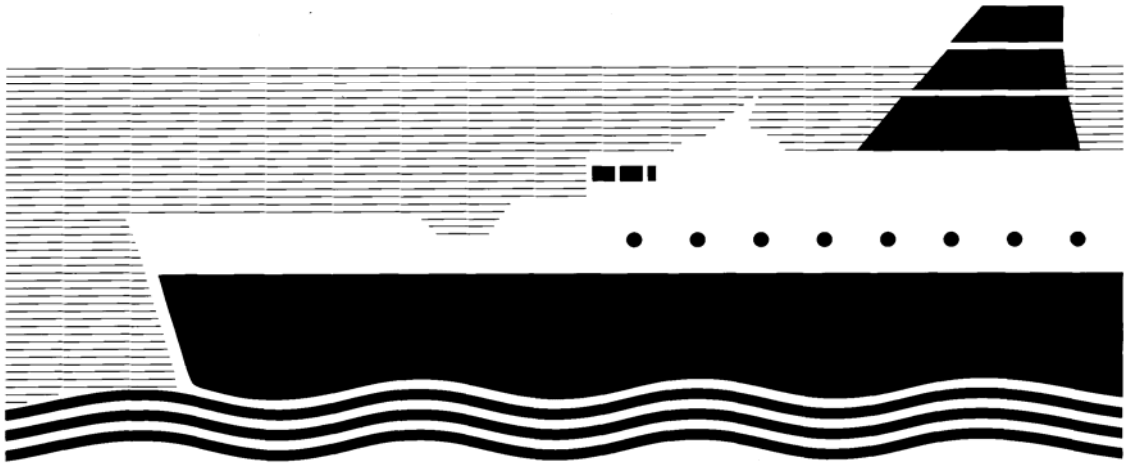
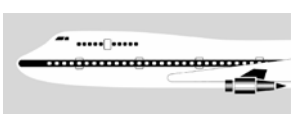
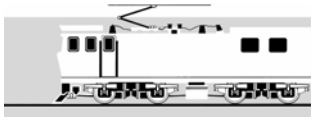


MARINE OCCURRENCE REPORT

05-212	**restricted limit passenger vessel, *Milford Sovereign,* loss of directional control, Milford Sound**	**20 November 2005**
incorporating:		
06-206	**restricted limit passenger vessel *Fiordland Navigator,* heel due extreme wind gust in Milford Sound**	**8 July 2006**


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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Report 05-212

restricted limit passenger vessel *Milford Sovereign*

loss of directional control

Milford Sound

20 November 2005

(incorporating Occurrence 06-206, restricted limit passenger vessel *Fiordland Navigator,* heel due extreme wind gust in Milford Sound on 8 July 2006)

Abstract

On Sunday 20 November 2005 at about 1400, the restricted limit passenger vessel *Milford Sovereign*, with a Master, 10 crew and 238 passengers on board, was on a cruise of Milford Sound when it was struck by a gust of wind that heeled the ship and turned it from its intended course. The Master was unable to return the ship to its original course, so decided to continue the turn initiated by the wind and took the ship through 180° onto the reciprocal of its original course and returned the ship to the inner Sound.

On the return journey, while travelling between Dale Point and Copper Point, further gusts of wind struck the ship, causing it to deviate again from its intended course. When abeam of Copper Point, the wind eased and the Master regained full control and decided to complete the final part of the shortened cruise. The ship returned safely to its berth at Fresh Water Basin without further incident.

There were no injuries and the ship did not sustain any damage.

Safety issues identified included:

- the design of the ship for the operating conditions
- human and organisational factors
- risk assessment for marine operations in Milford Sound.

Safety recommendations were made to the Director of Maritime Safety, the Chief Executive of Environment Southland and the Chief Executive of Real Journeys to address these issues.

The *Milford Sovereign* departing Fresh Water Basin

Contents

Figures

Foreword

The Commission was notified of the incident involving the *Milford Sovereign* on 21 November 2005, and launched an investigation to identify the circumstances surrounding and factors contributing to the incident. While the investigation was still in progress, the Commission was notified on 3 August 2006 of another incident involving the Real Journeys vessel *Fiordland Navigator* and another investigation was launched into that incident.

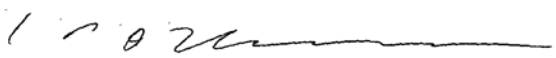
Owing to the similarities between both incidents, the Commission decided to incorporate the circumstances surrounding the second incident into the report on the first.

Fiordland is a relatively remote region of New Zealand where tourist activity is high, including maritime tourist operations.

As part of the Commission's inquiries and prior to making its deliberations on the findings of both incidents, the 3 Commissioners travelled to Milford Sound together with the investigator-in-charge to observe first-hand the tourist boat operations and the environs of Milford Sound. We made trips into Milford Sound on a number of the tourist boats and met with several groups of participants in the local maritime tourist activities.

The visit provided us with a good insight into the weather and topography-related challenges faced by the operators.

The Commission extends its thanks to the operators for their hospitality and the informative discussions that took place.



Hon Bill Jeffries
Chief Commissioner

Abbreviations

FW	fresh water
kW	kilowatt(s)
m	metre(s)
m^2	square metre(s)
mm	millimetre(s)
MSDA	Milford Sound Development Authority
N	Newton(s)
NZPHMS	New Zealand Port and Harbour Marine Safety
Pa	Pascal(s)
RPM	revolutions per minute
T° (°T)	degrees true
UTC	coordinated universal time
VHF	very high frequency

Glossary

abeam	at 90° to a ship's fore and aft line
anemometer	instrument for measuring wind speed and direction
ballast	weight put into a ship to improve stability
catamaran	twin-hulled vessel
displacement	when describing a hull form, indicates a vessel that remains fully immersed in the sea, rather than planing
double bottom tank	tank formed by the inner and outer bottom plating of the hull
draught (draft)	depth in water at which a vessel floats
Environment Southland	Southland Regional Council
finer	of the waterline shape of a vessel having a greater length-to-beam ratio than another vessel
forefoot	the point where the stem joins the forward end of the keel
frame	transverse strengthening members of a ship's hull. Usually used to identify positioning along the length of a ship
freeboard	distance from the waterline to the deck edge
gale	winds above 34 knots
heave (hove) -to	to maintain a vessel's position by bringing the head into, or nearly into, the wind. Usually used in heavy weather to prevent or reduce damage to a ship or its cargo
heel	the inclination of a ship by an external force
inclining experiment	deliberate listing of a vessel to determine its stability
inclinometer	device for measuring a vessel's angle of heel
keel	principal structural member of a ship running from forward to aft along the centreline of the ship's bottom
lee	area sheltered from the wind
leeward	on the lee side
lightship	weight of a vessel excluding fuel, stores, water and passengers
monohull	single-hulled vessel
round up	to turn into the wind
skeg	an extension of the keel for protection of propeller and rudder
slipping	lifting a boat from the water onto a dry facility
spring tide	period of highest and lowest tide in a lunar cycle
steady	maintaining its course
storm	winds above 48 knots
yawing	swinging from side to side of an intended course

Data Summary

Name:	*Milford Sovereign*
Type:	restricted limit passenger
Safe ship management company:	Fiordland Travel Limited
Limits:	enclosed area
Length:	40.0 m
Breadth:	8.60 m
Gross tonnage:	483.423
Built:	2003 at Bluff
Propulsion:	2 Volvo Penta TAMD 165A 6-cylinder, in-line diesel engines driving, through Twin Disc MG-516 Model XA747OG gearboxes, 2 fixed-pitch, 4-bladed propellers
Service speed:	11.5 knots
Owner/Operator:	Fiordland Travel Limited/Real Journeys
Port of registry:	Invercargill
Crew:	11
Date and time:	20 November 2005 at about 1400[1]
Location:	Milford Sound
Persons on board:	crew: 11 passengers: 238
Injuries:	nil
Damage:	nil
Investigator-in-charge:	Captain Doug Monks

[1] Times in this report are New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

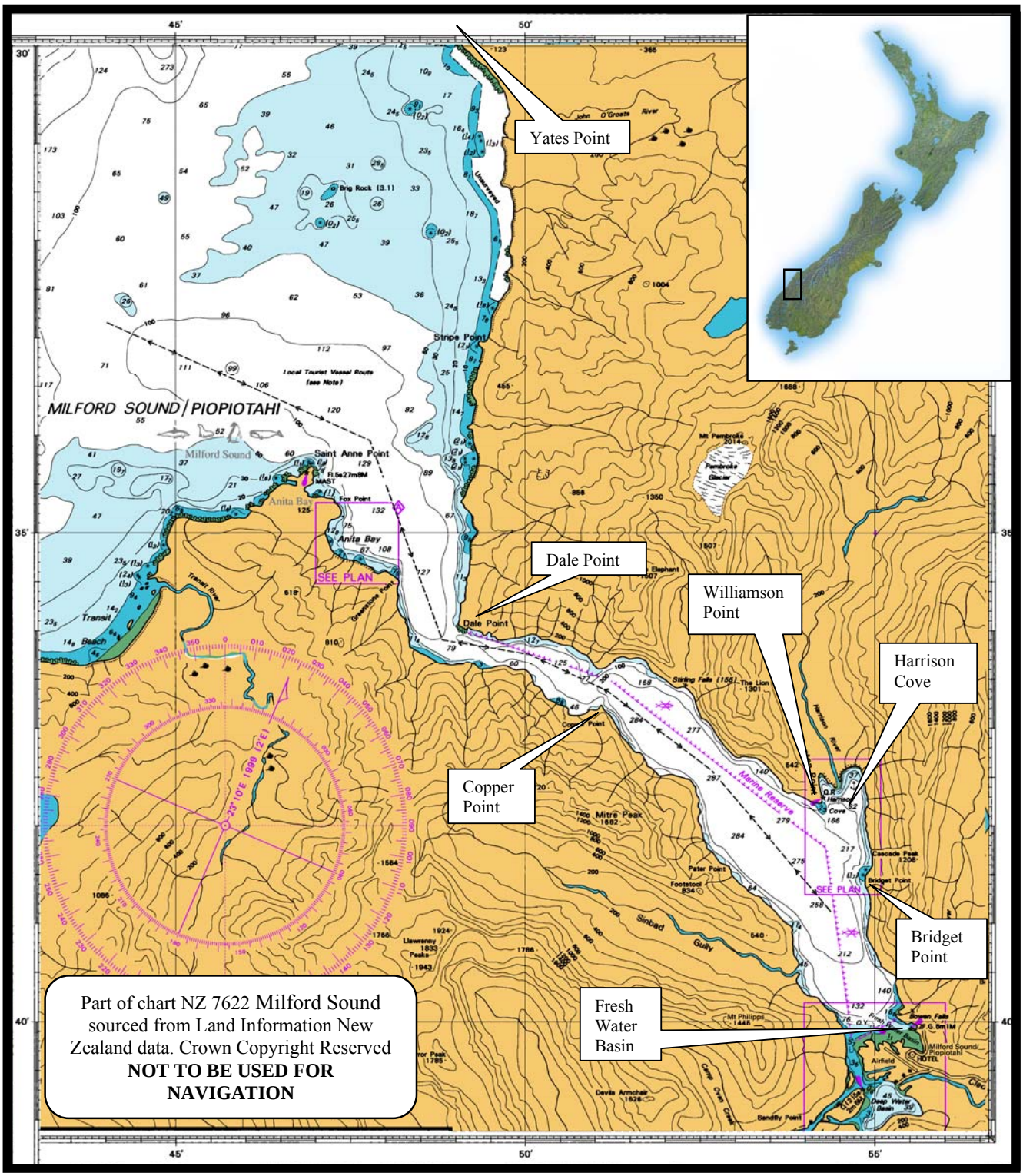


Figure 1
Chart of Milford Sound

1 Factual Information

1.1 Narrative

1.1.1 On Sunday 20 November 2005, the restricted limit passenger vessel *Milford Sovereign* was on a scheduled cruise of Milford Sound (see Figure 1) with the Master, 10 crew and 238 passengers on board. At about 1400, while on a westerly course with Dale Point abeam to starboard, the port bow of the ship was hit by a gust of wind estimated to be 70 knots, which caused the ship to heel to starboard and involuntarily turn to starboard. Being unable to control the ship effectively, the Master decided to allow the ship to continue turning to starboard. He applied starboard helm and reversed the propulsion on the starboard engine to complete the turn. He steadied the ship on an easterly course to return to the inner Sound.

1.1.2 The Master made a general call on the very high frequency (VHF) radio to advise other boats nearby that he was having difficulties and needed to be given a wide berth.

1.1.3 Soon after the ship was steady on the easterly course, another gust of wind hit the ship's starboard quarter, causing the bow to turn to starboard and the ship to be pushed sideways (see Figure 2). Although in no danger of running aground, the Master felt that he had again lost directional control of the ship. After the gust had passed, the Master was able to regain control, but more gusts occurred as the ship approached Copper Point, causing more control problems. However, once the ship was past Copper Point the wind eased sufficiently for the Master to regain full control of the ship.

1.1.4 Once in the sheltered waters of the inner Sound, the winds were light, so the Master decided that he could safely resume the shortened cruise, visiting Stirling Falls and Harrison Cove as they would ordinarily have done.

1.1.5 The ship arrived back at Fresh Water Basin shortly after 1500, without further incident.

1.2 Vessel information

1.2.1 The *Milford Sovereign* was operated by Real Journeys, the trading arm of the parent company and owner of the ship, Fiordland Travel Limited. Real Journeys had many tourist operations including coach services, air services, cruise boats and general attractions throughout Fiordland, Queenstown and Stewart Island. In total the company operated more than 20 vessels. The Milford Sound marine operation was divided into 2 main parts, daytime (or scenic) cruises and overnight cruises, however the overnight vessels also undertook day cruises. The scenic boats were the *Milford Sovereign*, the *Milford Monarch* and the *Milford Haven*, and the overnight boats were the *Milford Mariner*, the *Milford Wanderer* and the *Friendship*.

