The Bahamas Maritime Authority

THE COMMONWEALTH OF THE BAHAMAS

"m.v. Marco Polo"

IMO Number 6417097

Official Number 716438

Report of the marine safety investigation into a passenger fatality following a large wave strike off Ouessant (Ushant) on February 14th 2014

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

It should be noted that the Bahamas Merchant Shipping Act, Para 170 (2) requires officers of a ship involved in an accident to answer an Inspector's questions fully and truly. If the contents of a report were subsequently submitted as evidence in court proceedings relating to an accident this could offend the principle that individuals cannot be required to give evidence against themselves. The Bahamas Maritime Authority makes this report available to any interested individuals, organizations, agencies or States on the strict understanding that it will not be used as evidence in any legal proceedings anywhere in the world.

Date of Issue 27th October 2014

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Glossary

DNV – Det Norske Veritas

GMDSS – Global Maritime Distress and Safety System

ICLL – International Convention on Load Lines

OOW – Officer of the Watch (officer in charge of a navigational watch)

Sécurité, Sécurité, Sécurité – phrase preceding a safety message for all-ships in a geographical area

Side scuttle - round or oval openings with an area not exceeding 0.16 square metres. Round or oval openings having areas exceeding 0.16 square metres should be treated as windows (LL Unified Interpretation)

Significant Wave Height (H_s) – the average height of the highest one third of all waves

SOLAS – International Convention on the Safety of Life at Sea

STCW – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

STCW II/1 – Mandatory minimum requirements from certification of officers in charge of a navigational watch on ships of 500 gross tonnage or more

STCW II/2 – Mandatory minimum requirements from certification of masters and chief mates on ships of 500 gross tonnage or more

STCW IV/2 – Mandatory minimum requirements for certification of GMDSS radio officers

Storm cover - fitted to the outside of windows, where accessible, and may be hinged or portable (LL Regulation 23(1))

TSS – Traffic Separation Scheme

Window – rectangular openings generally, having a radius at each corner relative to window size in accordance with recognized national or international standards, and round or oval openings with an area exceeding 0.16 square metres (LL Unified Interpretation)

1. SUMMARY

1.1. This investigation has been carried out in accordance with the International Maritime Organization's Casualty Investigation Code (Resolution MSC.255(84)), as required by Regulation IX-I/6 of the International Convention on the Safety of Life at Sea, for the purpose of identifying any safety improvements which may need to be made to prevent such incidents in the future.

1.2. The Bahamas-registered passenger cruise ship Marco Polo was on the final leg of a 42-day roundtrip cruise from Tilbury, London, when it departed Ponta Delgada, Azores, on the 11th February 2014. The voyage plan indicated a four day pilot-to-pilot passage of 1502 nautical miles.

1.3. Prior to leaving the Azores the Master and navigating officers assessed weather forecast information for the planned route and noted the transit of a series of low pressure areas and associated storm conditions through the western approaches to the English Channel.

1.4. A plan was developed with the intention of entering the English Channel between the transit of two depressions and the ship departed Ponta Delgada earlier than scheduled in its original itinerary to make this weather window.

1.5. On the evening of the 13th February an alteration was made to the voyage plan to change course to use the "off Ushant" TSS. It is understood that this was intended to make use of the shelter provided against prevailing weather by the Brittany peninsula. The original voyage plan had the ship turning eastwards into the English Channel at a point much further north than the "off Ushant" TSS.

1.6. While conditions were generally as forecast for the first two days of the passage a significant deterioration in the weather was experienced during the early hours and into the morning of the 14th February with wind and sea conditions in excess of those seen on the weather forecast information available at departure. Throughout the voyage the ship's course and speed were actively managed by the navigating officers with the aim of ensuring the safety of the ship and minimising discomfort to passengers.

1.7. On the 14th February 2014 the wind speed (reported as 70 knots) encountered by the ship exceeded "hurricane Beaufort Scale". At 13:05 hours GMT the ship was hit on its starboard side by a significantly large wave while at a position approximately eight nautical miles from the entry point to the north-east bound traffic lane of the "off Ushant" TSS.

1.8. The wave strike resulted in two window panes being shattered and two window panes being dislodged intact. These windows were located in the side shell at Deck 6 in way of the Waldorf Restaurant.

1.9. Sixteen passengers and crew members were injured as a result of this event. The 19mm thick glass broke into pieces of up to 25 cm^2 in area and scattered up to 10m into the Waldorf Restaurant with a speed sufficient to cause impact scratches to bulkhead-mounted mirrors and other surfaces. Many of the injuries consisted of cuts from flying glass but two passengers suffered more serious injuries. One of these passengers was evacuated to a medical facility by helicopter; the other suffered an extremely serious head injury and was declared deceased on board.

