were fitted with reverse current trips, which were devices that sensed the direction of current flow and operated a protective trip device if the reverse current flow exceeded a preset limit. Normally these were used for parallel-connected, engine-powered alternator (generator set) protection where the normal current flow would be from the alternator to a distribution bus, then out to the connected loads. In some circumstances of a generator set failure or malfunction, the alternator could become a load. For example, if the engine stopped for any reason but the generator set remained connected to the bus, the alternator could draw current from the bus (reverse current flow to the normal direction of current flow) and act as a motor to continue to rotate the engine. A reverse current trip device would sense the reverse current flow and initiate a generator set circuit breaker trip to disconnect the generator set from the bus.

1.4.5 Steering was provided by 2 spade rudders, one aft of each propeller. In addition, the *Arahura* was fitted with 2 bow thrusters each of 1200 hp [895 kW], giving a combined bollard pull equivalent to 30 t. The *Arahura* was also fitted with a pair of active stabilising fins to reduce rolling and enhance passenger comfort, however active fins became progressively less effective as the ship's speed reduced.

1.4.6 The navigating bridge was fitted with the following equipment:

- 2 automated radar plotting aid (ARPA) radars, 1 x 10 cm and 1 x 3 cm
- 2 VHF radios
- one global positioning system (GPS) navigator
- one echo sounder
- one Doppler log
- 2 gyro compasses
- 2 rudder angle indicators
- one weather facsimile machine.

Diesel generator No.1 and cooling system

1.4.7 When the ship's engineers examined No.1 diesel generator after the incident they found that one of the cylinder head studs had fractured below the "O" ring seal (see Figure 4).

1.4.8 The last survey of the cylinder head and studs on No.1 diesel generator was undertaken at 53 704 running hours in September 2000. At the time of the incident, the engine had done about 77 644 running hours and was due for overhaul after the overhaul and survey of No.4 diesel generator in the aft engine room had been completed.

1.4.9 The fracture of the cylinder head stud allowed combustion gases and possibly some unburnt fuel from the cylinder to enter and pressurise the cooling water system. As the system became pressurised, water was expelled from the cooling water header tank to fall like rain over the engine room, and through the gap between the head and entablature caused by the fractured stud.

1.4.10 Interislander staff had previously experienced cylinder head stud fractures on the diesel engines. Wärtsilä NSD Corporation (Wärtsilä), the manufacturer of the engines, had issued a service letter concerning breakages in the cylinder head screws [studs] (see Appendix 2). This letter was distributed to the Wärtsilä NSD service network and owners/operators of Wärtsilä Vasa 32 engines, including Interislander, in August 1999. However, one of the *Arahura*'s chief engineers stated that the service letter was not received on board the ship until after the incident.

1.4.11 Wärtsilä did not specify a service life for the cylinder head studs. However, it did specify in the service letter that a cylinder head stud should be changed:

- whenever it has been over-tightened
- when corrosion pits with a depth in excess of 0.1 mm are present
- whenever in doubt.

1.4.12 The service letter gave the major reasons for broken studs and provided information on remedial action to be taken, noting that whenever in doubt the stud should be changed. Normal practice on board the *Arahura* was to examine the cylinder head studs visually during overhaul and to conduct a crack test with dye penetrant. Any studs that were suspect were replaced.

1.4.13 The cylinder head studs, as with many of the other connections within the engine where accuracy was essential, were tightened using a hydraulic tool as detailed in the Wärtsilä service letter. By using a hydraulic tool, the inaccuracies associated with tightening using a torque wrench or other hand device and the variable effects of friction were overcome.

1.4.14 The Wärtsilä service letter specifically mentions that too high an opening or loosening pressure on the hydraulic tool can cause the stud to develop an initial crack. Excess pressure in the hydraulic tool can be caused by use of the tool with an inaccurate pressure gauge.

1.4.15 Interislander staff on board the *Arahura* calibrated the pressure gauges on the hydraulic stud stretchers, using an Ashcroft 1327 portable test pump, prior to commencing an engine overhaul. This was to prevent the possibility of excess pressure caused by an inaccurate pressure gauge.

1.4.16 The cooling water system for the machinery and equipment in each engine room, as with many of the world's merchant ships, used fresh water passing through a common system to the machinery. The fresh water then passed through heat exchangers that were cooled by sea water. The diesel generators in each engine room, forward and aft, used for providing power to the propulsion system, were cooled by the same system such that if one part of the cooling system were compromised both diesel generators were affected. However, the auxiliary diesel generators ran on a separate cooling system.

1.4.17 Water has a large thermal capacity[3] and as such is often used in cooling systems, both open and closed. In contrast, air has a small thermal capacity as shown by its rapid rise in temperature when heated, and rapid fall when the heat source is removed. When air enters and mixes with water in a closed cooling system, the thermal capacity of the system is greatly reduced, dependent on the amount of air entering the system, causing a rapid rise in temperature of the coolant and overheating of the system. Air entering a closed system can also cause an "air-lock" in the circulating pumps, preventing the flow of cooling water and similarly overheating the system. Similarly, combustion gases, which are the product of the combustion process, entering the closed cooling system also cause a rapid rise in the temperature of the cooling system.