1.2.2 The *Milford Sovereign* was the newest ship in Real Journeys' Milford Sound fleet. It was a monohulled ship that was purpose built for the Fiordland tourism industry and was of similar design and construction to the *Milford Monarch*, a ship that had been launched in 1994. A local steel fabrication company, JK Stevenson Limited, was contracted to prefabricate sections of the hull at its facility in Invercargill before moving them to Real Journeys' boat shed in Bluff, where the sections were joined and the construction of the ship was completed. Another contractor constructed the accommodation module, which was lifted onto the completed hull. Other contractors were used for the electrical and plumbing work, and also for the general fit-out. The prefabrication of the hull and the overall construction of the ship were carried out under the direct control of a Real Journeys company representative. The ship was launched on 24 September 2003 from a boat-building facility in Bluff, Southland.

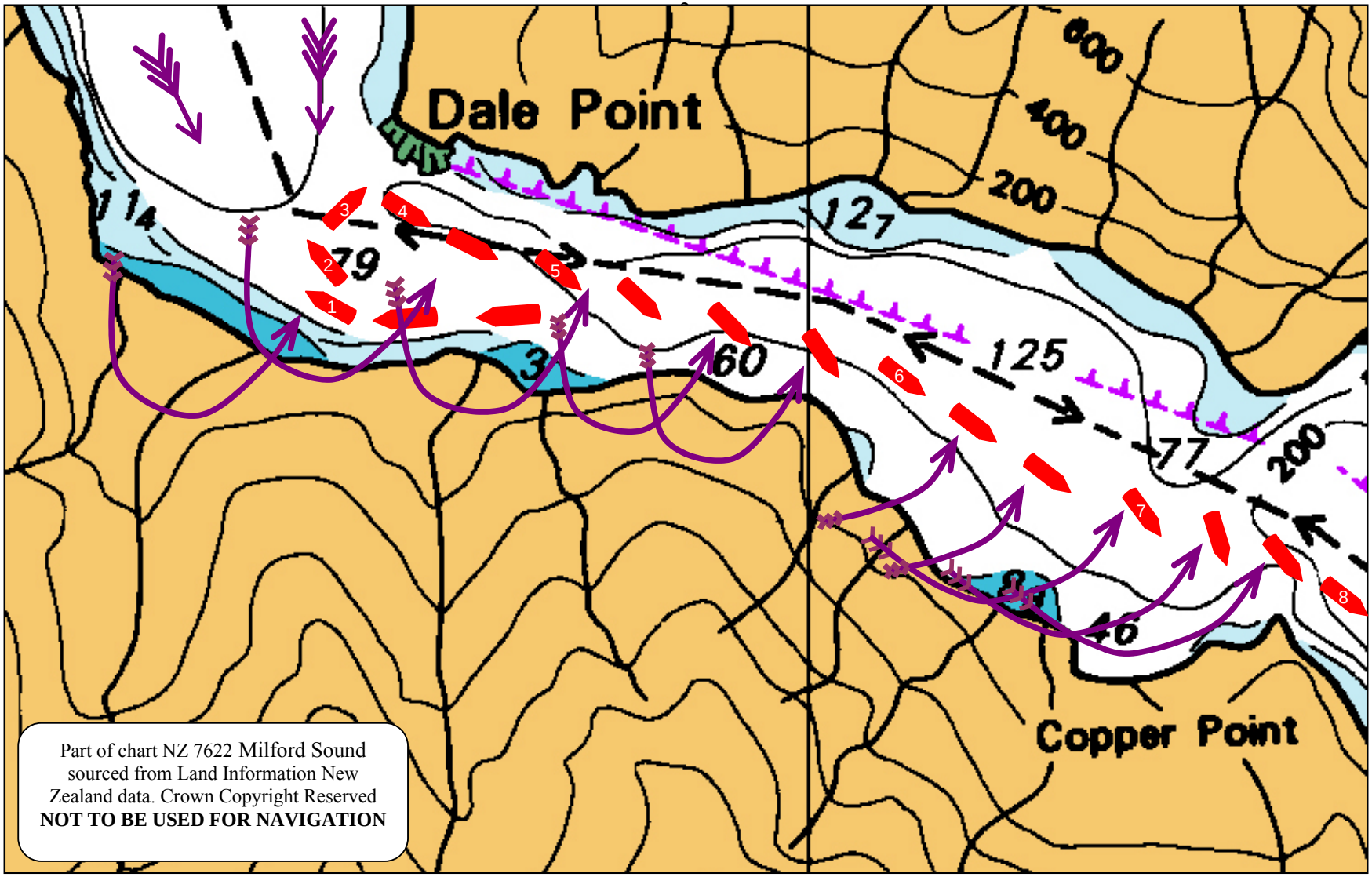


Figure 2
Chart showing incident sequence

Position number	Estimated		Approx heading	Approx intended course	Remarks
	Wind direction	Wind strength (knots)			
1	SW	60+	290	290	Gust of wind hits the port bow of the ship. Master attempts to maintain the ship's intended track
2	SW	60+	310	290	Ship fails to respond to engine and helm. Master decides to turn the ship around and return to inner Sound
3	SW	60+	020	turning	Starboard engine astern, port engine ahead, ship continues to turn to starboard, putting its stern through the wind
4	SW	<60	110	110	Ship steadies on a course to return to the inner Sound
5	SW	60+	130	110	Starboard quarter of the ship hit by gust of wind, causing the ship to deviate again from its course. Master unable to return the ship to its intended course. Ship carries on down the Sound approximately in its intended direction but lying across the wind
6	SW	30	125	125	Wind eases and Master brings the ship back to its intended course
7	SW	60	140	110	Starboard quarter of the ship hit by gust of wind, causing the ship to deviate again from its course. Master unable to return the ship to its intended course, but the ship carries on down the Sound approximately in its intended direction but lying across the wind
8	SW	20	125	125	Wind eases dramatically, full control resumed. Master able to complete the remainder of the cruise

Table 1
Key to Figure 2

1.2.3 The *Milford Sovereign* held a safe ship management certificate issued by Fiordland Travel Limited on 21 January 2004, which, subject to periodic audits and inspections, would remain valid until 27 September 2007. As part of an independent overview of the Fiordland Travel Limited safe ship management, the *Milford Sovereign* was inspected and declared to be fit for its intended purpose by SGS M&I on 21 June 2005. The safe ship management certificate allowed that up to 400 passengers could be carried in the enclosed water area.

1.2.4 The ship was powered by 2 Volvo Penta TAMD 165A 16-litre 6-cylinder, in-line diesel engines that each produced 389 kilowatts (kW) at the crankshaft at 1600 revolutions per minute (RPM). Each engine drove a fixed-pitch, 4-bladed propeller through a Twin Disc gearbox with a ratio of 3.06 to 1.

1.2.5 Immediately behind each propeller there was a balanced flat-plate rudder of 1202 millimetres (mm) height and reducing in length from 900 mm at the top to 700 mm at the bottom. The 2 rudders each had an area of 0.96 square metres (m^2), giving a total area of 1.92 m^2. About one-third of the rudder area was forward of the rudder stock; this decreased some of the torque necessary to turn the rudder. To give rigidity to the rudders there was a top plate and 2 additional shaped horizontal stiffener plates fitted at one- and two-thirds of the height.

1.3 Design, construction and survey

1.3.1 Maritime Rules Part 40A Design, Construction & Equipment – Non-SOLAS Passenger Ships laid down the requirements for, among other things, the stability and subdivision of restricted limit passenger vessels.

1.3.2 The process for designing, building and certifying a ship was as follows:

- the operational characteristics of the ship were decided between the owner and the design architect
- the design architect designed the ship in ongoing consultation with the owner
- once the design was agreed, plans were prepared and submitted to a recognised surveyor, who must be a naval architect, for design approval
- the ship was constructed under the supervision of a recognised surveyor
- the initial fit-for-purpose survey was carried out by the supervising surveyor
- sea trials were conducted to determine that the vessel met its design parameters and that it was fit for its intended purpose
- the ship entered service under a safe ship management exemption certificate (or provisional safe ship management certificate)
- within 3 months, the ship was required to submit to an initial vessel audit, which was a systems audit to ensure the safe ship management system was working
- on successful completion of the initial vessel audit, a full safe ship management certificate was issued.

1.3.3 Maritime Rules Part 40A.7(1)(a) required that design approval was given by a surveyor authorised by the Director of Maritime New Zealand. In part it stated:

> The ship's design is approved[2] by a surveyor recognised by the Director for that purpose under rule 46.29 as -
>
> (i) fit for its intended service and intended operating limits; and
>
> (ii) complying with all the applicable maritime and marine protection rules
>
> [2] Approval of the ship's design does not guarantee any performance of the ship's design other than in respect of the sufficiency and compliance with maritime and marine protection rules of those elements included in the definition of ship design in rule 40C.2.
> ["Ship's design" includes the ship's structural integrity, watertightness and weathertightness, safe means of egress and access, intact stability and reserve of buoyancy, the ship's compliance with any damage stability and buoyancy requirements, and the provision of machinery and other installed systems and equipment necessary for the safe working of the ship]

Authorised surveyors for design approval were required to be experienced naval architects. They inspected the submitted detailed plans of the vessel, and ensured that it met all the requirements of the Maritime Rules for hull strength, machinery, electrical installation and ancillary parts. The design of the *Milford Sovereign* was approved by an authorised naval architect from SGS M&I, who said that he had checked the vessel plans, where applicable, against the Maritime Rules or Lloyd's Classification Society Rules, which were equal to or exceeded the Maritime Rules.

1.3.4 The design approval process for the *Milford Sovereign* commenced in October 2002 when plans were submitted to the naval architect at SGS M&I. A series of approval letters followed as information on the specific parts of the vessel's construction became available. The last letter of approval, which referred to the stability booklet, was issued on 21 October 2003. Collectively the letters of approval specified the criteria that the vessel must meet for design approval, however there was no letter of complete design approval, as mentioned in the SGS M&I design approval letter of 27 November 2002, to confirm that all design criteria had been met.

1.3.5 Maritime Rules Part 40A.8 specified that a surveyor should not issue a fit-for-purpose certificate unless they were satisfied that the design had been approved and that it complied fully with the relevant Maritime Rules. For a surveyor to be able to issue such a certificate, it was necessary that they monitor and supervise the construction of the ship. On this occasion the SGS M&I surveyor from Invercargill oversaw the building of the *Milford Sovereign*, and on 1 October 2003 he carried out the initial fit-for-purpose survey. As part of the survey, he completed an 8-part checklist on the status of the ship and its equipment with respect to the Maritime Rules.

1.3.6 The management of Real Journeys and the SGS M&I surveyor from Invercargill confirmed that sea trials on the new vessel were completed on 24 September 2003. The Master and crew were accompanied on the sea trials by the Real Journeys Company Engineer, the Real Journeys Supervisor of Maintenance for Bluff, a fitter and a contractor. The only documentation that was available from the sea trial was an engine sea trial form completed by the Real Journeys Supervisor of Maintenance for Bluff. Although manoeuvring trials were reported to have been undertaken, no documentation was available, consequently there was no benchmark of the vessel's manoeuvring ability.

1.3.7 On 8 January 2004 the SGS M&I surveyor from Invercargill conducted the initial vessel audit to confirm that the safe ship management system and in particular the documentation was in order.

1.3.8 The safe ship management manual did not contain any maximum weather operating parameters for the vessel. The manual did, however, contain a generic delegation of responsibility to the Master. Section 3.5.5 (a) stated:

> The Master has full and complete authority to take such actions as the Master solely considers necessary in order to ensure the safety of life at sea and protection of the marine environment.

1.3.9 As part of a change in its policy, Maritime New Zealand decided in September 2005 to reassume the responsibility for conducting the initial audits on vessels entering the safe ship management system, so instead of an authorised surveyor conducting the audit a maritime safety inspector from Maritime New Zealand now conducted it. Once a vessel had passed the audit, Maritime New Zealand informed the relevant safe ship management company, which was then able to issue the full safe ship management certificate.

1.3.10 The *Milford Sovereign* was similar to the older ship *Milford Monarch*, but there were several significant differences between the 2 ships. These included:

- the *Milford Sovereign* had a length overall of one metre more than the *Milford Monarch*
- the superstructure at the stern of each ship was different. The *Milford Sovereign* had an open deck on the main deck and a closed deck on the bridge deck, whereas the *Milford Monarch* was the other way around
- forward of frame 45, the hull of the *Milford Sovereign* was slightly finer than that of the *Milford Monarch*
- the engines were from different manufacturers, with the Volvo Penta ones on the *Milford Sovereign* being 0.9 tonne heavier than the Cummins engines on the *Milford Monarch.* The *Milford Monarch* did have a spare engine stored in its engine room, which was put onboard after that ship's stability data was compiled
- the *Milford Sovereign* had double bottom tanks and a fresh water tank that extended up the side of the ship on either side forward of frame 45, whereas the *Milford Monarch* had double bottom tanks and 6 stainless steel free-standing potable water tanks in the forepart of the ship

- the keel on the *Milford Sovereign* was internal, while the *Milford Monarch* was fitted with an external keel of 100 mm in depth and 30 mm in width that extended from the forefoot forward to the skeg aft.

The weight variation between the 2 ships was allowed for in the initial calculation of the lightship weight of the *Milford Sovereign*.

1.3.11 To facilitate slipping the *Milford Sovereign* and to minimise the costs associated with that operation, the ship's design naval architect and Real Journeys management decided not to fit an external keel. Consequently the internal keel member was butted to the hull plating, giving an almost smooth underwater surface.

1.3.12 Maritime Rules Part 47 Load Lines required that all vessels over 24 m, and those under 24 m that carried cargo, were to be provided with load line certificates. Part 47.29 detailed the information that must be provided to the master. Part 47.29(3) stated that the inclining experiment required to be carried out on the completion of a vessel could be dispensed with "provided basic stability data is available from the inclining test of a sister ship and the Director or authorised organisation, as the case may be, is satisfied that reliable stability information for the ship can be obtained from that basic stability".