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2. DETAILS OF INVOLVED VESSEL(s) AND OTHER MATTERS

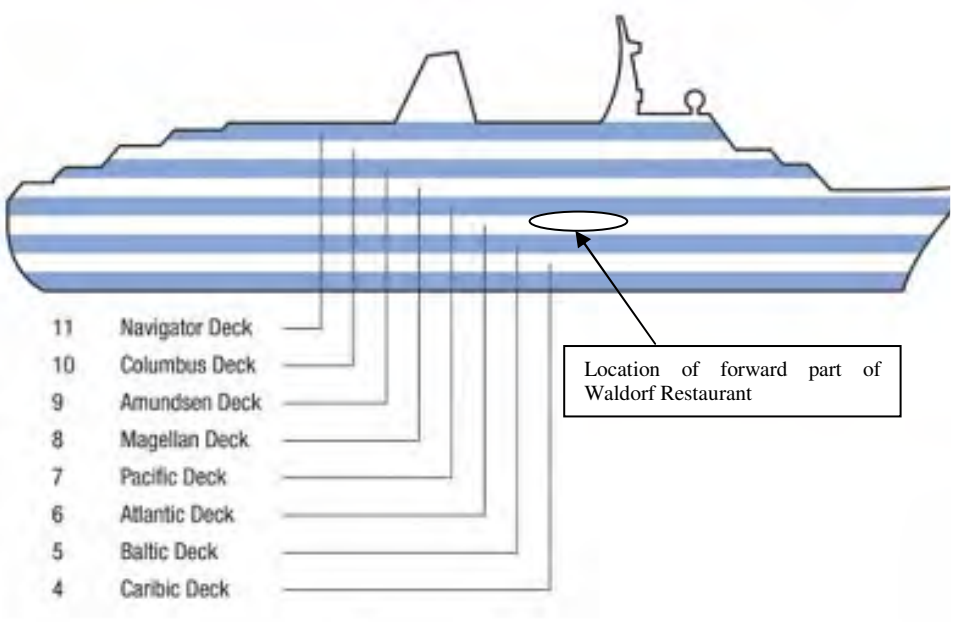
2.1. The mv Marco Polo is a cruise passenger ship which has been registered under the flag of the Commonwealth of The Bahamas since 1991. Principal details as of February 2014 were as follows:

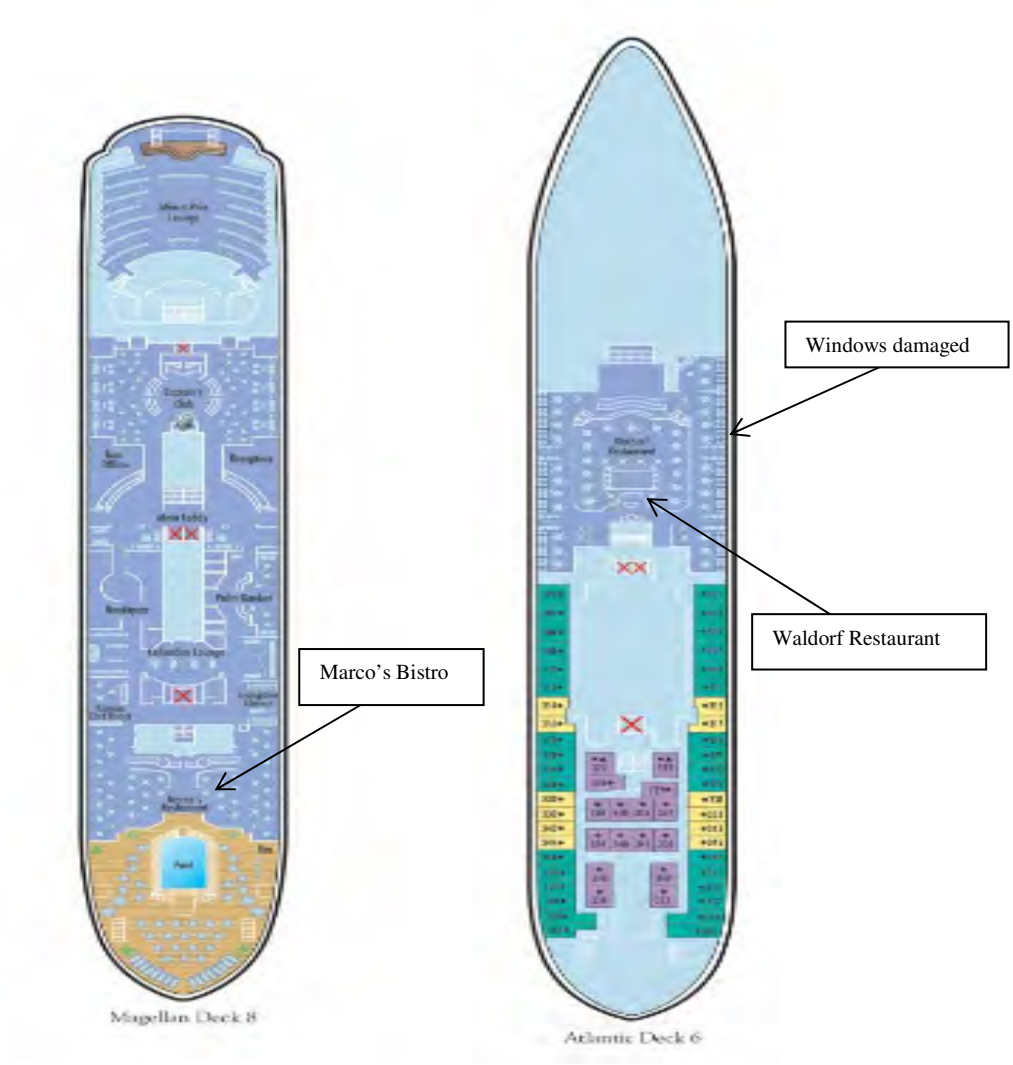
IMO Number	6417097
Date of Build	August 1968
Builder	VEB Mathias-Thesen-Werft, Wismar, (East) Germany
Re-build	Greece, 1993
Previous names	Aleksandr; Alexandr Pushkin
Tonnage	22080 (Gross) 5180 (Deadweight)
Length (overall)	176.28m
Length (bpp)	155m
Breadth	23.6m
Depth	13.5m
Draught	8.6m
Class Society	Det Norske Veritas (DNV)
	Bureau Veritas (BV) (1991-2001)
Class Entry	September 2001
Class Notation	+1A1 ICE-1C Passenger Ship
Propulsion	2 Wartsila NSD 7RD76 diesel engines
Brake Shaft Power	15666 kW
Cruising speed	16.5 kt
Passenger cabins	425
Max. Passengers	800