Stud examination post fracture

1.4.18 A metallurgist examined the broken stud after the failure. The metallurgist noted that the fracture had initiated where the local stud diameter had been decreased [waisted] and the stud showed localised corrosion pitting within this region consistent with exposure to an isolated corrosive liquid event. A black carbonaceous product was removed from the corrosion pits and this substance also covered approximately 15% of the initial fatigue crack propagation surface, showing that the corrosive liquid had been present for a significant proportion of the stud's service life. Analysis undertaken showed that the black carbonaceous product was consistent with that of a mixture of stud metal oxide corrosion products and oxidised oil.

[3] The capacity, or ability, of a substance to receive and store heat; equals the specific heat of a substance times its mass

1.4.19 Examination of the fracture face showed beach marks characteristic of fatigue crack propagation radiating from a corrosion pit. Fatigue crack propagation was evident through approximately 70% of the stud cross-section. The remaining 30% of the cross-section showed evidence of a rapid ductile overload fracture that completed the final failure.

1.4.20 The metallurgist estimated that fatigue crack propagation had probably been occurring for a period in excess of 3 to 5 years.

1.4.21 The underside of the stud nut showed no evidence of fretting so it was unlikely that crack initiation and propagation were associated with in-service loosening.

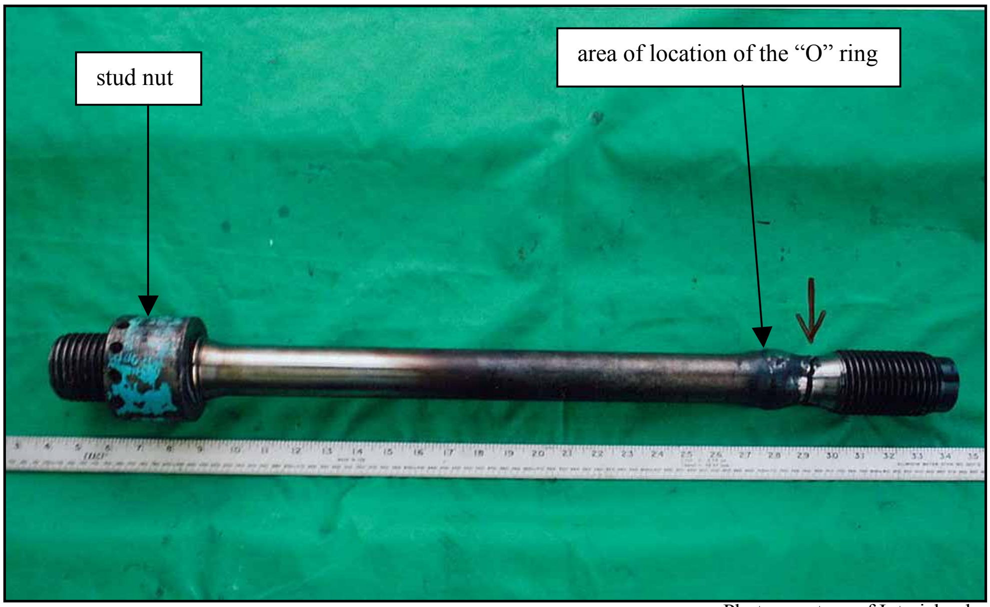


Photo courtesy of Interislander

Figure 4
General picture of the damaged stud; the arrow points to the fracture

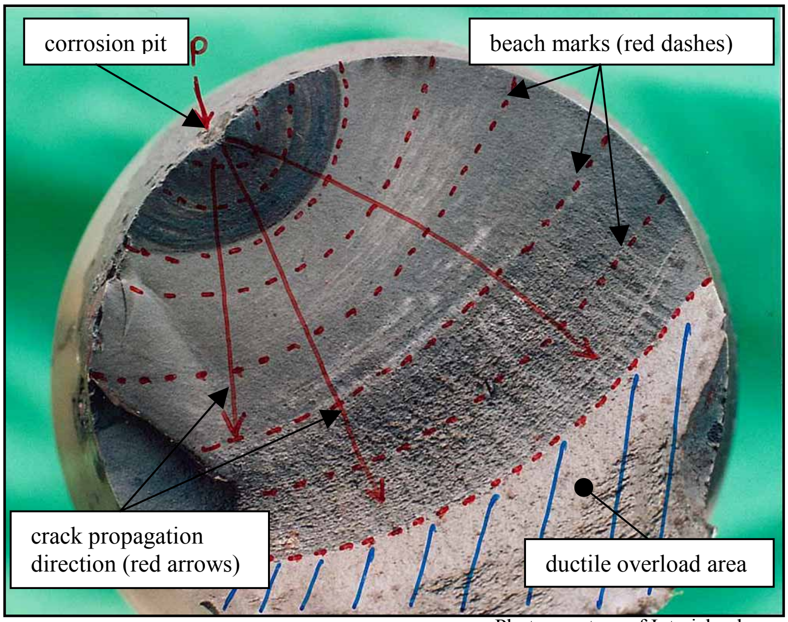


Photo courtesy of Interislander

Figure 5
Stud fracture surface showing corrosion pit “P”, beach marks, crack propagation and ductile overload

1.5 Personnel information and manning

1.5.1 The Master had started his seagoing career in 1972 and gained his Master's foreign-going certificate in 1984. He joined Interislander in 1990 and had sailed on all of the group's ferries. He was promoted to Master in 2000.

1.5.2 The navigating officer on watch at the time of the incident had started his seagoing career in 1988, and gained his Master's foreign-going certificate in 1999. He joined Interislander in January 2005 as third mate.