1.3.13 The Advisory Circular that accompanied Part 40A allowed that where identical or similar sister ships were constructed, the inclining and stability information for the first one could be applied to subsequent ships. However, Part 40A, which prescribed the intact and damage stability requirements, did not have any provisions or exemptions for sister ships.

1.3.14 The design naval architect was of the opinion that the *Milford Sovereign* was sufficiently similar to the *Milford Monarch* for them to be considered sister ships. He used the 1994 *Milford Monarch* inclining experiment as the basis of the lightship centre of gravity and therefore the statical stability for the *Milford Sovereign*. The stability booklet for the *Milford Sovereign* was prepared in October 2003 and approved by SGS M&I on 18 November 2003.

1.4 Stability

Note: On 13 September 2006, an inclining experiment was conducted on the *Milford Sovereign*. The stability information contained in the revised stability booklet was used in this report.

1.4.1 Maritime Rules Part 40A Appendix 1 Section 1.2 Intact Stability of Decked Ships (included at Appendix 1) required that a ship meet certain minimum stability criteria in different conditions of loading. In addition, the stability must be such that it could meet the following criteria:

> the angle of heel must not exceed 10° when any one of the following capsizing moments is applied, or 15° when the worst two capsizing moments are applied together -
>
> (aa) the passenger crowding moment; and
>
> (bb) the wind heeling moment; and
>
> (cc) the rudder heeling moment when turning:

1.4.2 Maritime Rules Part 40 A Appendix 1.2 (c) (ix) (Annex 1) required that a pressure of 350 Pascals (Pa) (equivalent to about 46 knots wind speed) be used when calculating the heel due to the wind for a vessel in restricted limits.

1.4.3 The stability book determined that the largest heeling moment was due to passenger crowding, which resulted in a heel of 4.25°. The combined heeling lever for the 2 worse heeling moments, passenger crowding and wind heeling, was 0.353 m, which equated to an angle of heel of 8.25°. Consequently, the ship met the requirements for single and double heeling moments.

1.4.4 The stability book prepared for the *Milford Sovereign* gave data for 6 standard conditions of loading of the ship (note: the number of passengers and crew used in the stability information was 30 more than the number of passengers the vessel was certified to carry at the time of the incident):

1. lightship
2. departure for cruise with 100% fuel, 100% FW and 100% ballast, 100% stores, 430 passengers and crew and empty holding tanks.
3. departure for cruise with 100% fuel, 100% FW and empty ballast tanks, 100% stores, 430 passengers and crew and empty holding tanks.
4. arrival from cruise with 10% fuel, 10% FW and 100% ballast, 10% stores, 430 passengers and crew and 90% full holding tanks.
5. arrival from cruise with 10% fuel, 10% FW and empty ballast tanks, 10% stores, 430 passengers and crew and 90% full holding tanks.
6. maximum achievable freeboard draught with 100% fuel, 100% FW and 100% ballast, 100% stores, 430 passengers and crew and 100% full holding tanks and 454 tonnes additional mass.

1.4.5 The estimated speed of the wind that struck the ship on 20 November 2005 was 70 knots (36 m per second). The wind pressure exerted on the ship was calculated using the formula:

Wind pressure = ½ x (density of air (1.25)) x wind speed^2
Wind pressure = ½ x 1.25 x 36^2
Wind pressure = 810 N/m^2 [Newtons per m^2] or Pa

1.4.6 The wind heeling formula contained in Maritime Rules Part 40A Appendix 1 when calculated for 70 knots resulted in:

wind heeling moment = 0.000102 x PAh, where

P = wind pressure P = 810 N/m^2

A = area of the ship above the waterline A = 248 m^2

h = vertical distance from the centroid of A and that of the lateral underwater area h = 5.1 m

The wind heeling moment for the ship in 70 knots of wind was 104.5 tonnes metre.

At the time of the loss of control, the loading condition of the ship was not the same as any of the standard conditions contained in the stability booklet. However, condition 4 was close to the actual condition and gave a displacement of 289.4 tonnes. The calculated heeling lever was 0.361 m, which gave an angle of heel of 7.4° from the ship's GZ curves.

1.4.7 When the ship was struck by the gust of wind, as well as the bow being pushed to starboard, the ship heeled to starboard. There were varying estimates of the extent of heel, but the one measurable, if approximate, value was that water was seen lapping the leeward fixed portholes of the galley on the lower deck. Those portholes were approximately one metre above the normal waterline. A simple trigonometric equation calculated that they would reach the water level when the ship was heeled about 13°. This method of calculating the angle of heel would be dependent on the height of any wave that was washing against the lee side of the ship and was of necessity only an approximation and a guide to the angle the ship reached during the event.

1.4.8 With an operating draught of about 1.8 m at the stern, and the ship heeled 10°, the windward propeller and rudder would be partially out of the water, making them less efficient. Because of the twin propeller design of the ship, the resulting turning moment would tend to cause the ship to round up into the wind.

1.5 Personnel information

1.5.1 The Master originally went to sea in the early 1970s and worked on various-sized inshore and offshore fishing boats. He gained a second-class diesel trawler engineer certificate in October 1977, and a mate of a deep-sea fishing boat certificate in March 1978. He had worked for Real Journeys for 10 years, serving on most of the company's vessels. He had been Master of the *Milford Sovereign* since it was launched in 2003. He was one of the masters that Real Journeys used for coastal passages to Bluff for ship surveys or repairs.

1.5.2 As part of the commissioning of the *Milford Sovereign,* the Master had prepared training and practical operation notes for the new ship. These notes had been incorporated into the company's crew and master training manuals. The Master had been given clearance to act as a launchmaster on the *Milford Sovereign* on 31 October 2003. The clearance followed the completion of the itemised training record that was part of the required familiarisation when a master joined the company or changed vessels. The training covered many aspects of the vessel operation, from routine through to emergency. The final aspect of the familiarisation training included was a check voyage with a senior launchmaster, which needed to be completed before the master was cleared to operate the vessel alone.

1.5.3 The training did not specifically include vessel handling, however the check voyage was such that it allowed the senior launchmaster to evaluate how a new master manoeuvred the vessel. Heavy weather vessel handling was not part of the initial training.

1.6 Previous incidents

1.6.1 Prior to the subject incident, the *Milford Sovereign* had experienced at least 2 other loss-of-directional-control events, on 21 February 2004 and on 30 September 2005.

1.6.2 On 19 February 2004 (see Figure 3) and 21 February 2004, extreme weather conditions were experienced in Milford Sound and a number of loss-of-control incidents involving the *Milford Sovereign* occurred on those days. No ship incident reports were completed, so the record of these incidents was limited to an internal report from the shore-based Area Manager for Milford Sound and a later report by the Safe Ship System Manager/Chief Launchmaster. On both days the Master had trouble controlling the ship, but on 21 February that loss of control almost resulted in the Master deciding to ground the ship intentionally.

1.6.3 The weather on 21 February was such that the morning cruise on the *Milford Sovereign* was cancelled. However, because there were insufficient wharves in Fresh Water Basin to accommodate all the vessels, the *Milford Sovereign* was required to stand off to allow the disembarkation of the overnight passengers from the *Milford Mariner*. While waiting to the north of the Basin, with no passengers on board, the *Milford Sovereign* was hit by a gust of wind. The Master said that the vessel heeled severely and moved sideways at an estimated speed of 8 knots towards the shore to the south of Fresh Water Basin. The Master considered intentionally grounding the vessel, but he regained control when they were close to the markers of the channel into Fresh Water Basin and was able to head back down the Sound. When sufficiently clear, he hove-to until 1230, by which time the wind had abated sufficiently for the ship to return safely to its berth. The Milford Sound Senior Launchmaster was in command of the vessel on this occasion.

1.6.4 During the period of bad weather between 19 February 2004 and 21 February 2004, the wind was of sufficient force to cause damage to the roof of the Milford Sound tourist centre and to a number of cars in the car park to the south of the tourist centre. In comment on the preliminary report, Real Journeys said that there was anecdotal evidence that the anemometer on the bridge of the *Milford Sovereign* indicated 110 knots during the incident on 21 February 2004.

1.6.5 The second loss-of-control event occurred on 30 September 2005 at about 1200, when severe winds deflected off the shore, striking the ship and it lost directional control.

1.6.6 The weather forecast for 30 September was for storm-force winds from the northeast at 35 to 50 knots in the morning, turning to northwest 40 knots about midday. The Master on that day said there was little wind during the morning cruise and at 1100 when they left Fresh Water Basin for the incident cruise. However, at about 1130, as the *Milford Sovereign* steamed down the Sound, the wind speed increased to a constant 50 knots with gusts to 60 knots when approaching Dale Point. The Master decided to shorten the cruise and turned around before they reached the entrance to the Sound. On the return journey, the ship managed to negotiate the narrow part of the Sound within Dale Point, but as it approached Copper Point, a gust that the Master estimated to be in excess of 65 knots hit the starboard quarter of the ship, causing it to heel over and turn to starboard against the applied port helm. The Master tried to regain control, but with the helm hard to port and full power on both engines, the ship would not turn to port and remained cast across the wind for about 4 minutes, during which time it crabbed sideways down the Sound.

1.6.7 Once past Copper Point, the wind eased and the Master regained control and was able to complete the cruise safely. The Master on that occasion was the same as in the occurrence under investigation.

Figure 3
The *Milford Sovereign* on 19 February 2004
An example of the weather that can be experienced in Milford Sound

1.6.8 In response to the incident on 30 September 2005, a meeting was organised between the design naval architect, the SGS M&I surveyor from Invercargill and Real Journeys staff, including the Chief Executive, the Company Engineer, the Te Anau and Milford Sound Area Managers, the Safe Ship Management Manager, the General Manager Maintenance and Supply, and 4 serving Masters. Two Maritime New Zealand representatives also attended. The meeting was scheduled to take place on 5 December 2005, the first opportunity when all the parties would be available. The intent of the meeting was to determine the nature and severity of the problem and particularly why the *Milford Sovereign* had less directional control than its assumed sister ship the *Milford Monarch.* The meeting did take place, but not before the further loss of control that occurred on 20 November 2005. The following action points resulted from the meeting:

- the ship's stability was not in question and an inclining test would not be carried out
- the fitting of ballast would be trialled to determine whether it improved the handling
- if ballast did not improve handling, a bar keel would be added to the ship
- the naval architect would consider the impact on the shafts and propellers of increasing the maximum engine speed by 200 RPM.

1.7 Climatic conditions

1.7.1 Milford Sound was within the marine weather forecast area Milford, which extended from Jackson Head in the north to Secretary Island in the south. The meteorological notes in the New Zealand Mariner's Handbook stated that coastal weather forecasts were a general indication of average conditions expected in a particular coastal area. The forecasts were for open waters to within 60 nautical miles of the coast and did not apply to enclosed areas such as sounds. The local topography, in particular the near-vertical mountainsides, caused variations in the direction and strength of the wind, with gusts that could exceed the mean wind strength. However, in the absence of any other weather forecasts, the coastal forecast gave the mariner the best indication of the expected weather inside the sounds.

1.7.2 Wind is the horizontal movement of air relative to Earth's surface. In basic terms, wind is caused by the differences in the temperature and therefore pressure within the atmosphere. The air above hot areas expands and rises, producing a low-pressure area, allowing cooler air from adjacent higher-pressure areas to flow in to replace the rising hot air, thus wind is formed. If the Earth's surface were smooth, the resultant wind would blow in one direction at a constant velocity, however because the Earth's surface is uneven the air movement is subjected to acceleration and deceleration as it passes over rugged ground, which forms turbulence with resulting gusts. This is particularly noticeable where the topography is extreme, and special weather conditions prevail as the wind is forced to go over or around mountain ranges.

1.7.3 In addition to the regular flow of wind onto the west coast of New Zealand, cold frontal systems with embedded cumulonimbus cloud, heavy precipitation and squalls regularly strike the Fiordland coast. The leading edge of a cumulonimbus cloud is preceded by a high-velocity squall called a gust front, which increases the velocity of the wind as it passes.

1.7.4 Chapter 1 of the New Zealand Pilot (Admiralty Sailing Directions NP 51) contained a description of the natural conditions that might be expected when operating around the New Zealand coast. Section 1.143 gave information on the winds that could be expected in the coastal area:

> Winds in coastal waters are also variable in speed and direction, and may differ significantly from the winds over the open sea due to the influence of local topography.
> Winds blowing through straits, along valleys and around headlands may be diverted and "funnelled", particularly when there is high ground in the locality. A very marked and unexpected local increase in wind speed can result and squalls may be experienced in strong wind conditions.

Section 1.144 described land and sea breezes:

> Land and sea breezes occur in some areas. Sea breezes develop on sunny summer days especially in North Island and along the E coast of South Island. Land breezes may set in on clear nights. Where the land rises steeply from the coast, katabatic or "down-slope" winds can blow with little or no warning in squalls which may be dangerous for small craft.

1.7.5 Section 5.124 of the New Zealand Pilot contained further information on the weather that might be experienced in the Fiordland area. In part it read:

> Weather conditions within the sounds are likely to be very different from those outside. In the sounds local katabatic winds may be experienced in strong wind conditions. Strong local gusts are common especially when the wind is from the N.
> Weather forecasts for the area should be treated with caution and mariners are warned that barometric anomalies may be experienced along the coast.

1.7.6 Masters and operators working in Milford Sound indicated that weather conditions changed considerably depending where you were in the Sound. For example, it could be calm at the Fresh Water Basin while gale- or storm-force winds existed further out into the Sound. The same masters suggested that winds at least twice those forecast could be expected in the Sound, particularly when from the west or northwest quarter. In addition, strong sea breezes regularly occurred in the afternoons during the summer months, adding to the prevailing northwesterly winds to give gale or stronger conditions.

1.7.7 During adverse weather, visibility was often restricted by heavy rain and wind-driven spume. Masters reported that "white-out" conditions often accompanied severe adverse weather. Reduced visibility was not reported to be present on 20 November 2005.