2.2. The ship was originally constructed in the German Democratic Republic as a trans-Atlantic liner in 1968 and was altered to fit the needs of the cruise market in 1991. Passenger accommodation and public spaces are arranged over eight decks as follows:

Deck 4 “Caribic”	Thirty-four (34) passenger cabins
Deck 5 “Baltic”	Sixty-nine (69) passenger cabins; hospital
Deck 6 “Atlantic”	Sixty (60) passenger cabins; Waldorf restaurant
Deck 7 “Pacific”	One hundred and fifty-two (152) passenger cabins
Deck 8 “Magellan”	Marco’s Bistro, Nansen Card Room, Livingston Library, Columbus Lounge, Boutiques, Palm Garden, Main Lobby, Tour Office, Reception, Captain’s Club, Marco Polo Lounge; Swimming Pool
Deck 9 “Amundsen”	Fifty-eight (58) passenger cabins; Scott’s Bar
Deck 10 “Columbus”	Twenty-two (22) passenger cabins; Internet Café; Beauty Salon; Jade Fitness Centre
Deck 11 “Navigator”	Twenty-six (26) passenger cabins; whirlpools

2.3. The layout of these decks is shown below:





Deck 8 "Magellan" Deck 6 "Atlantic"

2.4. The ship is owned by Story Cruise Ltd, Monrovia, Liberia, and technical and safety management is performed by Global Cruise Lines Ltd, Piraeus, Greece which had been issued a Document of Compliance (DOC) under the International Safe Management (ISM) Code in August 2013 by the Bahamas Recognised Organisation Det Norske Veritas (DNV), based on the audit carried out in Piraeus by a DNV auditor in August 2013. The certificate was valid for five years until August 2018 subject to the necessary audits.

2.5. At the time of the incident the ship was operated under the brand of Cruise & Maritime Voyages (CMV) which is a niche cruise operator with two other sea-going ships of similar size to the Marco Polo: the Discovery (Bermuda) and the Astor (Bahamas).

2.6. The cruises offered by CMV generally depart from ports in the United Kingdom: Bristol Avonmouth, Leith, Greenock, Rosyth, Hull, Liverpool,

London Tilbury and Newcastle on Tyne and operate departures throughout the year.

2.7. The ship held valid statutory certification required under International Conventions. Of relevance to this investigation are the following certificates:

- Classification Certificate (Full Term) – issued by DNV at Høvik, Norway, on 6th February 2013.
- Passenger Ship Safety Certificate (Full Term) – issued by DNV at Antwerp, Belgium, on the 17th December 2013
- Load Line Certificate (Full Term) – issued by DNV on the 6th February 2013 following a renewal survey carried out at Antwerp between 7th November and 18th December 2012. The certificate was endorsed for Annual Survey at Antwerp on 12th December 2013.
- Safety Management Certificate (Full Term) – issued by DNV on 24th September 2013, at Warnemünde, Germany.

2.8. At the time of the incident the ship carried 735 passengers and a total crew complement 349 including 39 in the "deck" department and 32 in the "engine" department. The profile of the crew was multinational and the passengers were mainly of UK nationality.

2.9. The Safe Manning Document (SMD) was issued by the Bahamas Maritime Authority 22nd November 2004 and the ship was in compliance with this document in respect of Master, Chief Mate, and OOW, and in excess of requirements in respect of Category 1 and 2 Seamen. The navigating bridge was manned by OOW in a "four-on eight-off" three-watch system.

2.10. The Master of the ship was a 50 year-old Greek national who held national certification in accordance with the provisions of STCW II/2 and IV/2. The original certification was issued in June 2001 and most recently re-validated in February 2011. The Master also held an Endorsement, valid until February 2016, issued by the Bahamas Maritime Authority in May 2013 in accordance with STCW Regulation I/10. He had joined the Marco Polo as Master on 3rd October 2013. The Master did not hold a navigating watch but remained available to support any OOW whenever necessary.

2.11. The Navigating Officer (1st Officer) on the 4-8 watch was a 47 year-old Ukrainian national who held national certification in accordance with the provisions of STCW II/2 and IV/2. He held an Endorsement issued by the Bahamas Maritime Authority in accordance with STCW Regulation I/10 in November 2010. The Endorsement was valid until January 2015. He had joined the ship on 5th January 2014.

2.12. The 2nd Officer on the 12-4 watch was 28 year-old Ukrainian national who held national certification in accordance with the provisions of STCW II/2, V/2 and V/3. He held an Endorsement issued by the Bahamas Maritime Authority in accordance with STCW Regulation I/10 in November 2013. The Endorsement was valid until December 2016. He had joined the ship on 3rd October 2013.