1.5.3 The Chief Engineer had started his seagoing career in 1963 and gained his Chief Engineer's certificate in 1970. He joined Interislander in 1971 and was promoted to Chief Engineer in 1972. The Chief Engineer had stood by the building of the *Arahura* in Denmark in 1983 and had served on the ship nearly continuously since then.

1.5.4 The engineering officer on duty at the time of the incident had started his seagoing career in the Royal New Zealand Navy in 1973 and, after 21 years, had moved to the merchant fleet. He had worked for Interislander for about 5 years and held a marine engineer class 3 certificate.

1.5.5 Normal operating procedures required that a watchkeeping engineer and an Electrician or standby engineer manned the control room during stand by periods. The Electrician or standby engineer was required to be in the engine room at least 5 minutes prior to stand by. At the time of the incident the duty engineer, due to the unfolding situation, had not had time to summon the Electrician or stand by engineer to the control room.

1.6 Climatic conditions

1.6.1 The area where the incident happened was in the Cook area of the New Zealand coastal waters forecast areas. The New Zealand Meteorological Service (Metservice) issued Coastal waters forecasts at well-documented regular intervals.

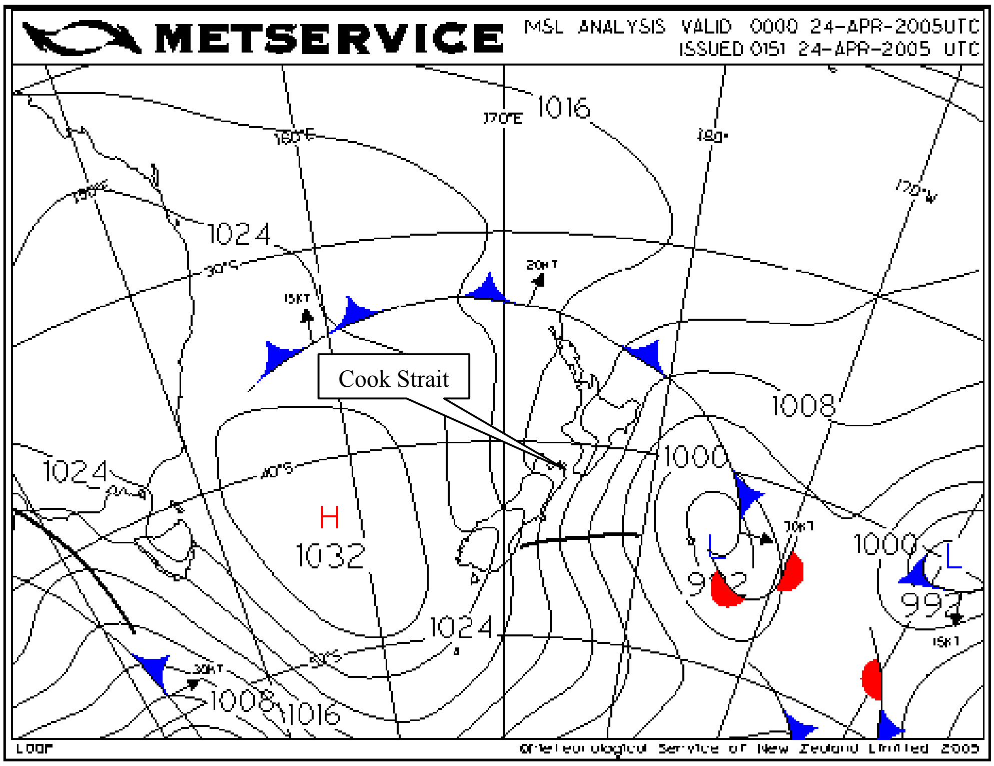


Figure 6
Mean sea level analysis synoptic chart for 1200 24 April 2005

1.6.2 The coastal waters amended forecast issued at 0421 24 April 2005 and valid until midnight 24 April 2005 for sea area Cook was as follows:

> COOK
> *STORM WARNING IN FORCE*
> Southerly 15 knots rising to 35 knots this morning and to 50 knots around midday. Southerly easing to 35 knots this evening. Sea becoming high for a time. Southerly swell rising to 4 metres. Poor visibility in showers this afternoon.
> OUTLOOK FOLLOWING 12 HOURS: Southerly 30 knots.

1.6.3 The coastal waters amended forecast issued at 0906 24 April 2005 and valid until midnight 24 April 2005 for sea area Cook was as follows:

> COOK
> *STORM WARNING IN FORCE*
> Southerly 40 knots rising to 50 knots around midday. Southerly easing to 35 knots this evening. Sea becoming high for a time. Southerly swell rising to 4 metres. Poor visibility in squally showers, easing this evening.
> OUTLOOK FOLLOWING 12 HOURS: Southerly 30 knots.

1.6.4 Metservice states that coastal area forecasts are a general indication of average conditions expected in a particular coastal area. The forecasts are for open waters within 60 nm of the coast and do not apply to enclosed areas such as small bays and harbours.