1.7.8 The direction and strength of the wind in Milford Sound often differed from those forecast for the area, and those experienced to seaward of the coast. For example, on this occasion gale-force (35 knots) winds from the northwest were forecast, but the gust that hit the ship was estimated to be 70 knots from the southwest, having funnelled through the entrance and been deflected off the mountains south of the entrance. In westerly quarter winds a line of increased wind strength is often experienced in the vicinity of Copper Point, where winds coming into the Sound are funnelled and deflected by the rising mountains.

1.7.9 Waves at sea are formed by the combination of swell and wind waves. Swell waves tend to be long-period, undulating waves that remain after a meteorological event has died down or moved away. Wind waves are localised and are formed by wind blowing across the surface of the sea. The longer and stronger the wind blows, the more the resultant waves increase in size and frequency. The narrow and confined topography of Milford Sound restricted swell entering the Sound and also did not allow wind waves to develop. Consequently a gale- or storm-force wind that would produce rough seas in open waters off the coast would be unlikely to produce a substantial sea in the Sound. Operators reported that the day breeze that occurs in the afternoons of hot summer days regularly reaches speeds in excess of 40 knots, but the sea rarely attained a height of one metre.

1.7.10 The wind and sea on the west coast of New Zealand were predominantly from the western quarter. The Fiordland sounds gave varying degrees of shelter depending on the direction of the wind.

1.7.11 The forecast for the marine weather forecast area Milford issued on the morning of 20 November 2005 and valid until midnight of that day had a gale warning in force.

> Northerly 25 knots rising to 35 knots this morning then changing northwest 20 knots this afternoon. Sea becoming very rough for a time. Southwest swell 2 metres. Northwest swell rising to 2 m for a time. Poor visibility in rain, easing this afternoon.

1.7.12 The only automatic weather-recording equipment in Milford Sound was located at the airport, between Fresh Water Basin and Deep Water Basin. The wind direction and speed were recorded on an hourly basis and were the average over 10-minute intervals. In addition to the automatic data collection, the air traffic services staff manually recorded the weather at hourly intervals when the airport was operational. The instruments for the automatic and manual stations were about 300 m apart.

1.7.13 Table 2 indicates the recorded direction and speed of the wind for the day of the incident. When the Master was experiencing 70-knot winds, between 1300 and 1400, the recorded wind at the

airport was southeasterly at 9 knots. In addition to the weather instruments at the airport there was an anemometer, situated at the tourist centre, that was monitored from the harbour control building. The Harbour Controller noted that the wind speed never rose above 8 knots after he heard the Master of the *Milford Sovereign* give his warning on the VHF radio about being unable to control his ship.

Weather station	Milford Sound Airport automatic weather station		Milford Sound Airport manual weather observations	
Time	Wind direction °(T)	Wind speed knots	Wind direction °(T)	Wind speed knots
1000	330	3	170	4
1100	120	4	60	2
1200	130	8	130	9
1300	130	9	130	10
1400	130	9	130	9
1500	130	6	120	5
1600	260	3	270	3

Table 2
Wind speed and direction readings for the period around the time of the *Milford Sovereign* incident

1.7.14 Westport was the standard tidal port from which the Milford Sound tides could be calculated. A full moon occurred on 16 November 2005; consequently it was shortly after spring tides. The following were the calculated times and heights of the tides on the day of the incident.

Low water		High water		Low water	
Time	Height	Time	Height	Time	Height
0736	0.7 m	1342	2.1 m	1958	0.6 m

1.8 Topography and characteristics of Milford Sound

1.8.1 Milford Sound is smaller than many of the other sounds in Fiordland. It is entered from the Tasman Sea between Saint Anne Point and Yates Point (see Figure 1). At Dale Point, about 2 nautical miles inside the entrance, the Sound turns at almost right angles towards the east and decreases in width to about 450 m. In this area the shore becomes precipitous, with sheer cliffs rising towards the adjacent mountains (see Figure 6), resulting in a region where stronger winds were often experienced. At the inner end of the narrow section lies Copper Point, locally known as "Windy Point"; once past this, the Sound increases to about one nautical mile in width. Harrison Cove lies on the eastern side of the inner Sound, with the Milford Deep Underwater Observatory lying close to Williamston Point at the entrance to this Cove. Fresh Water Basin lies at the southeastern extremity of the Sound and is where the local tourist vessels berth. Further towards the southern side of the Sound lies Deep Water Basin, which is used principally for fishing vessels.

Figure 4
Relief map of Milford Sound

1.8.2 Of all the Fiordland sounds, Milford Sound is the only one with road access. It also has an airport, where more than 200 movements could occur each day during the high season. The relatively easy access made Milford Sound a popular tourist destination. In 2002, the Department of Conservation estimated that there were 410,000 visitors to Milford Sound annually and some sources suggested that the number had increased to about 500,000 by 2005. Although not all the visitors took a cruise, the vast majority did, and there were at least 12 vessels offering cruises on the Sound. The economic significance of the tourist industry in the Fiordland area was considerable.

1.8.3 The types and sizes of the tourist vessels operating in Milford Sound were diverse, from monohull to catamaran, from 15 m up to 40 m in length. On the afternoon of 20 November 2005, there were at least 6 vessels, including a 25 m and a 34 m catamaran and 4 monohulls of between 17 m and 40 m, operating in the Sound. All of those vessels, although experiencing similar strength winds, were able to complete their cruises without incident.

1.8.4 Even though it was connected by road to Te Anau, Milford Sound was relatively isolated, being at least 1.5 hours' drive from Te Anau on a twisting mountain road, which was liable to closure due to snow and avalanche danger, particularly during the winter months. Transit New Zealand, the Crown entity responsible for state highways, indicated that the number of road closures between Te Anau and Milford Sound varied considerably from year to year. However, for the years 2002 and 2003 the road was closed for 216 hours and 673 hours respectively due to avalanche danger alone.

1.9 Regulatory environment of Milford Sound

1.9.1 Commercial tourist operations in Milford Sound were governed by a voluntary Harbour Code of Practice that was prepared and maintained by the Milford Sound Development Authority (MSDA). MSDA was an alliance between Southland District Council and the 2 largest commercial operators, Real Journeys and Red Boats. Fresh Water Basin was under the direct control of MSDA, but compliance with the Harbour Code of Practice was voluntary throughout the rest of the Sound. The Harbour Code of Practice addressed operations including the main route of the tourist boats being clockwise around the Sound, which was opposite to the usual direction of flow of traffic in confined waters. However, it did not address operating parameters.

1.9.2 Milford Sound came under the jurisdiction of Environment Southland, which was responsible for preparing and implementing the navigation bylaws. The bylaws in force at the time of the incident came into force on 2 August 2004. The Southland Harbourmaster was responsible for administering the bylaws.

1.9.3 In 2004, Maritime New Zealand published the New Zealand Port and Harbour Marine Safety (NZPHMS) Code, which aimed to promote good practice in the conduct of safe marine operations in ports and harbours. It gave a national standard framework on which regional authorities could build, and be measured against. The NZPHMS Code was supported by a number of guideline documents designed to assist with its implementation. Although not law, the NZPHMS Code represented best practice, and compliance with it would show that a regional council had taken all reasonable steps to ensure safe marine operations within its ports and harbours.

1.9.4 The NZPHMS Code defined the statutory responsibilities of regional councils. These were:

(a) Making a code application assessment for the purpose of identifying harbours and port operations within them to which the provisions of the Code and its supporting Guidelines will apply;
(b) Coordinating and conducting a harbour risk assessment for each harbour within its jurisdiction;
(c) Coordinating and developing a harbour safety management system for each harbour within its jurisdiction and, where appropriate;

(d) Coordinating and developing standard operating procedures in respect of each harbour within its jurisdiction;
(e) Ensuring that the appointed harbourmaster is adequately resourced and funded to exercise his or her statutory powers and functions.

1.9.5 In 2005, Environment Southland, with some assistance from a consultant, had prepared a risk assessment plan. The plan had been submitted to Maritime New Zealand, which had sought clarification on a number of areas and had requested that a consultant carry out a review of the plan. The review was completed in May 2007 and was being considered by Environment Southland with a view to amending the risk assessment plan. The Harbourmaster pointed out that the concerns that Maritime New Zealand held in relation to the original risk assessment plan related primarily to the operation of cruise liners in and around the Fiordland sounds. The risk assessment referred to the operation of tourist cruises in Milford Sound, and included loss of propulsion and grounding as the top 2 ranked overall risks. The report described the prevailing weather, but did not link it to the operation of vessels in the Sound.

1.9.6 Once the harbour risk assessment had been revised and approved by Maritime New Zealand, the regional authority was required to develop safety management systems and standard operating procedures for each of the harbours in its jurisdiction.

1.9.7 Amongst other things, the NZPHMS Code called upon regional authorities to consider the environmental factors that affected operations within the harbours. These included the provision of adequate meteorological monitoring equipment.

1.10 Damage

1.10.1 There was no damage to the ship or injuries to the passengers and crew.

1.11 Post-incident actions

1.11.1 On 10 October 2005, following the loss-of-control incident on 30 September 2005, the Safe Ship System Manager/Chief Launchmaster wrote to the affected Master, with copies to the other masters of the *Milford Sovereign*, reiterating that the decision on whether or not to sail in adverse conditions lay with the Master:

> It is clearly understood by all that the decision on whether to sail in adverse conditions has always been the Skipper's, respected by the shore based staff who have to work around that decision. Management of Real Journeys have always accepted that the safety of the vessel is paramount and ultimately the Skipper's responsibility, as stated in the Maritime Transport Act and our own Safe Ship System Manual.

1.11.2 On 23 November 2005, in response to the incident on 20 November 2005, the Safe Ship System Manager/Chief Launchmaster, by way of a memorandum to masters, put in place operational parameters for the *Milford Sovereign* that limited operations to forecast or actual wind speeds of up to 45 knots.

1.11.3 On 14 December 2005, the Real Journeys General Manager Maintenance and Supply carried out a displacement check between the *Milford Sovereign* and the *Milford Monarch*. The *Milford Sovereign* had empty sewage tanks and full ballast, fuel and fresh water tanks. No crew were onboard. Observed draught marks were 1.41 m forward and 1.81 m aft. The *Milford Monarch* had empty sewage tanks and full ballast and fresh water tanks. It had 1200 litres less than a full load of fuel, and there were 6 crew onboard. Observed draught marks were 1.42 m forward and 1.95 m port aft and 1.94 m starboard aft. So, the forward draughts of each ship were almost identical, but the *Milford Monarch* was drawing 0.135 m more aft.

1.11.4 On 22 December 2005, as part of its internal incident investigation, Real Journeys employed an independent naval architect to determine whether the use of the sister ship inclining experiment data was valid, given the differences between the ships and the elapsed time between their

construction. On 11 January 2006, the independent naval architect stated that it was accepted naval architectural practice for data from sister ships to be used to calculate stability information for a later ship. However, there was no definition of what constituted a sister ship, and the allowable degree of difference between ships was open to interpretation for them to be so considered. The independent naval architect was of the opinion that the *Milford Sovereign* and the *Milford Monarch* should not be considered sister ships for the purpose of stability because of the differences between them and the period between each of them being built. He recommended that an inclining experiment be carried out on the *Milford Sovereign* to verify the information contained in its stability book. He further suggested that, should there be a significant difference between the result of the inclining experiment and the data used to prepare the original *Milford Sovereign* stability book, a new stability book would need to be prepared.

1.11.5 Real Journeys expanded the scope of the investigation carried out by the independent naval architect to include the directional aspects of the control of the ship and for him to recommend how to improve that aspect of the ship's handling. His report into the directional aspects, published in February 2006, concluded that the *Milford Monarch* had substantially more resistance to lateral movement than the *Milford Sovereign*, principally due to the external bar keel on the former ship. The report went on to recommend that a bar keel or similar underwater appendages be fitted to the *Milford Sovereign* to increase its lateral resistance. He also suggested that improved rudder design, such as converting the flat-plate rudders into more efficient foil-shaped rudders, might improve both ships' handling.

1.11.6 On 21 January 2006, at the suggestion of the design naval architect, 22 tonnes of lead solid ballast were placed about the centreline in the bilges of the *Milford Sovereign*; 10 tonnes forward, between frames 45 and 50, and 12 tonnes aft, between frames 8 and 13. On 31 January 2006, to adjust the trim of the ship, 3 tonnes of lead were removed from forward.

1.11.7 On 7 February 2006, after the ballast was loaded, the limiting condition of not operating in forecast or actual wind speeds of 45 knots or more was lifted in order to evaluate what change, if any, the ballast had made to the *Milford Sovereign*'s handling. At the start of each day the Masters were required to note the condition of the tanks, the passenger numbers and the draughts. During the cruise they were to observe and record the weather and sea conditions and the ship's handling characteristics, especially any changes from its behaviour prior to loading the ballast.

1.11.8 On 22 March 2006, the design naval architect and the Company Engineer carried out post-ballasting sea trials on the *Milford Sovereign*. They determined that the ship steered well in the prevailing conditions of up to about 30 knots of wind. When deviated from its course by an external force (wind), the ship took up and remained steady on the new course. Turning trials were undertaken and the ship completed 180° turns with a diameter of 50 m, as measured by the GPS. The ship was stopped head to wind, strength 17 to 24 knots, and allowed to assume its natural position to the wind and then to drift. It settled on a heading close to beam-on to the wind with little yawing and drifted downwind at a rate of 2.7 knots, which reduced to 2.0 knots as the wind speed decreased to 17 knots. Later, 2 concerns regarding the handing of the *Milford Sovereign* compared to the *Milford Monarch* were demonstrated by the Senior Launchmaster:

1 The ship, when rotated within its own length, tends to continue rotating when power is reduced and not come to rest as quickly as would be expected.

2 The ship at slow speeds, five knots or below, with the wind on the beam or on the forward quarter, tends to drop the bow more than other ships in the fleet.

1.11.9 The design naval architect in his report on the sea trial recommended that a vertical fin of the same size as the keel on the *Milford Monarch* be fitted to the *Milford Sovereign* at the next slipping. A non-structural keel was fitted to the *Milford Sovereign* in August 2006.