2.13. The 2nd Officer on the 8-12 watch was a 40 year-old Romanian national who held national certification in accordance with the provisions of STCW II/1, and IV/2. He held an Endorsement issued by the Bahamas Maritime Authority in accordance with STCW Regulation I/10 in December 2013. The Endorsement was valid until December 2016. He had joined the ship on 15th December 2013.

2.14. In addition to the personnel detailed above the "deck" department of the ship was also provided with a Bosun, two Quarter-masters, seven Able Seamen, five Ordinary Seamen and four Deck Cadets.

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3. NARRATIVE OF EVENTS

3.1. All times are given as ship time (GMT).

3.2. The Marco Polo left the London International Cruise Terminal at Tilbury on the River Thames, England on January 5th 2014. The itinerary 42-day voyage was described as the "Annual Marco Polo Amazon Cruise" incorporating port calls at Amsterdam (Netherlands), Lisbon (Portugal), Funchal (Madeira), Mindelo (Cape Verde Islands), Santarem, Boca da Valeria, Manaus, Parintins, Alto do Cao, Santana/Macapa, (all Brazil), Iles du Salut (French Guiana), St George's (Grenada), Kingstown (St Vincent), Castries (St Lucia), Bridgetown (Barbados), Horta (Azores), Ponta Delgada (Azores) and Tilbury.

3.3. The ship arrived at Horta on the morning of 10th February 2014 for a scheduled seven-hour stay. The Master undertook a review of the weather forecast information at noon and noted the prospect of bad weather for the northern Bay of Biscay and the approaches to the English Channel during the scheduled arrival period. On review of the weather forecast information for the 14th February he identified a weather window, between the transits of two low pressure areas, which he judged would provide calmer conditions for the voyage through the northern Bay of Biscay into the more sheltered waters of the English Channel.

3.4. To facilitate this strategy he requested permission from the Designated Person at Global Cruise Lines (the Company) to depart from the next port, Ponta Delgada, three hours earlier than scheduled, and at a higher speed, with the intention of arriving in the area ahead of the forecast storm conditions associated with the second low pressure area.

3.5. The ship left Horta on the evening of the 10th February and arrived at Ponta Delgada on the morning of the 11th. Shortly after departure from Horta the Master made an announcement to alert passengers and crew to the fact that the ship would be departing earlier than scheduled from Ponta Delgada in view of the forecast bad weather. Following this announcement the Staff Captain sent a gale warning notification to Heads of Department on board.

3.6. During the stay at Ponta Delgada the Master called a meeting of navigating officers on the navigating bridge at 11:00 hours to review the passage plan for the voyage to Tilbury in light of the contents of the weather forecast obtained by the ship.

3.7. Following this meeting the Staff Captain briefed the Bosun and Deck Carpenters on the upcoming voyage including the weather conditions which were anticipated to be encountered. The Staff Captain also gave orders to the Safety Officer, Officers of the Watch, Bosun and the fire and safety patrol members to perform more frequent rounds and report any concerns to him. In addition he gave instructions to the Deck Carpenters to close cabin porthole deadlights on Decks 4, 5 and the forward part of Deck 6.

3.8. The ship departed from Ponta Delgada at 23:07 hours on the 11th February at which time the local weather conditions were reported as wind speed of 25-30 knots with a 4-5 metre swell. The departure draughts were 7.8m forward and 7.9m aft. Engine speed was set at 107 revolutions per minute, as previously agreed with the Company, against the original planned speed of 97 rpm. Shortly after departure the Master deployed the fin stabilisers in order to reduce ship movements.

3.9. At 18:00 hours on the 12th February, a meeting was chaired by the Master at which other senior officers including the Staff Captain, Safety Officer, Hotel Manager, Guest Service Manager and Cruise Director discussed preparations for encountering bad weather. Topics discussed included the securing of loose items of furniture on open decks; closing of deadlights on lower decks; closing watertight doors, hatches and other openings; dumping swimming pool water; minimising free surface effects in ship's tanks; calculation and maintenance of stability; checking lashing of lifeboats, liferafts and other life-saving equipment; making regular safety rounds and safety announcements; and restricting or preventing access to open decks and posting warning signs.

3.10. During the evening of the 12th and the morning of the 13th the ship made good progress on a course of 049º making a speed through the water of between 17.5 and 17.9 knots. The wind speed experienced during this period was Beaufort Scale 4-5 from the west-northwest to westerly direction while the barometric pressure dropped from 1016 mbar at midnight to 1013 mbar at midday. The bridge logbook notes that porthole deadlights in the cabins on Deck 6 aft were all closed at 09:00 hours.

3.11. Wind and sea conditions remained largely stable until mid-afternoon on the 13th at which time the barometric pressure began to fall more quickly. At 13:00 hours the pressure was recorded as 1012 mbar but by 18:00 hours this had dropped to 1000 mbar. While the wind speed remained unchanged at Beaufort Scale 5 during this period the direction continued to change in an anticlockwise direction from west to south. The ship was now on a heading of 051°, in accordance with the voyage plan, at a speed of 17.7-18 knots.

3.12. Through the evening of the 13th the barometric pressure continued to drop until, by midnight, it stood at 991 mbar. Concurrently the wind speed increased to Beaufort Scale 8 from the south or southwest. At 20:00 hours, at position 45º 59.9'N 012º 06.1'W, the heading was changed from 051º to 059º to place the ship on a track to enter into the "off Ushant" TSS northeast bound traffic lane.