1.6.5 Metservice provided an aftercast of the weather that would have been experienced in the area at the time of the incident as shown below:

> **Situation:**
> A deep depression lies near Chatham Islands moving quickly away to the east. An anticyclone lies in the south Tasman Sea moving slowly northeast. Between these two systems a southerly air stream covers New Zealand.
>
> **Weather conditions:**
>
> **4 nm east of Tory Channel, Cook Strait; 1000 to 1300 hours 24 April 2005:**
> **Wind**: Blowing from the south, the 10-minute mean speed was varying between 25 and 30 knots, and momentary gusts were between 35 and 45 knots.
> **State of Sky, weather and visibility:** Partly cloudy and brief showers. Visibility generally 12 to 15 km but reduced to 5 to 7 km in the showers.
> **Sea state:** Rough[4] to very rough seas. Significant wave height[5] was about 3.5 metres and occasional waves about 5 metres.
> **Swell:** From the south, significant wave height about 2 metres, and occasional waves about 3.5 metres.
> **Combined waves:** Significant wave height about 4 metres and occasional waves about 6.5 metres.

1.6.6 The predicted tides for Picton and Wellington detailed in the New Zealand Nautical Almanac for 24 April 2005, were:

Picton							
Low Water		High Water		Low Water		High Water	
0221	0.2	0926	1.4	1448	0.1	2146	1.4

Wellington							
High Water		Low Water		High Water		Low Water	
0418	1.5	1032	0.8	1647	1.5	2309	0.7

4 These sea state terms have the same meanings as those defined in the Beaufort Scale of Sea State.

5 "Significant wave height" is the average height of the highest 1/3 of waves present. This applies to heights of the sea, swell and combined waves.

1.6.7 The range of tides tabulated in the New Zealand Nautical Almanac for Picton was 1.44 m for the spring range and 0.54 m for the neap range. The range at the time of the incident was 1.3 m and therefore a spring tide.

1.6.8 Tidal stream rates were shown on the chart for specific geographical positions designated by a magenta diamond shape enclosing a letter, known as a tidal diamond. The rates shown are for average spring or neap tides referred to high water at Wellington. If the tidal range is greater than normal (e.g. full or new moon coinciding with perigee) the rates will be increased roughly in proportion. The spring rates for relevant diamonds as shown in Figure 1 were:

Position	Time	Direction	Rate
Diamond “L”	1047	193º	0.3 kn
41°14’.80S	1147	225º	0.8 kn
174° 21’.55E	1247	232º	1.3 kn
Diamond “J”	1047	192°	1.7 kn
41° 13’.80S	1147	192°	2.3 kn
174°29.60E	1247	192°	2.3 kn

1.6.9 The New Zealand Nautical Almanac states in the section concerning tidal streams the following:

> The tidal streams in and around Cook Strait are unreliable, and masters are warned to exercise every precaution when navigating in the vicinity. The streams often run in one direction for 8 to 10 hours, while cases have been reported of them going so for 18 hours and more. When the streams have been running in one direction, for say 8 to 10 hours, it has been found that the opposite stream is much weaker and, in some cases, hardly noticeable. The maximum rates shown on the chart, which are usually attained at springs, are also liable to be experienced at any other time. In the vicinity of Karori Rock and Cape Terawhiti a rate of up to 7 knots is frequently experienced, but as a rule it does not last for more than about an hour. Small vessels are warned to keep well clear of tide rips, as they may lose steerage way and may, in extreme cases, capsize.

1.6.10 When a tidal stream runs against a sea and swell it causes the sea to steepen and the wave period to decrease. Conversely when a tidal stream runs with a sea and swell it causes the sea to flatten and the wave period to increase.

1.6.11 The Admiralty Sailing Directions New Zealand Pilot (NP51) states the following about Cook Strait:

> Cook Strait is particularly affected by the frequency and strength of NW and S to SE winds due to the close proximity of high land on both sides producing a funnel effect; these are the only violent winds but they give rise to the worst storms experienced in New Zealand waters, averaging about 25 each year. Strong to gale force NW winds are very localised, but S gales affect the whole strait. Gales from SE, which are experienced more often, are strongest in the W part of the strait around Cape Campbell, and over the N parts of Marlborough Sounds.
>
> Broken water is experienced in Cook Strait; this may in part be due to the influence of a cold bottom current being forced to the surface. When the flow is strong, heavy tide rips occur in the vicinity of the deep submarine canyons in the strait.
>
> During gales, very rough seas are a feature of Cook Strait. The heaviest seas are caused by S gales, which can produce very high and dangerous swells, particularly across the strait S of Wellington Harbour and N and S of The Brothers islands.

1.7 Damage

1.7.1 One cylinder head stud on No.1 diesel generator in the forward engine room failed, requiring all 4 cylinder head studs on this cylinder to be renewed.

2 Analysis

2.1 The crossing of Cook Strait was undertaken in less than ideal conditions. However, the Master instigated and followed the company's heavy weather procedures and amended the vessel's track to best suit the conditions. Crossings in the conditions prevailing at the time of the incident were not uncommon and the procedures had been developed to minimise the risk.

2.2 When the Master was advised of the problem in the engine room he, in conjunction with the remainder of the bridge team, took swift and decisive action to prevent the *Arahura* from getting any closer to a lee shore. Throughout the incident the bridge team exercised good Bridge Resource Management and kept those on board and the appropriate shore-based entities apprised of the situation as it developed.

2.3 The Master of the *Arahura* was also able to contact the *Aratere* and prudently requested the *Aratere* to stand by in case the situation did escalate.