1.11.10 There was some dispute between the design architect and the independent naval architect, so in April 2006 Real Journeys briefed a third naval architect, from Tasmania, Australia, to assess the design of the *Milford Sovereign*, the stability documentation, the directional stability and control, and the effect of wind forces on the ships. In his report issued on 20 July 2006, the third naval architect noted that "Both the vessels are very similar in design and the *Milford Sovereign* is clearly a derivative of the former [the *Milford Monarch*]". In conclusion the third naval architect outlined his opinions, which read in part:

1. There are no apparent, inherent faults in the design of the ***Milford Sovereign*** that should cause fundamental concern.
2. The vessel's Stability Booklet reflects the vessel's stability characteristics to a sufficient degree of accuracy and there is no fundamental concern with regard to intact or damaged stability.
3. The vessels ***Milford Monarch*** and ***Milford Sovereign*** are not sister ships since there is a definite variation in the hull form but the use of the former as a basis for the Light ship characteristics of the latter is reasonable in principle and unlikely to result in any inaccuracy such as to meaningfully undermine the accuracy of the subsequent stability analysis.
4. The presentation, completeness, consistency and general rigour of the Stability Book leave a lot to be desired and it should be updated.
5. Since the two vessels are based on the same hull form and the topsides about the main deck are almost identical, in the absence of data from detailed manoeuvring trials there is no immediately apparent reason other than the absence of the bar keel in the ***Milford Sovereign*** as to why the two vessels should have noticeably different manoeuvring characteristics.
6. The bar keel should be fitted to the ***Milford Sovereign*** as proposed.
7. A set of formal manoeuvring trials should be conducted on the ***Milford Sovereign*** after fitting the bar keel.
8. Consideration should be given to the management of risks associated with manoeuvring close by shoreline features in Milford Sound in a similar manner to assessing the risk of entering the port in adverse conditions.
9. Such risk management should take the form inter alia of quantitative guidance on prudent sea room versus wind speed and standing orders if necessary as to preferred manoeuvring tactics in extreme winds.
10. While it is understood that bow thrusters can be a mixed blessing, the fitting of a modestly sized unit might be considered if only to increase the wind speed within which the vessels can safely manoeuvre or to provide additional capability in extreme conditions.
11. Alternatively the fitting of high lift, "Becker" type, flap rudders might be considered.
12. These matters should be considered within the context of investigating alternative operational responses to extreme weather events (especially extreme winds) and in the context of a more general, formal risk assessment of vessel operations.
13. If not already so addressed, consideration be given to signage and passenger briefing to the effect of the need for caution using stairways generally but more particularly due to the possibility of sudden wind gust, similarly to advice given to airline passengers regarding the effects of air turbulence.

1.12 Subsequent incident

Occurrence 06-206, the *Fiordland Navigator,* heel due extreme wind gust, in Milford Sound on 8 July 2006

1.12.1 At 1230 on 8 July 2006, the *Fiordland Navigator,* with a Master, 5 crew and 31 passengers on board, departed Fresh Water Basin in Milford Sound for a scheduled 2½-hour nature cruise of the Sound. Although a gale warning was in force for the Milford weather forecast area, the weather at Fresh Water Basin was benign. The Master said that as he proceeded towards the outer Sound the wind did start to freshen and he estimated it to be about 25 knots as he passed Copper Point. As they passed the Bridal Veil Falls, which were further towards the mouth of the Sound, the wind strengthened further. However, the wind was not so strong that the Master considered it necessary to curtail the voyage.

1.12.2 Meanwhile, another ship, the *Milford Monarch*, which was scheduled for a one hour and 40 minute scenic cruise, had departed Fresh Water Basin at about 1300. At about 1320, the Master of that ship called the Master of the *Fiordland Navigator* on the VHF radio to warn him that there were winds in excess of 60 knots in the vicinity of Copper Point.

1.12.3 The *Milford Monarch* and the *Fiordland Navigator* were using the same berth at Fresh Water Basin, but because it was on a shorter trip, the *Milford Monarch* was scheduled to arrive back at the berth by 1440, disembark its passengers and be standing off by the time the *Fiordland Navigator* was due to berth at 1500.

1.12.4 During the return passage into the Sound, the Master of the *Fiordland Navigator* estimated the wind to be constantly above 50 knots. This made controlling the ship difficult, so the Master was unable to approach closely, or stop at places of interest to the passengers. Consequently, the cruise progressed faster than usual, so the Master had to reduce speed in an attempt to maintain his schedule. The reduction of speed caused further problems with the handling of the ship. Each time a strong gust hit the ship, the bow turned to port even though the helm was hard to starboard. The handling problems and the following westerly quarter wind made slowing the ship difficult, so the Master decided to take shelter in Harrison Cove to wait for the *Milford Monarch* to clear the berth at Fresh Water Basin.

1.12.5 The Master said later that the weather in Harrison Cove was unusually bad for westerly quarter winds, but there was an area of relative shelter to the south and east of Williamson Point. The Master hove-to, steering the ship's head into the west to northwest wind. However, to do this he had to make slight headway, so the ship slowly moved out of the sheltered area towards the heart of the Sound. The Master decided to turn back into the Cove, but while partway through the turn to starboard, a severe gust of wind struck the port beam and heeled the ship to starboard.

1.12.6 The Master said that he saw the pointer of the inclinometer at 15°, which he thought was at the time that the ship was at the maximum starboard heel. However, other crew members without the benefit of an inclinometer thought the maximum angle of heel was more, possibly as much as 25°. The ship did heel sufficiently for a box of cutlery and some crockery to fall to the deck and for some of the passengers to become frightened. The Master attempted to drive the ship out of the heel by applying full-ahead power on both engines while keeping the wheel hard to starboard. This resulted in severe vibration from the port-side propeller and drive train, but the ship did not respond.

1.12.7 The wind gust, which the Nature Guide read on the ship's anemometer as 73 knots, eased after 5 to 10 seconds and the ship returned to the upright, allowing the Master to regain control and complete the starboard turn. Although the wind remained above storm force, there were no further severe gusts and the Master was able to heave-to in Harrison Cove until there was a clear berth. At 1530, about 30 minutes behind schedule, the *Fiordland Navigator* berthed without any further incident and disembarked its passengers.

1.12.8 The *Fiordland Navigator* was purpose built for the Fiordland tourism industry. It was a restricted limit passenger ship, of monohull form. Real Journeys built the ship at its facility in Bluff. The keel was laid in 2000 and construction was completed in November 2001. The ship was certified to carry 100 passengers in the enclosed area and could carry, and had berths for, 85 passengers in the inshore area. The ship had a length overall of 40.0 m, a gross tonnage of 693, a breadth of 10.0 m and an operating draught of 1.9 m.

Figure 5
The *Fiordland Navigator*

1.12.9 The ship was powered by 2 Volvo Penta TAMD 163A 6-cylinder, in-line marine diesel engines each rated at 389 kW at 1600 RPM, which drove, through ZF BW 161-1 reversing gearboxes of 3.605 to 1 ratio, 2 fixed-pitch, 4-bladed propellers. The propellers each had a diameter 1300 mm and a pitch of 1200 mm. The ship was fitted with 3 self-furling sails that the Master was able to set automatically using the electronic ship management system. The operating speed of the ship was 10.4 knots. The ship normally operated out of Deep Cove, Doubtful Sound, but had been repositioned to Milford Sound in June 2006 to replace the overnight vessel, the *Milford Mariner*, which was due to go to Bluff to undergo its annual survey.

1.12.10 The *Fiordland Navigator* had a similar design as, but larger rudders than those fitted to, the *Milford Sovereign.* Each rudder had an area of 1.215 m^2, giving a total area of 2.43 m^2.

1.12.11 The underwater hull of the *Fiordland Navigator* was of similar design and construction to that of the *Milford Mariner* except that it did not have an external keel. The superstructures were almost identical. No previous incidents involving the directional control of the *Fiordland Navigator* had been reported.

1.12.12 The Master of the *Fiordland Navigator* had started work in the Fiordland area in 1986 and had worked at Milford Sound, Doubtful Sound, Lake Manapouri and Lake Te Anau. He held a commercial launchmaster certificate, and had been with Real Journeys since 1996. He had worked primarily on the overnight boats, the *Milford Wanderer* and *Milford Mariner* out of

Milford Sound, and the *Fiordland Navigator* out of Doubtful Sound. During the summer season immediately before this occurrence, the Master had not been assigned to a particular ship but had been relieving other masters so that they could take leave. Consequently, he was used to the various handling characteristics of each vessel and the conditions that could be expected in Milford Sound.

1.12.13 During the winter or low season, the number of trips for each of the vessels was reduced. The overnight vessels did only one day cruise per day rather than the 2 day cruises that they did during the high season. The overnight cruises were reduced to about once every 5 days instead of every night.

1.12.14 The forecast for the Milford weather forecast area issued on the morning of 8 July 2006 was:

> FORECAST ISSUED BY METEOROLOGICAL SERVICE OF NEW ZEALAND
> AT 0422HRS 08-JUL-2006
> VALID UNTIL MIDNIGHT TONIGHT 08-JUL-2006
> SOUTH ISLAND:
>
> MILFORD
> *GALE WARNING IN FORCE*
> Southwest 35 knots easing to 25 knots tonight. Very rough sea easing.
> Southwest swell rising to 6 metres. Poor visibility in rain at times.
> OUTLOOK FOLLOWING 3 DAYS: Southwest easing Sunday morning to 20 knots, tending Sunday afternoon northwest 25 knots, easing for a time Monday, then rising later Tuesday to 30 knots. Sea rough at times. Heavy southwest swell easing Monday.
>
> This forecast was updated at about 0923 to:
>
> MILFORD
> *GALE WARNING IN FORCE*
> Southwest 40 knots easing to 30 knots tonight. Very rough sea easing.
> Southwest swell rising to 6 metres. Poor visibility in rain at times.
> OUTLOOK FOLLOWING 3 DAYS: Southwest easing Sunday morning to 20 knots, tending Sunday afternoon northwest 25 knots, easing for a time Monday, then rising later Tuesday to 30 knots. Sea rough at times. Heavy southwest swell easing Monday.

1.12.15 The weather stations at Milford Sound recorded the following wind speed and directions for the period of the occurrence:

Weather station	Milford Sound Airport automatic weather station		Milford Sound Airport manual weather observations	
Time	Wind direction °(T)	Wind speed knots	Wind direction °(T)	Wind speed knots
1200	200	5	310	1
1300	190	5	190	5
1400	210	6	220	5
1500	080	8	200	9

Table 3
Wind speed and direction for the period around the time of the *Fiordland Navigator* incident

1.12.16 There were no injuries to the passengers or crew, nor was there any damage to the *Fiordland Navigator*.

1.13 Human and organisational factors

1.13.1 Human and organisational factors is that branch of science and technology that includes what is known and theorised about human behavioural, cognitive and biological characteristics that can be validly applied to the specification, design, evaluation, operation and maintenance of products, jobs, tasks and systems to enhance safe, effective and satisfying use by individuals, groups and organisations[2].

1.13.2 Today more emphasis is placed on the systematic analysis of accidents and incidents in many safety-critical activities such as aviation, nuclear power production and shipping. Such methodology requires that not only the person at the "coal face" be looked at for their part in the occurrence, but also the safety health of the organisation as a whole should be considered, right from the highest levels, the board of directors and executive officer, down to the most junior employee.

1.13.3 All humans make mistakes and all organisational systems have faults. It is those errors and faults that it is necessary to mitigate by putting in place strong defences such as efficient safety management systems and comprehensive hazard and risk management. Safety is also promoted by having a robust organisational culture where there are good lines of communication, responsibility is shared, safety is actively sought and failures lead to wide-ranging reforms.

1.13.4 The highest level of management and governance, be it for an airline, a shipping company, a power plant or a factory, is responsible for the design and management of the equipment used in the venture, the policy and financial planning for the business and providing the defences against potential hazards.

1.13.5 Failures fall into 2 main categories, active and latent. Active failures have an immediate and direct impact, whereas latent failures may lie dormant for long periods, sometimes years, before they combine with active failures and local triggering events to breach the system's defences[3].

1.13.6 Local triggering events are the proximate conditions that precipitate an occurrence. They are like the catalysts in a chemical reaction.

1.13.7 Humans can suffer from hazardous attitudes from which hazardous thoughts develop and affect the standard of their decision-making. These attitudes depend upon an individual's characteristics and the type of environment in which they are operating. Factors that influence decision-making are commercial pressure, peer pressure and the corporate environment in which the decisions are made.

1.13.8 Ideally safety and efficiency should be built on a proactive approach where possible problems are identified and rectified before they can cause any major disturbance in operation[4].

1.13.9 In every enterprise there is an element of commercial pressure; this is particularly so in transport industries. The tourist industry in Milford Sound was particularly challenging because of its remote location, the high number of tourists and the rapidly changing weather patterns experienced there.

[2] Human factors definitions revisited. *Human Factors Society Bulletin*, 31, 7-8. Christensen, Topmiller, and Gill 1988.
[3] Beyond aviation and human factors. Daniel E Maurino, James Reason, Neil Johnston and Rob B Lee 1995.
[4] Organisational Factors; Their definition and influence on nuclear safety. Prof B Wahlstrom 1998.

2 Analysis

The *Milford Sovereign* and Milford Sound

2.1 This incident was a combination of extreme weather conditions, a ship that had issues with its directional control in those conditions and masters not being trained to handle the ship in those conditions.

2.2 The weather in Milford Sound often differed from that forecast for the surrounding sea area, and was liable to change very quickly. On 20 November 2005, the wind at Milford Airport did not rise above 10 knots during the period that the ship was being buffeted by winds of 70 knots in the outer Sound. This demonstrates the difficulty experienced by operators trying to predict if and when the wind strength would impact on the safe operation of their vessels. The direction of the wind had a significant effect on the strength of the wind in the Sound and the amount of shelter available. Winds from the east or north did not funnel directly into the Sound, so did not produce extreme conditions. Conversely, winds from the west or northwest had free access to the Sound and as such funnelled through the mountains, increasing in strength and changing direction. The greatest change in weather conditions occurred when a passing weather system caused the wind to change direction from north or northeast to northwest.