3.13. This was a significant change from the original voyage plan. The original plan, as provided to the investigation, did not take the ship through the "off Ushant" TSS but took a path further north to 49º 20'N, 006º W followed by a course change to head 076º up the English Channel. While it is reasonable to conclude that this change was made in order to take advantage of the shelter offered by the Brittany peninsula to the weather coming from the south-westerly direction and while this has not been confirmed to the investigation team it is consistent with communications sent from the ship (see 3.17 below).

3.14. At 19:45 hours, prior to making this course change, the Master made a public broadcast safety announcement to advise passengers that weather conditions and forecasts had been closely monitored during the course of the voyage since the departure from Ponta Delgada and that stronger winds and heavier swells were expected after midnight. Passengers were advised to take extra care when moving around the ship and to avoid using open decks. For the information of interested passengers weather maps were posted on the Navigational Chart mounted in the Reception area and passenger lifts were shut down for safety reasons.

3.15. In the early hours of the 14th February the Master remained on the bridge to support the Officer of the Watch until around 03:00 hours when he returned to rest in his cabin in the knowledge that the Navigating Officer would take over the watch at 04:00 hours. Between 00:00 and 06:00 the barometric pressure continued to drop to 982 mbar and the wind speed increased Beaufort Scale 8 to Beaufort Scale 11 (37 knots to 60 knots).

3.16. At 07:28 hours the engine speed was reduced to 97 rpm, following a request from the Chief Engineer, as engine "racing" was being experienced as a consequence of the propellers emerging from the water due to the rolling and pitching motion of the ship. This reduction was made to protect the engines against damage, but resulted in a drop in ship speed from 17 knots to 15.5 knots.

3.17. At approximately 08:45 (computer clock indicated 10:45) the Master sent an email to the Company regarding the bad weather. This message stated that the ship was almost 80 miles from the "off Ushant" TSS and that winds were blowing at up to 70 knots with a swell from the south-west of up to 7 metres. The reduction in engine speed was reported along with the decision to maintain speed and enter the English Channel as

soon as possible for the comfort of passengers and crew. The temporary closure of Marco's Bistro was also reported.

3.18. By this time the effect of the increasingly strong wind, now coming from the south-westerly to southerly direction at Beaufort Scale 10/11 (52 to 60 knots), on the ship resulted in a highly variable heading as the stern of the ship was pushed to port. Consequently steering was taken off auto-pilot onto hand steering with a second steering motor being brought into use to maintain the desired course.

Photograph of conditions in the early morning of the 14th February – looking forward

Photograph of conditions in the early morning of the 14th February – looking aft

3.19. During this period the Master returned to the navigating bridge to support the 2nd Officer holding the 8-12 watch.

3.20. Barometric pressure continued to drop to stand at 977 mbar by 12:00 hours when the reported wind speed was Beaufort Scale 11 from a south-westerly direction. Sea conditions were assessed as being 8 to 9 metre waves with heavy spray.

Photograph showing the deteriorating conditions late morning

Looking aft starboard from bridge deck – around midday 14th February

3.21. Passenger safety announcements were made at 09:45 hours and 12:00 hours by the Cruise Director and at 10:20 hours by the Guest Service Manager. These messages communicated the need for passengers to take care when moving around the ship and the fact that Marco's Bistro on Deck 8 was closed for safety reasons. Scott's Bar located in the aftermost section of Deck 9 had also been closed to passengers at the suggestion of the Safety Officer following an earlier fall of a passenger and noting that there was a risk of more serious injuries because furniture was not fixed down. The closure of Marco's Bistro and Scott's Bar resulted in the exclusive use of the Waldorf Restaurant for passenger meal service.

3.22. After the change of watch at 12:00 hours, at position 48º 20.4' N 006º 26.3' W, the incoming OOW completed a Heavy Weather Checklist and continued with hand steering using two quartermasters who were on alternating 30 minute duty periods. Keeping the ship on a constant heading of 059º was becoming increasingly difficult due to the effect of the wind and waves on the starboard quarter of the ship which was tending to rotate the stern towards port and the heading towards starboard. This required heavy port helm movements to try to bring the head back around to the desired course of 059º.

3.23. Between 12:00 and 13:00 hours conditions deteriorated further as the barometric pressure continued to fall. The wind speed was measured as 70 knots from the south-west with 10 metre seas. The rolling motion of the ship was estimated to be 15º each way. At 13:00 hours the ship was at 48º 28.5' N, 006º 08.9' W, at which point the OOW called Ushant ((C.R.O.S.S. Corsen / Regional Operations Centre for Monitoring and Rescue at Corsen OUESSANT TRAFIC) to submit the required report prior to entry into the TSS.

3.24. Meanwhile the OOW noted that the heading of the ship was about 80º (course over ground was some 12º towards north), rather than the specified heading of 59º, due to the increasing effect of the wind on the starboard quarter of the ship. The helm was at this time generally at hard to port but the ship's rudder could not provide the necessary turning force to bring the ship back onto its desired course due to the effects of the waves and wind on the ship - despite the fact that the ship's speed remained at 15 knots over the ground and 14 knots through the water.