2.4 It was not unusual for the *Arahura* to be running on 3 diesel generators with the fourth under maintenance. The ship was able to navigate safely to Picton after power had been restored on 2 diesel generators only. As the auxiliary diesel generators were on a separate cooling system to the main diesel generators, when the main diesel generators cooling system was compromised the auxiliary diesel generators continued to function providing power for steering, navigation, hotel and other services.

2.5 When a situation developed that he did not recognise, the watchkeeping engineer prudently requested help from more senior engineers and advised the Master not to enter the Tory Channel. However, had more senior or more qualified personnel been present in the control room during such a critical phase of the crossing, they may have recognised the signs and been able to rectify or isolate the problem more quickly and have prevented the loss of all 4 propulsion motors.

2.6 The action of turning the ship hard to starboard to clear the coast, probably with full starboard rudder may have contributed to the propulsion motors stalling when the power of one diesel generator only was available. This may have also had a bearing on the difficulty experienced by the engineers and electrician in initially re-starting the propulsion motors.

2.7 It was probable that the reverse current trips and the load-limiting equipment not operating correctly also contributed to the propulsion motors stalling.

2.8 The Chief Engineer, other engineers and Electrician followed procedures, and worked efficiently to identify the problem and restore propulsive power to the ship in a minimal amount of time.

2.9 As air and/or combustion gases entered the system and mixed with the cooling water, the thermal capacity of the cooling water would have dropped, causing overheating first in the affected engine and then in the other parts of the system. It would also have been possible for the circulating pumps to become air-locked, thus preventing the flow of cooling water round the system and similarly adding to the overheating problems.

2.10 The Wärtsilä service letter giving guidance on the cylinder head stud renewal was sent to Interislander. However, no copy was found and no record or memory of receipt could be found on board the *Arahura*. Whether or not it was received on board prior to the incident could not be proved. The crew on board the *Arahura* were therefore denied the opportunity of the guidance of this document.

2.11 The cylinder head studs on No.1 diesel generator were last examined in September 2000, about 4½ years prior to the incident. The metallurgist estimated that the cracking had been occurring for in excess of 3 to 5 years. Therefore it is possible that the cracking may have been initiated at or just before the time of the last examination or just after it.

2.12 The most probable cause of the failure of the cylinder head stud was corrosion pitting. This cause was one of those detailed in the service letter and it occurred in the region below the "O" ring seal identified in the service letter. Wärtsilä had properly identified a problem and had instigated procedures to remedy it.

2.13 The other possible cause detailed in the Wärtsilä service letter was over or under tightening during maintenance. This cause was unlikely because procedures were followed to test and calibrate the hydraulic equipment prior to the studs being tightened or loosened, and the metallurgist found no evidence of fretting wear indicative of in-service loosening.

2.14 Had the service letter been received on board when Wärtsilä disseminated it in August 1999, then the ship's crew would have been alerted to the problem and may have identified the need to replace the cylinder head stud at the examination in September 2000.

3 Findings

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

3.1 The *Arahura* suffered a complete loss of propulsion caused by combustion gases entering the closed cooling water system of the forward engine room main diesel generators.

3.2 Combustion gases probably entered the cooling system through a gap in the joint between a cylinder head and the engine block, caused by the failure of a cylinder head stud.

3.3 Because of the configuration of the cooling water system, this caused both the diesel generators in the forward engine room to shut down due to high-temperature alarms.

3.4 All 4 propulsion motors stalled when power was available from one diesel generator only. This was probably due to a combination of the forces exerted on the propellers by the amount of helm being applied, and the incorrect operation of No.2 diesel generator's reverse current trips and the load-limiting equipment.

3.5 After the power failure the Chief Engineer and engineers followed procedures and worked efficiently to identify the problem and restore power to the vessel.

3.6 Had more senior or highly qualified personnel been in the engine control room at the time, the incident may have been averted.

3.7 Had the engineers on board the vessel been in receipt of the service letter when it was issued, they may have identified a problem at the last cylinder head stud examination.

3.8 The Master and crew took appropriate actions and followed the authorised contingency plans to maintain the safety of the vessel during the incident.

3.9 The ship was correctly certificated and manned at the time of the incident.

4 Safety Actions

4.1 After the incident Interislander carried out the following safety actions:

- all the cylinder head studs on diesel generators 1, 2 and 3 were ultrasonically checked while in situ, replacing 3 studs that showed indications of cracks
- the cylinder head studs on diesel generator 4, which was already under survey and maintenance, were tested by magnetic particle inspection for cracks, replacing any that showed indications of cracks
- in the maintenance schedule for the 20 000 hour survey a requirement was included to have all cylinder head studs tested by magnetic particle inspection
- a fleet instruction was issued that the Chief Engineer was to be in the engine room when the vessel was in pilotage waters. If the Chief Engineer was unavailable, a First Engineer with a class 1 certificate of competency as a marine engineer was to substitute for the Chief Engineer.

4.2 In view of the safety actions taken by Interislander, no safety recommendations covering these aspects have been made to Interislander.

5 Previous safety recommendations

5.1 Following a machinery space flooding on the *Arahura* on 7 June 2001 (Marine Occurrence Report 01-208) the Commission recommended on 10 December 2001 to the Managing Director of Tranz Rail Limited, that he:

> critically review the experience and manning levels for engine room watches and stand by periods, and ensure an appropriate level of experience is present in the engine room at all times. (071/01)

On 7 January 2002, Tranz Rail's General Manager, Health, safety & Environment, replied:

> **Final Safety recommendation 071/01**
> Tranz Rail accepts this recommendation. Completion is expected by 28 February 2002.