2.3 The direction and strength of the wind experienced depended on a vessel's position in the Sound and could vary dramatically over a very short distance, usually being stronger near the entrance and along the section between Dale Point and Copper Point. Persons in the inner Sound could not see the conditions in the outer Sound, nor were there any automatic weather stations in the outer Sound from which guidance could be gained.

2.4 The incident on 20 November 2005, and those in February 2004 and September 2005, occurred when gale or storm warnings were in place for the marine weather forecast area Milford, so strong winds should have been expected. The operator and serving masters indicated that when gales were forecast, the wind strength often did not reach that predicted, but stayed below that at which the vessels could safely operate. However, the same masters also said that winds of more than twice the strength forecast were often experienced. In order to minimise unnecessary inconvenience to passengers and loss of income, it was usual to continue operations until the predicted adverse weather actually arrived, but in so doing there was the inherent risk of the vessels being in the outer Sound when exceptionally strong winds occurred. Using this philosophy it was incumbent on the operator to both design its vessels to cope safely with those weather extremes, and develop strategies to afford them a safe return to more sheltered waters.

2.5 The type of weather that might be experienced in the Sound was well documented in the New Zealand Pilot. The wind on 20 November 2005 was consistent with that forecast and described in the Pilot.

2.6 The wind and sea conditions experienced in Milford Sound radically differed from those that may be expected in the open sea or conventional harbours. The extreme and gusty winds created by the mountainous terrain were accompanied by relatively low sea conditions. At sea, the strength of the wind was usually a reliable measure of the severity of the sea conditions, but in Milford Sound, the prevailing sea conditions fell well below that which might be expected in high winds. Consequently in Milford Sound, high wind conditions that would normally appear to be too severe to continue operations could, for a well found ship, have been reasonable to continue operations. However, having the mindset that it was acceptable to operate in 50 knots could have made it more difficult to set realistic operational parameters.

2.7 On 20 November 2005, the 6 other ships operating in the same area as the *Milford Sovereign* were able to continue operating without loss of control. This would indicate that the *Milford Sovereign* had less directional control than those vessels, and was less able to withstand the extreme conditions.

2.8 The design, construction and initial fit-for-purpose survey of the *Milford Sovereign* had confirmed that it met the requirements of the Maritime Rules for a restricted limit passenger vessel. However, both the *Milford Sovereign* and the *Fiordland Navigator* had shallow draught relative to a high windage superstructures. The absence of an external keel for directional control, and high efficiency rudders for good turning and track-keeping qualities, raise the question as to their fitness to operate in an area that had sporadic high winds.

2.9 The management decision to not install an external keel, while having the desired affect to facilitate slipping and minimise ongoing associated costs, resulted in the ships becoming unmanageable in the conditions with which they should have been designed to cope.

2.10 Both the *Milford Sovereign* and the *Fiordland Navigator* were fitted with flat-plate rudders that were less efficient than similar-sized foil-shaped or articulated rudders. Bearing in mind the frequency with which the ships had to manoeuvre close to the shore and other vessels, often in strong wind conditions, they should have been designed with a higher level of manoeuvrability.

2.11 The *Milford Sovereign* did undergo sea trials after it was launched, but those trials were carried out primarily by Real Journeys personnel and were less demanding and insufficiently documented. Had the ship been built by an autonomous ship-building company, extensive sea trials would have been required for contractual and guarantee purposes.

2.12 Real Journeys management had been aware of the handling difficulties experienced by the masters when operating the *Milford Sovereign* in high wind speeds. Since its launch, the ship had been described by its masters as "slippery", that is, it used to move readily sideways under the influence of wind on the beam. It had also been noted that the ship continued to turn when power was reduced and did not come to rest as quickly as would have been expected. The incidents in February 2004, although not previously reported as maritime accidents or incidents, were included as part of a report to management by the manager of the Milford Sound shore facility and that report gave an overview of events that occurred on 19 and 21 February 2004 at Milford Sound. The Safe Ship Management Manager also compiled a report into the incident, which was presented to management. At that time, the company did not investigate why the ship handled differently from similar ships operating in the area, nor were procedures put in place to reduce the likelihood of the ship being caught in adverse weather.

2.13 Following the incident that occurred on 30 September 2005, the company acknowledged that a problem existed and planned a meeting to discuss ways of improving the handling of the ship at the earliest opportunity that all the necessary personnel were available. However, that meeting had still to take place when the 20 November 2005 incident happened.

2.14 There appeared to be some initial scepticism on the part of Real Journeys management and the design naval architect that the *Milford Sovereign* had handling difficulties. However, masters of the ship and others in the Milford Sound area had reported that the ship "slipped" sideways more than any other vessel in the port.

2.15 The operation at Milford Sound, like many commercial transport operations, was dependent on the weather conditions. However, the situation was exacerbated by Milford Sound's geographical location and the fact that the majority of tourists, particularly those booked on the large vessels, travelled by coach from Queenstown each day. The coaches left Queenstown early each morning for the 4-hour drive to Milford Sound. Part of the overall package was that the tourists were provided with lunch during the scenic cruise of Milford Sound. Therefore the decision not to run a cruise necessitated making many alternative plans for the passengers; consequently such a decision was not taken lightly. However, where a cruise was cancelled because of adverse weather, and a tourist party was already in transit to Milford Sound, they were given lunch on board the vessel while alongside the wharf.

2.16 There was a discrepancy between the calculated angle of heel due to wind for the conditions on the day and the approximate observation of water lapping the galley portholes. The difference between the 2 values was most likely due to:

- the slight discrepancy between the actual loading of the ship and the standard condition in the stability booklet
- the ship initially heeling to a larger angle before coming to rest close to the calculated angle
- the approximate angle determined from the galley porthole immersion being dependent on the water lapping the leeward side of the ship and any wave that formed due to the ship moving through the water.

The actual maximum angle of heel that the vessel reached was likely to lie between the 2 values of 7.4° and 13°.

2.17 The harbour risk assessment plan prepared for Environment Southland was still being reviewed at the time of writing this report, so the regional council had not yet moved on to the subsequent parts of the NZPHMS Code strategy of developing a harbour safety management system or standard operating procedures in respect of each harbour within its jurisdiction.

2.18 Part of the NZPHMS Code required that regional authorities provide adequate meteorological monitoring equipment. If the conditions in the outer Sound could be remotely monitored from Fresh Water Basin, operators would be able to make more informed decisions on whether it was suitable to sail or whether to remain within the inner Sound. Such monitoring and communication equipment has up to now been technically complex and expensive, but recent advances have made monitoring and communication equipment more accessible.

2.19 The Harbour Code of Practice for Milford Sound would be a suitable vehicle through which Environment Southland could place operating limitations on vessels working in the Sound or, alternatively, require operators to have their own limitations in place.

2.20 There were fewer berths in Fresh Water Basin than vessels operating out of the Basin, so when weather conditions were such that trips had to be cancelled, some of the ships had to stand off to make way for other vessels to come alongside. This was the case on the 21 February 2004 loss-of-control incident, which occurred while the *Milford Sovereign* was standing off to allow the *Milford Mariner* to berth to disembark overnight passengers.

2.21 The safe ship management system operated by Real Journeys was approved by Maritime New Zealand and was audited each year by Maritime New Zealand and external auditors. However, the safe ship management manual for the *Milford Sovereign* did not contain any limiting parameters or guidelines for when to cease vessel operations. This left the Master in the difficult position of having to make decisions without any guidance from the management of the company.

2.22 The attraction of Milford Sound is its remoteness, however that inaccessibility could be problematic should it be necessary to respond to a major accident. Consequently, urgent response to an occurrence would need to be by air or handled with local resources.

2.23 The topography of Milford Sound is exceptionally rugged, with mountains rising directly out of the water. Once out in the Sound there is little, if any, shelter or safe anchorage, and returning to either the Fresh Water Basin or the Deep Water Basin can be difficult in adverse weather. Milford Sound is an area where a master needs to be in full control and confident in the ability of their vessel.

2.24 The delicate nature of the environment and the number of passengers that visited the area annually made maintaining a safe operation imperative. It was therefore surprising that it had taken 3 directional control incidents and more than 2 years before such a fundamental problem was addressed. The record-keeping and administration surrounding the problems with the ship's handling were deficient, so audits would be less likely to detect latent failures.

The *Fiordland Navigator*

2.25 The *Fiordland Navigator* usually operated in Doubtful Sound where the prevailing weather was similar to that of Milford Sound but, because of the greater area and less precipitous topography, was less susceptible to extreme wind gusts. Also, Doubtful Sound had many arms that penetrated further inland, affording masters more options to find sheltered waters.

2.26 The *Fiordland Navigator* had a high superstructure and masts similar to those on the *Milford Mariner*, the ship it was replacing in the Milford Sound operation. The Master of the *Fiordland Navigator* had trouble maintaining a course during the return inward passage as they passed along the northern side of the Sound. This suggested that the directional control of the ship was less than optimal and that a keel, as recommended by the independent naval architects for the *Milford Sovereign*, would be equally advantageous for the *Fiordland Navigator*. Although the Master did not estimate the sideways slippage during the heeling event, he was unable to manoeuvre out of the situation, which further suggested that the vessel had poor directional control in these conditions.

2.27 The high superstructure and masts resulted in a large windage area that would increase the ship's tendency to heel in wind. There was more superstructure towards the after end of the ship, possibly providing more resistance to the ship turning away from the wind as it was attempting to in this instance.

2.28 The draught of the *Fiordland Navigator* was slightly greater than that of the *Milford Sovereign*, so its propellers and rudders may have been marginally less susceptible to loss of efficiency when the ship was heeled. However, the vibration that the master identified as coming from the port-side drive train suggests that the windward propeller and rudder would have been closer to the surface and so would have been operating below optimum. This would have further reduced the ship's ability to turn away from the wind during the time it was being heeled.

2.29 The Master of the *Fiordland Navigator* had to reduce speed and delay the ship's return to Fresh Water Basin in order to allow the *Milford Monarch* to disembark its passengers and clear the berth. The fact that there were insufficient berths in Fresh Water Basin for the number of vessels needing to use them, and that there were restrictions over which berths certain ships could use, made it inevitable that at times some ships had to wait for a berth. In adverse weather, with little or no natural shelter in the Sound, ships were sometimes forced to ride out the extreme winds in the heart of the Sound. Harrison Cove usually provided some shelter from the westerly quarter winds, but the Master said that on this occasion there were extreme gusts coming down the Cascade Range on the Cove's eastern side.

2.30 The approach to Fresh Water Basin was such that, in strong westerly quarter winds, it would be almost impossible for a ship such as the *Fiordland Navigator* to turn up safely into the wind should it be necessary to abort the planned manoeuvre. Consequently, once south of Bridget Point a master was committed to enter the harbour. Should that not be possible, the ship would face a high likelihood of being driven onto the ground south of the Basin. Because of this potential risk, the Master's decision to remain hove-to off Harrison Cove until the berth was available and he had a direct run into the Basin, was reasonable.

2.31 The incident involving the *Fiordland Navigator* again showed the difficulties of operating relatively shallow-draught to-high-windage-type vessels in the extreme weather conditions that occur, not frequently, but regularly in Milford Sound. The difficulty of being able to forecast when such extreme conditions will occur may make it necessary to reassess the maximum operating conditions in which it is safe for such vessels to operate. Nevertheless, each of the incidents involving a loss of directional control occurred during periods when either gale or storm warnings had been issued by MetService.

Human and organisational factors

2.32 Real Journeys did not put any pressure on masters to sail in adverse weather and had contingency plans to care for passengers who had their excursions disrupted. However, in addition to the obvious loss of revenue, the subconscious commercial pressure of inconveniencing large numbers of passengers would have weighed heavily on the masters' minds when making the decision on whether to sail or not. Should any of the other operators continue to operate, the masters of the *Milford Sovereign* would be subject to a certain amount of peer pressure and that, coupled with questions raised by passengers, might make it particularly difficult for them to cancel trips. The hazardous thoughts of "I can do it" or "it won't happen to me" might enter a master's decision-making. A master later reported that there was an unofficial agreement between the 2 larger operators in Milford Sound that if one of them decided that the conditions were unsuitable and suspended their operation, the other one would follow suit. It was also unusual for the smaller operators to continue operating once the larger companies elected not to.

2.33 At the head of the causal pathway are the organisational processes. These are the decisions made at the management level that impact on and flow down to all levels of the company's operations. In Figure 6 the left-hand side of the diagram lists the local working conditions; those that determine the working environment. Below that are the active failures; those that have an immediate impact on the incident and are usually performed by people in direct contact with the vessel. On the right-hand side are the defensive safeguards; these are the measures put in place to remove, mitigate or minimise the potentially hazardous actions involved in the operation. Latent failures are those that may lie dormant for many years until they combine with active failure and local triggers to result in an occurrence. Latent failures are usually introduced by people separated both physically and historically from the vessel and are usually the product of managerial or organisational decisions.

2.34 Every decision by a board or executive officer impacts on an operation's local working conditions. For example, changing operating schedules or altering manning levels will have an impact on the actual operation. The working conditions need to be understood by the board and executive and appropriate strategies put in place at the highest level to mitigate any increased risk. Furthermore, interactions between senior officers and staff can subtly influence day-to-day operations. For example, in aviation, it has been found that management policies and methods can influence the way pilots react when faced with adverse weather. In companies that place emphasis on the maintenance of schedules, and where management questions pilots for failing to do so, pilots could be more inclined to push ahead into adverse weather than return or divert to a safe airport. Alternatively, where management has a high risk avoidance or strong safety culture, pilots are more likely to take the safer option of returning or diverting to a safe airport. These findings relate equally to other modes of transport.

2.35 To minimise risks, the board and executive officer are responsible for putting in place safeguards such as a safe ship management system, quality control and hazard management. The decision by Real Journeys to run the safe ship management system internally instead of using an external contractor necessitates additional safeguards to ensure the self-managed system is robustly monitored and audited. Telarc and Maritime New Zealand carried out quality assurance audits of the safe ship management system. Fit-for-purpose and survey inspections were carried out by SGS M&I. These checks assisted in maintaining the health of the management system, but on this occasion did not assist in identifying and addressing the control issues with the *Milford Sovereign*.