Video still of weather conditions looking to starboard from navigating bridge wing 14th February 2014

3.25. At 13:05 hours in position 48º 28.958' N, 006º 06.062' W the ship was struck by a wave which broke against the starboard side of the ship, causing a small amount of water to enter the bridge through gaps at the edges of the navigating bridge door located some 15 metres above the waterline. At this stage the helm was generally hard to port but the ship's head was slow to respond due to the adverse conditions and the heading was fluctuating around 085º.

3.26. The Master, who had felt the unusual impact, immediately returned to the bridge along with other officers. Within a minute a telephone call was received on the bridge to alert the Master to the fact that window damage had been experienced in the Waldorf Restaurant on Deck 6. The height of the lower sill of the windows in the Waldorf Restaurant is 6.5m above the waterline.

3.27. The Staff Captain, who was working in his office aft of the navigating bridge, and the Safety Officer, who was on Deck 6 en-route from the Officers' Mess to the bridge, were alerted to the situation in the Waldorf Restaurant by a VHF radio message from one of the Ship's Carpenters.

3.28. They went immediately to the restaurant to find that two panes of glass had been completely shattered, with pieces of glass of up to 25 cm^2 having been scattered up to 10 metres towards the centre-line of the ship, and two other panes dislodged from their positions and lying on the deck near a half-height partition some two metres from the ship side. A substantial amount of water had entered and wind and spray was entering the Restaurant.

Photograph of four displaced or shattered windows and securing arrangements (stated to have been taken directly after the wave strike)

Damage in Waldorf Restaurant

Video still – undamaged pane of glass being carried away

3.29. The Ship's Doctor was in the Hospital which is located on Deck 5 directly under the Waldorf Restaurant when the wave struck and he made his way up to Deck 6 immediately as the sound and sensation felt so unusual to him. On arrival he found several passengers and crew members suffering from cuts and other impact injuries and immediately started to deal with the most serious cases.

3.30. Meanwhile numerous other crewmembers had arrived in the Waldorf Restaurant and they proceeded to block the window openings with materials close to hand while the lightweight 8mm thick aluminium closing plates were retrieved from their storage location on Deck 6.

3.31. The Master requested the OOW to assess whether there were any Ports of Refuge which the ship could make for but in light of the weather conditions, size of the seas and the wind direction it was decided that making for any port in the conditions was not practicable.

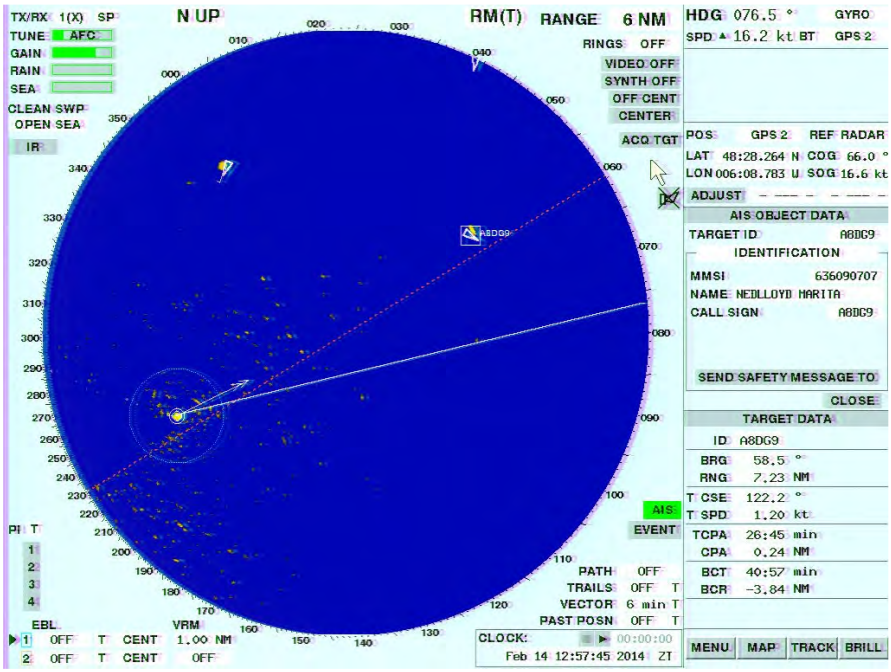
Video still illustrating crew efforts to block window openings

Video still – closing plate retrieved from store for fitting into opening

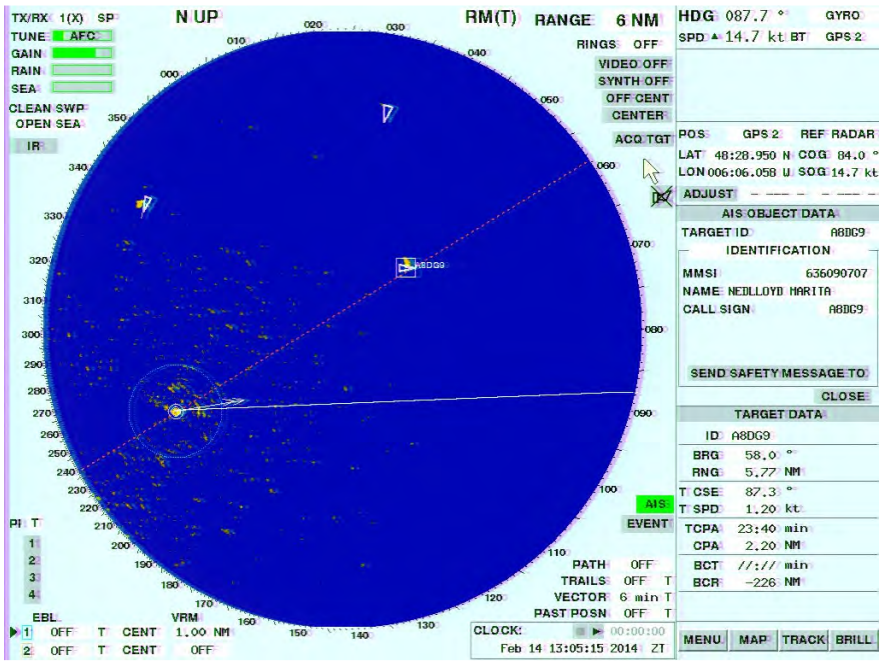
3.32. With the ship rolling to 15º, speed reduced to 11-12 knots and with steering hard to port the heading, while still highly variable, had altered to around 120º over the course of a minute between 13:08 and 13:09.