On 26 September 2002, the Commission closed the recommendation as "closed acceptable" from information supplied by Tranz Rail that stated:

> that Tranz Rail had completed a review of experience and manning levels for engine room watches and had established that existing arrangements were acceptable.

6 Safety Recommendation

6.1 On 22 November 2005, the Commission recommended to the General Manager, Interislander, Toll NZ Consolidated Limited that he:

6.1.1 review the procedures for the distribution of manufacturer's service bulletins and letters to ensure that all company vessels receive all applicable current and future documentation and the distribution and receipt are adequately recorded. (106/05)

6.2 The Marine Operations Manager, Interislander replied to the preliminary safety recommendations, which were subsequently adopted unchanged as the Commission's final safety recommendation. That reply dated 22 November 2005 was:

> Interislander accepts this recommendation. All service bulletins from all manufacturers of equipment on our vessels will be encompassed in ship-specific registers in the office, which will be duplicated on board. Where sequential numbering of bulletins have not been provided by the manufacturer, Interislander will create its own. Interislander ISM system provides for regular reconciling of ship and shore-based registers to ensure each ship has received the appropriate documents. Close out date for this recommendation is targeted for April 2006.

Approved on 16 December 2005 for Publication

Hon W P Jeffries
Chief Commissioner

Appendix 1

HEAVY WEATHER

This procedure applies when there is, or when there is expected to be, adverse sea or wind conditions which may affect the safety of the ship, cargo or passengers.

MASTER RESPONSIBLE FOR:

- ❑ Ship and cargo secured ready for any expected weather conditions
- ❑ All departments informed
- ❑ Announcement to passengers, (see heavy weather announcement in safety manual.

DUTY MATE RESPONSIBLE FOR:

- ❑ Rounds made prior to leaving sheltered waters with particular attention to the securing of:
  - ♦ stern door, gangway doors, bunker doors and portholes
  - ♦ cargo, rubbish bin, funnel doors, loose equipment
  - ♦ forecastle hatches and door, anchors and mooring lines
  - ♦ lifeboats and liferafts, (lifeboat drain plugs out); and,
  - ♦ equipment in galley, pantries and restaurants
- ❑ Ventilators and air pipes, covered/closed as necessary
- ❑ Scuppers and drains clear
- ❑ Rounds made as the ship reaches the open sea and frequently thereafter until the ship reaches sheltered waters, entry made in the bridge log book.
- ❑ I.R's on continuous cargo watch when required.

THE BRIDGE OFFICER OF THE WATCH IS RESPONSIBLE FOR: -

- ❑ Speed and/or direction the ship is heading is adjusted to reduce excessive pounding or rolling
- ❑ Stabilisers operating if beneficial, (if in doubt put them out).

ENGINE ROOM WATCHKEEPER RESPONSIBLE FOR: -

- ❑ Equipment in the engine room spaces is adequately stowed and secured.
- ❑ Stabilisers are in an operable condition
- ❑ Fuel tanks, lub. oil storage and service tank levels are such that overflowing may only occur under extreme conditions.
- ❑ Duty service tanks have sufficient content so that the outlet/rundown to running machinery will not be exposed and allow air to enter service lines during extreme motion of the vessel.
- ❑ Standby fuel is sufficiently full as above.
- ❑ Engine room casing doors are shut, so that water will not enter engine room spaces.
- ❑ Train deck floodwater drain tanks are empty and that equipment to pump them out is in an operable condition.

Appendix 2

WÄRTSILÄ NSD CORPORATION

SERVICE LETTER

Service, Wärtsilä NSD Finland Oy			Huoltokirje		Servicebrev	
Engine section	Engine type	Ref.	Date	Issue	Document No.	Page
12 Cylinder head	**Vasa 32**	WNSFI–S	30.11.1998	01	3212S034GB	1(2)

Cylinder head screws (M56)

Spare Parts Number 100094.

Engine type This Service Letter concerns Wärtsilä Vasa 32 engines.

General In recent years there have been a few cases where the cylinder head screws have broken during operation. The result is blown-out cylinder head gasket, combustion gases entering cooling spaces and the engine shut-down due to high temperature in the HT-cooling water circuit. Normally, only renewing of gasket and screws is required. *See page 2 for instructions on when and how to change the screws.*

The major reasons for broken screws are:

- Corrosion of bottom part of screw (below O-ring 100095).

  The main reason for corroded screws is that the O-ring has deteriorated due to age and does not seal properly. Thus, water (e.g. while washing) will enter the compartment between screw and engine block and cause corrosion.

- Too high opening or loosening pressure used on hydraulic tool.

  Excess hydraulic tool pressure will not cause the screw to break immediately, but it will cause an initial crack, especially in a screw that is weakened by corrosion.

Letter distribution Wärtsilä NSD Service Network and owners/operators of Wärtsilä Vasa 32 engines.

Letter validity Until further notice.

Enclosure From the Wärtsilä Vasa 32 engine instruction manual: Chapter 07, page 11 and 12.