2.36 Where defences are not as effective as they should be, there is an increased possibility that latent failures will surface. Usually latent failures only become apparent when certain factors coincide at the local working condition level. This means that while it is possible to attribute an error to a crew member, such an error could equally be facilitated by failures of the defensive safeguards. If the error had not been made by that crew member at that time it would probably have happened to another crew member at another time. In other words, if an occurrence would

have occurred if one operator had been substituted for another, latent failures will almost certainly be present. In the case of the *Milford Sovereign,* at least 2 other masters had experienced similar loss-of-control events in the past, and the Master of the *Fiordland Navigator* experienced a similar incident, demonstrating that latent failures existed.

2.37 There were directional control problems with vessels operating in the environment of Milford Sound. However, the masters had not been trained in how to cope with their vessels when they experienced a loss of control through adverse weather conditions.

2.38 In any kind of operation, decisions are constantly being made and acts being performed. Poor decisions or unsafe acts can result in unsafe conditions that may have lain dormant for some time, just waiting for an unfortunate sequence of corresponding local events to culminate in an accident or incident.

2.39 There were a number of latent and environmental factors that contributed directly to these incidents, namely:

- the decision not to fit an external keel
- allowing the masters to be the sole arbiters of the operational parameters
- the little or no documentation of the directional control incidents that were experienced by the masters, and the incidents that were known about not being properly investigated and addressed
- the difficulty of, and lack of training for, extreme weather conditions and also the lack of a system for reviewing a master's ability to handle such situations
- the unpredictable and extreme weather conditions
- the process for assessing whether the *Milford Sovereign* and the *Fiordland Navigator* were fit for purpose, which did not require the specific intended operating area and prevailing environmental conditions to be taken into account.

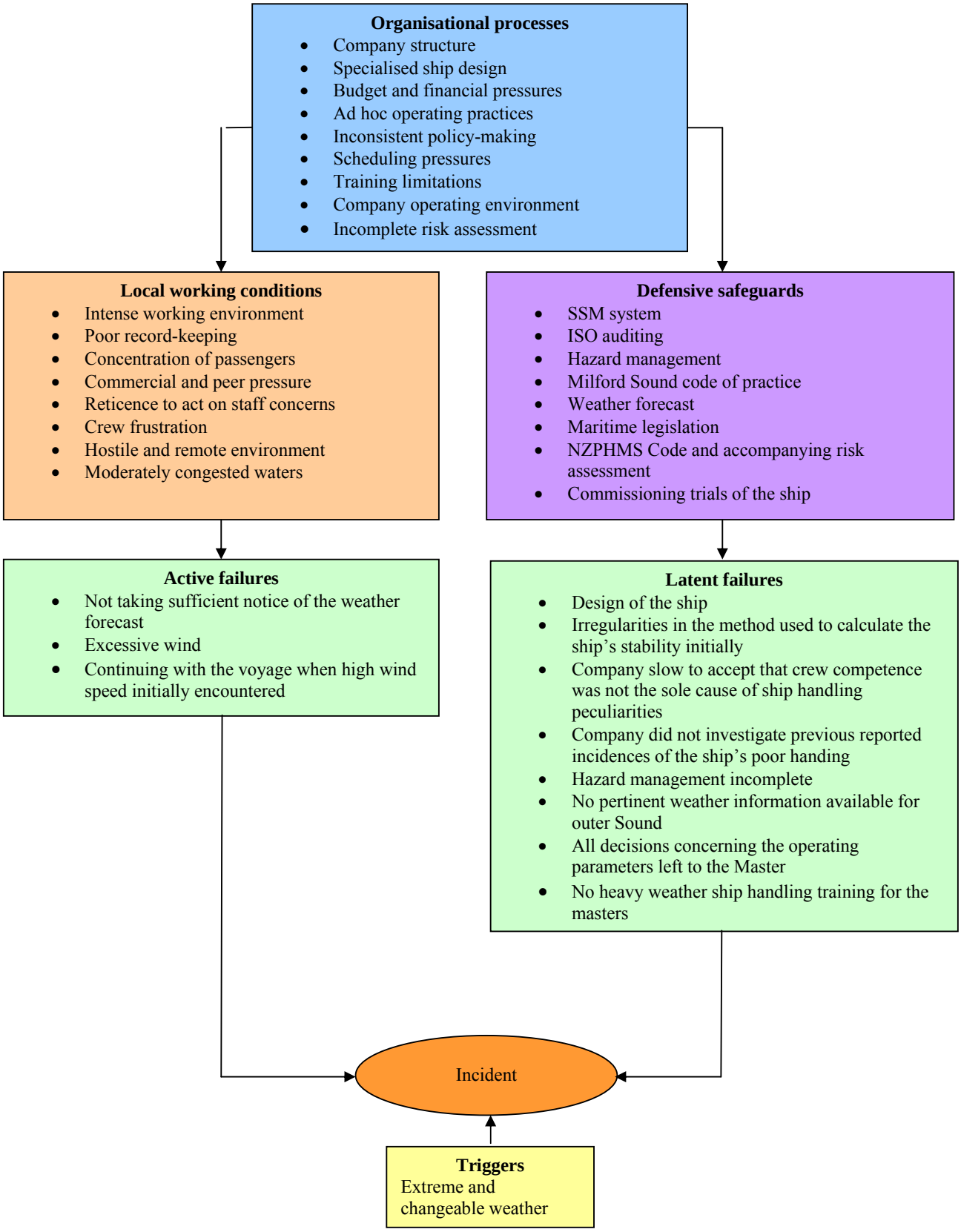


Figure 6
Causal pathways model

3 Findings

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

3.1 The weather in Milford Sound could be both extreme and unpredictable. Small changes of wind direction produced severe changes of resultant wind strength and direction as it was deflected and funnelled by the precipitous topography.

3.2 The Master lost directional control of the *Milford Sovereign* and deviated from its intended course, predominantly due to the smooth underwater hull of the ship providing poor lateral resistance, together with low-efficiency-type rudders not providing sufficient turning performance for the extreme wind conditions.

3.3 The Master received no warning that the conditions had deteriorated in the outer Sound because there were no automatic weather stations in the outer Sound.

3.4 Although the weather experienced was extreme, it was not sufficient to cause other vessels operating in the same area at the time to suffer any loss of directional control.

3.5 The design naval architect and owners of the ship had made the conscious decision to not fit an external keel without considering the consequences for the ship's manoeuvrability.

3.6 The design process, the design approval and the initial fit-for-purpose survey did not identify the limitations of the handling of the vessel in severe winds, neither were restrictions in the operating parameters imposed.

3.7 The in-house nature of the design and building, coupled with an internal safe ship management system, led to less formal commissioning tests and documentation than otherwise may have been the case.

3.8 Real Journeys management had been aware of the handling difficulties experienced on the *Milford Sovereign* through feedback and incidents reported by the masters. The fact that the issue had not been addressed for some 2 years indicates a flaw in the safe ship management system.

3.9 Appropriately, the final decision on whether it was safe to sail was left to the Master's discretion, but the company had not provided any operational parameters or guidelines to assist that decision.

3.10 The unpredictable weather and lack of current weather data in the Sound resulted in masters making the decision to sail, even with gale- or storm-force winds forecast, without knowing the actual weather conditions in the outer Sound.

3.11 Should it be necessary to cancel a trip, many hundreds of tourists would be inconvenienced and there would be a corresponding loss of revenue. This placed subconscious commercial and social pressure on the masters to maintain the service, even though the company said it supported a master's decision not to sail.

3.12 The small, close-knit community of tourist vessel operators in Milford Sound bred a degree of peer pressure among the masters of the vessels. Should one master decide to sail, the other masters might feel subconscious pressure to follow suit. However, this was mitigated by the unofficial agreement between operators to cease operations in unison.

3.13 Because Fresh Water Basin had fewer berths than the number of ships needing to use them, it was often necessary for a vessel to leave the safety of the harbour to allow another vessel to berth to embark or disembark passengers, which occasionally left vessels prone to severe weather conditions.

3.14 Environment Southland had no requirement in either the bylaws or the Milford Sound Harbour Code of Practice for operators to place limits on the weather in which they operated.

3.15 Following the harbour risk assessment review, the regional authority was in the process of developing a safety management system and standard operating practices for Milford Sound.

3.16 The Milford Sound area has key environmental and economic significance, so any accident there could have major consequences. Fortunately, this incident did not develop as it may have done, but it does serve to warn all operators in, and administrators of, the area of the potential for accidents.

3.17 The extreme topography and lack of places of refuge in Milford Sound required that a master be in full control of, and have complete confidence in, their ship. The handling characteristics of the *Milford Sovereign* and *Fiordland Navigator* did not instil this confidence in their masters.

3.18 The *Milford Sovereign* should have undergone an inclining experiment after it was launched instead of relying on the data held on the similar ship, the *Milford Monarch*. However, the *Milford Sovereign* exceeded the minimum stability requirements, and the statical stability of the vessel did not contribute to any of the incidents referred to in this report.

3.19 The occurrence that involved the *Fiordland Navigator* reinforced the difficulties the masters experience when operating ships with high freeboard and shallow draughts in high winds. The directional control issues for the *Fiordland Navigator* were similar to those experienced on the *Milford Sovereign*, the only other ship in the Real Journeys fleet that did not have an external keel.

4 Safety Actions

4.1 In December 2005, Real Journeys engaged an independent naval architect to determine the validity of the stability information of the *Milford Sovereign* and his report was produced in January 2006. His brief was expanded to include the directional control aspects of the ship's design and the report on this was published in February 2006.

4.2 There was some dispute between the design naval architect and the first independent naval architect, so in April 2006 Real Journeys briefed a third naval architect to determine how best to overcome the directional problems the ship had experienced. The opinion from that report is quoted in paragraph 1.11.10, but was largely comparable with the opinions expressed by the first independent naval architect.

4.3 In August 2006, the *Milford Sovereign* was slipped at Bluff and a non-structural bar keel was fitted. On 26 October 2006, the manoeuvring characteristics of the *Milford Sovereign* were reassessed by the Company Engineer and the Milford Sound Senior Launchmaster. The handling was found to be much improved and was now comparable to the similar ship, the *Milford Monarch*. The manoeuvring trials were conducted in fine conditions with the wind rising to about 23 knots with the advent of the day breeze, so the handling characteristics in heavy weather were not tested. Subsequent discussions with the Milford Sound Senior Launchmaster confirmed that the vessel now had more directional control in strong winds.

4.4 On 13 September 2006, an inclining experiment was carried out on the *Milford Sovereign* and a new stability booklet was prepared from the data gathered. The resulting stability data was substantially similar to that contained in the original stability booklet, with slight differences in the displacement and the vertical centre of gravity and a slightly larger difference in the longitudinal centre of gravity. The vessel complied in every respect with the intact and damaged stability requirements contained in the Maritime Rules.

4.5 On 16 May 2007, Maritime New Zealand held a training seminar for safe ship management companies and their surveyors where the findings of this report were presented. The meeting

was attended by the Commission's Chief Investigator of Accidents, who reminded the participants of the need for the geographical and environmental conditions of a vessel's intended area of operation to be taken into account when conducting fit-for-purpose surveys. In addition, it was noted that section 17.7 of the safe ship management code of practice allowed for operating limits to be imposed if there were any factors that might restrict a vessel's performance.

4.6 Between 10 and 13 April 2007, at the request of the Commission, Maritime New Zealand advanced its scheduled performance audit of Real Journeys' safe ship management system. The audit found that the company's safe ship management system was well implemented at all levels and compliant with the Safe Ship Management Code of Practice. No non-conformances were raised at the audit, but there were 5 observations raised:

1 The stability booklet for Milford Sovereign requires updating, to show correct operating limits.

2 Training and peer reviews of ship's staff should be conducted and recorded.

3 Standardised sea trial checklist to construct and implement.

4 Milford Sovereign, the reason for engine stalling to be further investigated and reported to Maritime NZ. In the meantime, it should be ensured that the revised operating procedures notification is adhered to.

5 Crew training forms, not all are completed or signed off by the Master. More control of this process should be implemented.

The audit concluded that the safe ship management operations showed high levels of compliance with the policies and procedures of Real Journeys, and that senior management was committed to ensuring that all the vessels were operated in a safe, efficient manner.

5 Safety Recommendations

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

5.1 On 2 April 2007 the Commission recommended to the Director of Maritime New Zealand that she:

009/07 Undertake a full review of the Safe Ship Management system and make changes to ensure the system promotes and effectively regulates a safe and sustainable maritime industry consistently throughout New Zealand.

5.2 On 24 July 2007, the Director of Maritime New Zealand replied:

> MNZ constantly monitors the SSM system, which has been formally reviewed three times since its introduction in 1998. Each review, by independent bodies external to MNZ, found that the philosophy behind the system was sound, and since the system was introduced safety statistics in all commercial maritime sectors have improved. While feedback from the industry indicates solid support for the intent of the system MNZ considers that there is still room for improvement in how the system is implemented and delivered by MNZ and SSM companies.
>
> In line with our continuous improvement policy, a review of the SSM system has been identified as the key strategic priority for MNZ in its 2007-2010 Statement of Intent. MNZ has commenced a programme of work to enhance the sustainability and effectiveness of the SSM system by:
>
> 1. Ensuring that the regulatory framework supporting SSM is robust and appropriate by reviewing the maritime rules that govern its operation. A draft discussion document summarising proposed changes to Maritime

Rules Part 21 (Safety Management Systems) and Part 46 (Surveys, Certification and Maintenance) is due for public release in late 2007;

2. Complementing existing guidance material (Health and Safety: A Guide; FishSAFE Health and Safety Guidelines; various leaflets) with additional material including a comprehensive resource to support owners in the development of their SSM systems, specific fatigue management material, and health and safety guidelines for passenger and non-passenger operations. This additional material is being progressively released through until December 2007 in association with targeted training material;
3. Increasing the amount and quality of formal and informal training and education that is available to all those working in the system, including MNZ and SSM Company staff, surveyors, owners and operators. This training will be supported by the development of a mentor network utilising experienced industry participants to provide support and advice to their peers;
4. Reviewing the current capacity and quality of service delivery by both MNZ and SSM Companies in the area of SSM and comparing this with requirements in order to identify and address necessary areas for improvement;
5. Allocating additional resources to the SSM team within MNZ to allow for more responsive contact with industry and other stakeholders, along with the provision of personalised assistance where required to owners and operators; and
6. Structured auditing by MNZ of SSM service providers.