3.33. With the weather now almost beam on to the starboard side making the efforts to close the window openings extremely difficult, and unable to bring the ship course back around to the desired heading, the Master judged that the slow speed was making steering ineffective and ordered an increase in engine speed to 107 rpm. This increase had the effect of improving the steering effectiveness and the ship responded to the helm order and the heading of the ship was brought around to 030º to provide some shelter for crew working in the Waldorf Restaurant.

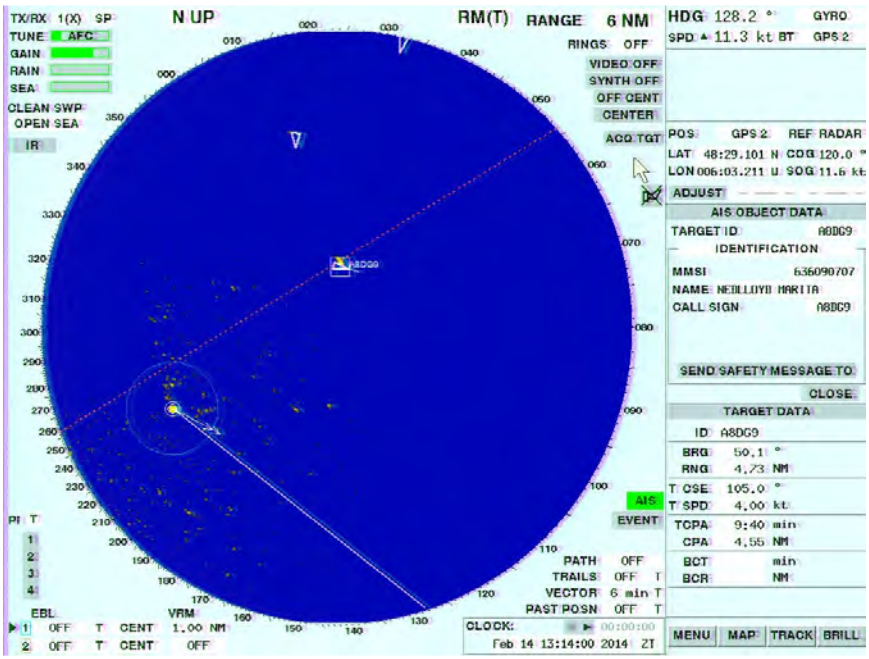
3.34. The following screenshots are taken from the Voyage Data Recorder and illustrate the effect of the weather on the heading of the ship from eight minutes before the wave strike until eighteen minutes after.



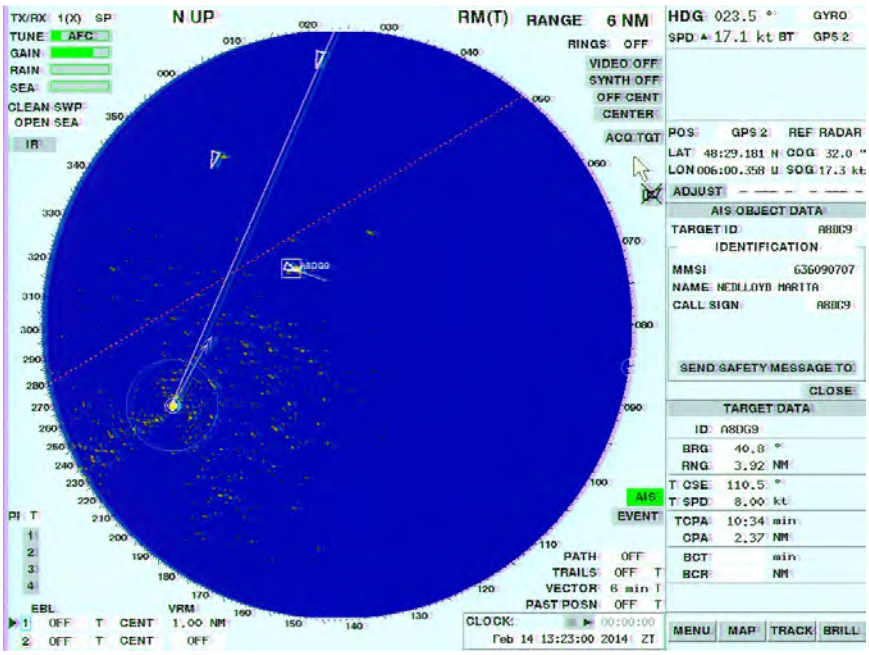
Situation at 12:57 – heading 076.5º while attempting to maintain 059º



Situation at 13:05 – ship heading being pushed to starboard and at 087.7º despite hard to port rudder angle



Situation at 13:14 – ship heading pushed further to starboard to the greatest extent of 128.2º



Situation at 13:23 – heading 023.5º after speed increase

3.35. A further passenger safety announcement was made at 13:30 hours requesting passengers to sit on the floor where they were and not to move around the ship due to the extreme weather being experienced. Passengers were prohibited from going outside and instructed to stay in their cabins.