Instructions

Wärtsilä NSD recommends the following actions:

- Change the cylinder head screw whenever it has been over-tightened (whenever max. tightening or loosening pressure has been exceeded). Refer to the enclosure.
- Change the O-ring (100095) at every piston overhaul.

If corrosion damages occur, the following should be done:

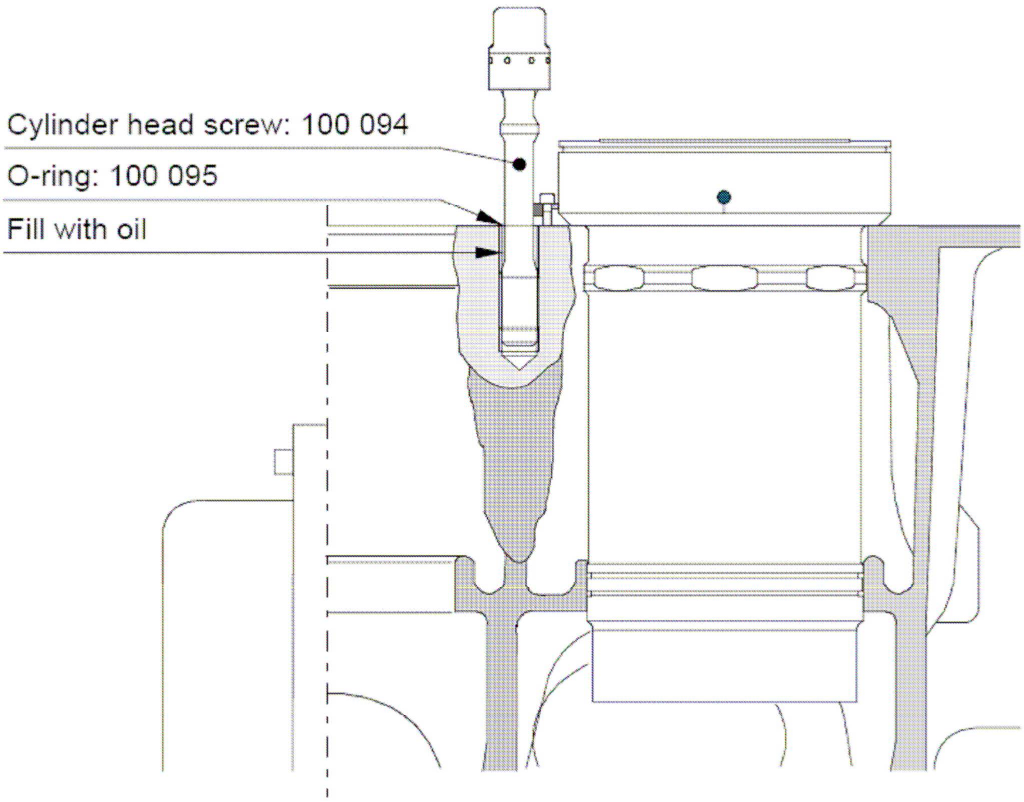
- Corrosion pits with a depth of less than 0.1 mm: Grind/polish away the pits with a small hand grinder.
- Corrosion pits with a depth of more than 0.1 mm: Change the screw.

NOTE

Corrosion depth in threads can be hard to determine, thus it is recommended to change the screw, whenever in doubt.

Mounting of cylinder head screw

1. Put lubricating oil on the threads of the screw.
2. Mount the screw and tighten to specified torque.
3. Fill the compartment between screw and engine block with lubricating oil.
4. Mount the O-ring.