This work is being actively progressed and monitored within MNZ. It is also intended to establish an external consultative group to ensure that all industry and other stakeholders remain fully involved with, and aware of, the programme as it is developed and implemented.

5.3 On 10 July 2007 the Commission recommended to the Chief Executive Officer of Real Journeys that he:

020/07 Specify maximum operating parameters for each of the vessels operating in Milford Sound, or put in place guidelines and procedures to assist masters to decide on the maximum safe operating weather conditions.

021/07 Consider the fitting of more efficient rudders, to increase the wind speed within which the vessels can safely manoeuvre or to provide additional manoeuvrability in extreme conditions.

022/07 Conduct a risk assessment of vessel operations in adverse weather conditions and put in place procedures and guidelines to minimise the risks inherent in such operations. Guidance should include, but not be limited to, clearing distances off the shore and other vessels, areas of operation, ship board organisation and how best to handle the vessel in the prevailing conditions.

023/07 Evaluate the hull and directional control characteristics of the *Fiordland Navigator* and, where appropriate, adopt for that ship the remedial actions for the *Milford Sovereign*.

5.4 On 31 July 2007 the Chief Executive Officer of Real Journeys replied:

Thank you for your letter dated 10th July 2007, Real Journeys have implemented the following guide lines and parameters as per the recommendations in your letter.

020/07 Recommendation accepted: Guidelines given are as follows, where adverse weather conditions exist or are forecast, masters should consider the following factors before deciding to put to sea;

1. Current weather must be visually assessed
2. Up to date weather forecast and weather trends must be assessed
3. Indicators such as waves breaking on the Milford Sound Airport Foreshore during Northerly and North West conditions should be taken as a warning of stronger winds further out into the fiord.
4. No Real Journeys ship will sail in winds exceeding 35 knots at the Milford Sound Wharf.
5. Excessive winds should be monitored visually and trends recorded
6. Should weather conditions be such that sailing may be questionable, a management representative and an experienced master from each of the other operating companies (real Journeys, Red Boats, and at least one other) will confer and make a joint recommendation to effected masters.
7. Masters retain full discretion relating to the safety of their ship and passengers, as per Real Journeys Safe Ship Management Manual, and the Maritime Transport Act, referenced in Section 3.5.5 of the Safe Ship Manual.
8. Weather Data Logger, when installed will be used to determine weather and records used to show trends. This initiative is being lead by Environment Southland with full support of Real Journeys.
9. These guide lines will be reviewed periodically in line with new technology and changing weather patterns.

021/07 Recommendation declined on the following grounds;

1. Real Journeys ships are highly manoeuvrable, and can turn within their own length.
2. Discussions with Naval Architects and other professional maritime personnel indicate that high lift rudders will not improve efficiency and are inappropriate for the operating areas and conditions.
3. The operating guidelines will negate the ships operating within extreme conditions
4. The cost of fitting high lift rudders exceeds Transport Accident Investigation Commission core statement of “safety at reasonable cost”

022/07 Recommendation accepted; guidelines given are as follows, in the event of a ship being subjected to adverse weather conditions during the course of a cruise the master will observe professional seamanship principles, these will include,

1. Maintaining ships head to wind
2. Maintain sufficient seaway for steerage
3. Maintain situational awareness of proximity to shore and location of other vessels.
4. Maximise available sea room
5. Ensure crew stow hot and insecure items
6. Instruct passengers to come off upper decks and close off

7. Instruct passengers to take care on companionways should they need to move and instruct passengers to remain seated.

8. Consider seeking shelter depending upon severity and expected duration of wind gusts, (in Milford Sound, Harrison's Cove will most likely be the first option considered).

9. These guide lines will be reviewed periodically to reflect new technology and changing weather patterns.

023/07 Recommendation accepted; hull and longitudinal direction control characteristic have been evaluated and the Milford Navigator is programmed to dry dock at Bluff In August 2007 to have a keel bar fitted, in line with that fitted to Milford Sovereign.

When implemented into Real Journeys Safe Ship Management System, documentary evidence will be provided as per your letter.

5.5 On 10 July 2007 the Commission recommended to the Chief Executive Officer of Environment Southland that he:

024/07 Ensure that the harbour risk assessment fully addresses the operation of tourist vessels in the Fiordland area. Take note of the identified risks when developing, in compliance with the New Zealand Port and Harbour Marine Safety Code, the harbour safety management system and standard operating procedures for Milford Sound.

025/07 For operations in Milford Sound, either implement maximum meteorological parameters, or require operators to include maximum meteorological parameters in their safety management documentation.

026/07 Investigate, possibly in conjunction with the Milford Sound Development Authority, the installation of a remote automatic weather station in the outer part of Milford Sound to give operators contemporaneous weather conditions.

5.6 On 31 July 2007 the Maritime Manager/Harbourmaster for Environment Southland replied:

In response to the final safety recommendations in the letter from Chief Commissioner Hon W P Jeffries, dated 12 July 2007, concerning these incidents in Milford Sound, I have the following comments:

024/07 The harbour risk assessment review has been completed and the original risk assessment will now go back to the various interested parties for further consultation. Although the intention of the review was to re-evaluate the risks associated with cruise ships in Fiordland waters, I propose to widen the scope to include the operation of tourist vessels. This will in turn lead to a Port and Harbour Safety Management System that will take into account any additional hazards identified in the operations in Fiordland.

Please record the status of this recommendation as "Open" – I am unable to give you a date for implementation.

025/07 It is not my intention, at the moment, to implement any maximum meteorological parameters or to require operators to include such parameters in their operating procedures without more consultation. It is possible, however, that some form of maximum parameters may arise from the revised risk assessment process.

Please record the status of this recommendation as "Open" – I am unable to give you a date for implementation.

026/07 Environment Southland has investigated the installation of a remote weather station at Copper Point, Milford Sound. In conjunction with the Milford Sound Development Authority we have accepted a proposal to install the equipment before the end of

September, and we are in the process of applying to the Department of Conservation for a concession for the installation.

Please record the status of this recommendation as "Closed - acceptable"

Safety recommendation from previous occurrence report

5.7 On 27 April 2006, the Commission approved for publication occurrence report 05-210 into the restricted limit passenger vessel *Milford Mariner* engines' stall that resulted in grounding in Harrison Cove, Milford Sound on 18 September 2005. On 5 April 2006, as a result of that report, the Commission recommended to the Chief Executive Officer of Real Journeys that he:

011/06 Establish quality assurance procedures within Real Journeys to ensure safety critical operational defects are properly addressed.

On 12 April 2006 the Chief Executive Officer of Real Journeys replied that he had established quality assurance procedures in place under the safe ship management system, which was independently audited by Telarc and approved by the Director of Maritime New Zealand. The system was audited on 3-4 May 2006 by the Maritime New Zealand audit team.

The response from Real Journeys was insufficient for the Commission to close the recommendation, so it remained open at the time of writing this report.

The intent of this recommendation is equally applicable to this incident, so no further recommendation relating to the way safety-critical defects are addressed has been made.

Approved on 24 July 2007 for publication

Hon W P Jeffries
Chief Commissioner

Appendix 1

Maritime Rules Part 40A Appendix 1 Intact Stability of Decked Ships

1.2 A new single hull decked ship that is 15 metres or more in length overall or that is certified to carry more than 50 passengers must comply with the following intact stability requirements:

(a) the lightship weight, vertical centre of gravity (KG), and longitudinal centre of gravity (LCG) of the ship must be determined from the results of an inclining experiment conducted or witnessed by a surveyor recognised for that purpose by the Director under rule 46.29:

(b) curves of statical stability (GZ curves) must be produced for -

(i) loaded departure with 100 percent consumables; and

(ii) loaded arrival with 10 percent consumables:

(c) a surveyor referred to in Appendix 1.2(a) must be satisfied that the curves of statical stability for the loaded conditions meet the following criteria -

the area under the righting lever curve (GZ curve) must not be less than 0.055 metre-radians up to 30 degrees angle of heel and not less than 0.09 metre-radians up to 40 degrees angle of heel or the downflooding angle if this angle is less; and

the area under the GZ curve between the angles of heel of 30 and 40 degrees or between 30 degrees and the downflooding angle if that angle is less than 40 degrees, must be not less than 0.03 metre - radians; and

the righting lever (GZ) must be at least 0.20 metres at an angle of heel equal to or greater than 30 degrees; and

the maximum GZ must occur at an angle of heel of not less than 25 degrees. However where the ship has a hull form that results in the maximum GZ occurring at an angle of heel less than 25 degrees but not less than 15 degrees, this may be accepted by a surveyor provided the area under the GZ curve up to the angle (θ m) at which the maximum GZ occurs is not less than $0.055 + 0.001(30 - \theta$ m) metreradians; and

after correction for free surface effects, the initial metacentric height (GM) must not be less than 0.35 metres:

the angle of heel must not exceed 10° when any one of the following capsizing moments is applied, or 15° when the worst two capsizing moments are applied together -

(aa) the passenger crowding moment; and

(bb) the wind heeling moment; and

(cc) the rudder heeling moment when turning:

the righting lever GZ, at the intersection of the curve of righting levers and the heeling lever curve (determined from the combined effects of passenger heel and the more severe of either wind or rudder heel), must not exceed 0.6GZ max:

the area under the curve of righting levers above the passenger heeling lever curve taken up to the downflooding angle θd or the second intercept with the righting lever curve (whichever is less), must not be less than one quarter of the total area under the curve of righting levers up to the downflooding angle θd or the second intercept with the righting lever curve (whichever is less):

the passenger crowding, wind and rudder moments must be determined as follows -

(aa) the passenger crowding moment must use a standard mass per person of 75 kgs, and distribution of 4 passengers per square metre. The centre of gravity of a standing person must be taken as 1 metre above the deck and a seated person as 300 mm above the seat.

(bb) the wind heeling moment must be derived from the equation -

M = 0.000102 PAh tonnes metres

Where

P = gusting wind pressure in Pascals determined from the following table

Operating Limits	Wind Pressure
Offshore/Coastal	500 Pa
Restricted Coastal	450 Pa
Restricted Limits	350 Pa

A = projected area of ship above waterline in metres^2

h = vertical distance between centroid of A and that of lateral underwater area in metres.

(cc) The rudder heeling moment when turning is derived from the formula -

$$\frac{0.0053\ V^2\ \Delta d}{L} \quad \text{tonnes metres}$$

where
V = service speed in knots
L = waterline length of ship in metres
Δ = displacement in tonnes
d = vertical distance between centre of gravity of ship and centroid of lateral underwater area of ship in metres.

This formula only applies to ships where $V/\sqrt{L}$ is less than 4.

Appendix 2

Milford Sovereign and *Fiordland Navigator*

November 2001	*Fiordland Navigator* launched in Bluff
September 2003	*Milford Sovereign* launched in Bluff
21 February 2004	*Milford Sovereign* loss of control
30 September 2005	*Milford Sovereign* loss of control
20 November 2005	*Milford Sovereign* loss of control
23 November 2005	Real Journeys imposes upper operating limit on the *Milford Sovereign*
5 December 2005	Meeting at Te Anau re control issues
22 December 2005	Independent naval architect contracted to determine the veracity of the *Milford Sovereign* stability booklet
11 January 2006	Independent naval architect's report into the *Milford Sovereign* stability booklet received
19 January 2006	Independent naval architect contracted to look into the directional control of the *Milford Sovereign*
21 January 2006	Solid lead ballast loaded into the *Milford Sovereign:* 10 tonnes forward and 12 tonnes aft
31 January 2006	3 tonnes of ballast removed from bow area
7 February 2006	Removal of upper operating limit for the *Milford Sovereign*
14 February 2006	Independent naval architect report into the directional control of the *Milford Sovereign* received
22 March 2006	*Milford Sovereign* manoeuvring trials carried out
April 2006	Third independent naval architect contracted to look into stability booklet and directional control of the *Milford Sovereign*
8 July 2006	*Fiordland Navigator* loss of control
21 July 2006	Third independent architect report into stability booklet and directional control of the *Milford Sovereign* received
July 2006	*Milford Sovereign* taken out of service prior to docking in Bluff. Remaining 19 tonnes of lead ballast removed
August 2006	*Milford Sovereign* non-structural keel bar fitted in Bluff
13 September 2006	*Milford Sovereign* inclining test completed
26 October 2006	*Milford Sovereign* manoeuvring trials carried out

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

06-205	fishing vessel, *Lady Luck*, collision and subsequent foundering, Motiti Island, Bay of Plenty, 23 June 2006
06-203	fishing vessel *Venture*, grounding, Tipi Bay, Tory Channel, 19 April 2006
05-211	container ship *Spirit of Resolution,* collision with bridge, Onehunga, 8 October 2005
05-210	restricted limit passenger vessel *Milford Mariner*, engines' stall resulting in grounding, Harrison Cove, Milford Sound, 18 September 2005
05-208	passenger freight ferry *Santa Regina*, near grounding, Tory Channel eastern entrance, 9 June 2005
05-207	freight and passenger ferry *Santa Regina* and private launch *Timeless*, collision, off Picton Point, Queen Charlotte Sound, 2 May 2005
05-206	passenger/freight ferry *Arahura*, loss of propulsion, Cook Strait, 24 April 2005
05-205	restricted limit passenger vessel *Black Cat*, control cable failure and collision with rock wall Seal Bay, Akaroa Harbour, 17 April 2005
05-202/204	passenger freight ferry *Aratere*, steering malfunctions, Wellington Harbour and Queen Charlotte Sound, 9 February and 20 February 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

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