07.3 Hydraulically tightened connections

07.3.1 Tightening pressures for hydraulically tightened connections

Hydraulically tightened connections

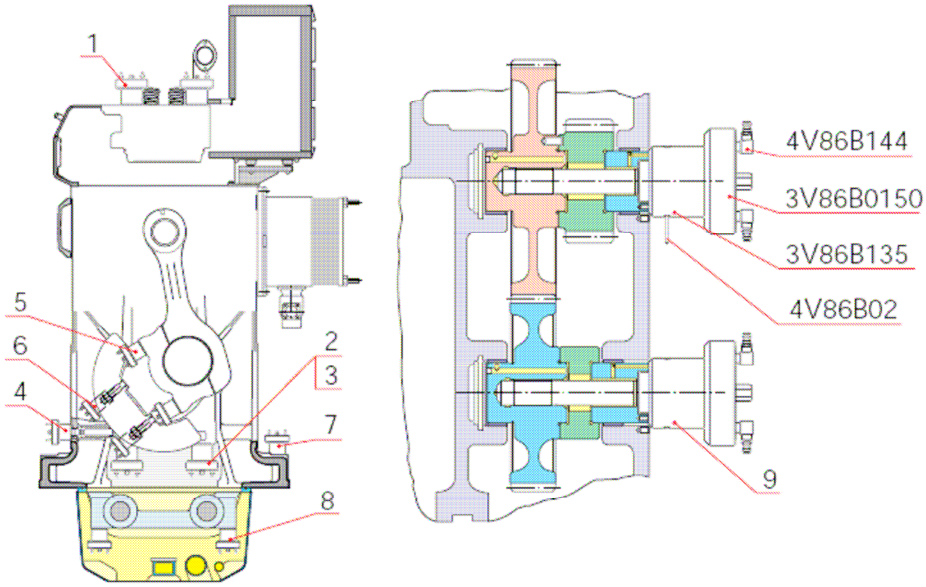


Fig 07-12 3207669045

Pos.	Screw connection	Max. hydraulic pressure (bar)		Hydraulic cylinder
		tightening	loosening	
1.	Cylinder head screws M56: — outer diameter of cylinder liner 440 mm — outer diameter of cylinder liner 450 mm	 425 500	 445 (520) 520	3V86B79
2.	Main bearing screws M56	615	635	3V86B79
3.	Thrust bearing screws M42	615	635	3V86B78
4.	Lateral screws of main bearings and thrust bearing M42	615	635	3V86B78
5.	Connecting rod screws : — M42 (O-profile) — M45 x 3 (H-profile)	 800 725	 820 745	 3V86B78 3V86B139
6.	Counterweight screws M42	600	620	3V86B78
7.	Engine fastening screws M42	x)		3V86B78
8.	Fastening screws M42 for balancing shaft bearing bracket	715	735	3V86B78
9.	Intermediate gears M56	660	680	3V86B0150
	Note! Older version: Intermediate gear I M42	800	820	3V86B78
	Intermediate gear II M48 x 3	660	680	2V86B127

x) Pos. 7 see installation instructions.

The stud bolts are tightened to the casting at the following torques:

Screw dimension	Tightening torque (Nm)
M56 Cylinder Head	400±20
M56 Main Bearing	300±10
M45 Connecting Rod	200±10
M42 and M48x3	200±10

Exception! **Screws acc. to pos. 4 and 7.**
Pos. 4 see chapter 10, section 10.2.3.

Caution! **The screws will be overloaded if the maximum hydraulic pressure is exceeded.**
It is recommended to change the screws if maximum hydraulic pressure is exceeded for some reason.

If it is impossible to turn the nuts, when the maximum hydraulic pressure is reached: check for corrosion in threads; check tool condition and manometer error.

07.3.2 Filling, venting and control of the high pressure hydraulic tool set

The hydraulic tool set consists of a high pressure hand pump with an integrated oil container, hoses fitted with quick-couplings and non-return valves, cylinders and a pressure gauge mounted on the hand pump but not connected to the pressure side of the pump.

The components are coupled in series with the pressure gauge being the last component thus securing that every cylinder is fed with the correct pressure.

The non-return valves in the hoses are integrated with the quick-couplings and are opened by the pins located in the centre of the male and female parts. If these pins get worn the coupling must be replaced because of the risk of blocking.

- In the high pressure hydraulic tool set it is recommended to use a special hydraulic oil or in any case an oil with a viscosity of about 2°E at 20°C.
- During the filling of the container of the high pressure pump it is recommendable to couple the set according to scheme B, Fig 07-13. Before filling, open the release valve (2) and empty the cylinders (4) by pressing the piston and cylinder together. After that, the container can be filled through the filling plug (1).
- After filling, vent the system by pressing in, with a finger, the centre pin of the female part of the last quick-coupling, the coupling being disconnected from the pressure gauge. Keep on pumping until airfree oil emerges from the coupling.

Recent Marine Occurrence Reports published by
the Transport Accident Investigation Commission
(most recent at top of list)

05-206	passenger/freight ferry *Arahura*, loss of propulsion, Cook Strait, 24 April 2005
05-201	passenger ferry *Quickcat* and restricted passenger vessel *Doctor Hook*, collision, Motuihe Channel, 4 January 2005
04-219	restricted limit passenger vessel *Tiger 111*, grounding, Cape Brett, 18 December 2004
04-217	fishing vessel *San Rochelle*, fire and foundering, about 96 nm north-north-west of Cape Reinga, 27 October 2004
04-216	passenger freight ferry *Aratere*, total power loss, Queen Charlotte Sound, 19 October 2004
04-215	restricted limit passenger vessel *Southern Winds*, grounding, Charles Sound, Fiordland, 15 October 2004
04-214	passenger freight ferry *Aratere*, loss of mode awareness leading to near grounding, Tory Channel, 29 September 2004
04-213	restricted limits passenger ferry *Superflyte*, engine room fire, Motuihe Channel, Hauraki Gulf, 22 August 2004
04-212	Fishing vessel *Iron Maiden*, foundered off Pandora Bank, Northland, 16 August 2004
04-211	coastal cargo vessel *Southern Tiare,* loss of rudder, off Mahia Peninsula, 4 July 2004
04-210	restricted limit passenger vessel *Esprit de Mer,* fire, Milford Sound, 30 June 2004
04-209	fishing vessel *Joanne* and motor tanker *Hellas Constellation,* collision, entrance to the Port of Tauranga, 19 May 2004
04-208	jet boat *CYS*, propulsion failure and capsize, Waimakariri River, 13 May 2004
04-207	fishing vessel *Poseidon,* grounding, north of Manukau Harbour entrance, 15 April 2004
04-205	fishing vessel *Bronny G*, grounding, Banks Peninsula, 26 March 2004
04-204	restricted limit passenger vessel *Freedom III*, grounding, Lake Manapouri, 24 February 2004
04-203	coastal passenger and freight ferry *Arahura*, heavy weather incident, Cook Strait, 15 February 2004

Transport Accident Investigation Commission
P O Box 10-323, Wellington, New Zealand
Phone: +64-4-473 3112 Fax: +64-4-499 1510
E-mail: reports@taic.org.nz Website: www.taic.org.nz

Price $26.00 ISSN 1173-5597