3.36. At 13:35 hours, having made an initial assessment of the situation and rendered urgent assistance to the injured, the Doctor advised the bridge by telephone that one passenger was in a critical condition as a result of head injuries and requested that medical evacuation be arranged. The call to Maritime Rescue Co-ordination Centre MRCC Corsen was made at 13:40 hours requesting helicopter assistance for a medical emergency evacuation.

3.37. By 13:56 hours the aluminium closing plates had been secured to the four window openings in the Waldorf Restaurant and the ship was located in the separation zone between the traffic lanes of the "off Ushant" TSS. However, by 14:20 hours it had been steered to a heading along the line of the northeast bound lane.

3.38. Over the following 60 minutes, while the ship proceeded along the inbound lane, communications continued between the ship and MRCC Corsen to arrange the helicopter evacuation. By 14:30 it had been decided that a second passenger was in need of emergency medical evacuation and the ship advised MRCC Corsen accordingly. At 14:38 hours MRCC Corsen advised the ship that the helicopter arrival was anticipated for approximately 20 minutes later.

Scan of chart BA 2647 in use with GPS ship positions recorded – incident location lower left, helicopter evacuation top right

3.39. At 15:00 hours the ship was near the exit point from the TSS in position 48º 50.1'N, 005º 31.1'W. At 15:11 hours a safety announcement was made to alert passengers to the fact that the ship would have to turn to head into the wind to allow the helicopter evacuation operation to commence. By this time the swell was estimated to have increased to around 13 metres, with a wind speed varying between Beaufort Scale 10-12 (from 50 knots to above 60 knots).

3.40. At 15:15 hours the ship sent a Sécurité, Sécurité, Sécurité safety message to alert any other shipping of the impending manoeuvre and turned onto a course of 220º at a reduced speed of 5 knots following the request of the helicopter pilot. Crew members prepared for the arrival of the helicopter by making ready the identified drop zone on the aft deck 8.

Crew member with fire hose awaiting helicopter arrival

3.41. By 15:35 hours a member of the helicopter crew had landed on board the ship to direct the operation. However, it was not possible for the doctor on the helicopter to land on deck – the sea conditions at this point were estimated as having increased to 15m swell.

3.42. The ship's doctor had made a decision as to which of the two passengers to disembark first. He considered that one passenger's injuries were not "compatible with life" and as a consequence the other should be given priority. The passenger with the better prognosis therefore embarked into the helicopter which then left the scene to fly back to a medical facility.

View astern - helicopter crew member on board

3.43. Taking into account the very high seas and winds being experienced, the ship movements with the ship heading into the weather, the fact that the ship was being pushed towards the mouth of the outbound lane, and the return time of 90 minutes for the helicopter, the Master took the decision to revert back to the original course and continue to make way into more sheltered waters in the English Channel. With the manoeuvre safely completed between 16:10 and 16:14 hours the ship resumed full speed at 107 rpm.

3.44. At 16:38 hours the ship received a call from MRCC Corsen requesting that the ship reduce speed and head for the coast of France to facilitate the helicopter return to pick up the second passenger. The Master judged that these two actions would place the passengers and crew in greater danger and declined the request. At around this time the Master was made aware of the reported loss of a large number of containers from the Svendborg Maersk in the vicinity and this was a further navigation risk which had to be taken into account. At 17:02 hours a similar request was made with a similar response. Meanwhile the ship maintained full speed on a course of 061º towards its destination.

3.45. The helicopter returned to the ship at 17:34 hours which had, by that time, turned into the weather again on a course of 220º at reduced speed. By 17:42 hours the ship was in position 49º 05.4'N, 005º 02.7'W making 2 knots in seas estimated at 10-20 metres. After a request from the helicopter the ship changed course to 240º in readiness for the evacuation. However, the second passenger, whose injuries had already been determined by the ship's doctor as "not compatible with life" was declared deceased by the ship's doctor at 17:50 hours.

3.46. After the member of the rescue team who had remained on board following the evacuation of the first passenger had been embarked back into the helicopter it departed back to its base at 18:00 hours. The ship prepared to turn back onto its course and completed that manoeuvre at 18:07 hours at position 49º 04.7 N, 005º 05.6 W. By 18:14 hours it was steering a course of 070º at full speed to reach its destination of Tilbury as soon as possible.

3.47. From 19:00 hours the barometric pressure began to rise slowly from 978 mbar attaining a pressure of 989 mbar by 00:00 on the 14th February. The wind speed remained at Beaufort Scale 11 until 22:00 hours before gradually decreasing to Beaufort Scale 9 by 00:00.

3.48. Over the remainder of the voyage to Tilbury the weather remained poor with wind speed remaining above Beaufort Scale 8 until 03:00 hours on the 15th February. The ship berthed at the London International Cruise Terminal at 22:35 hours.

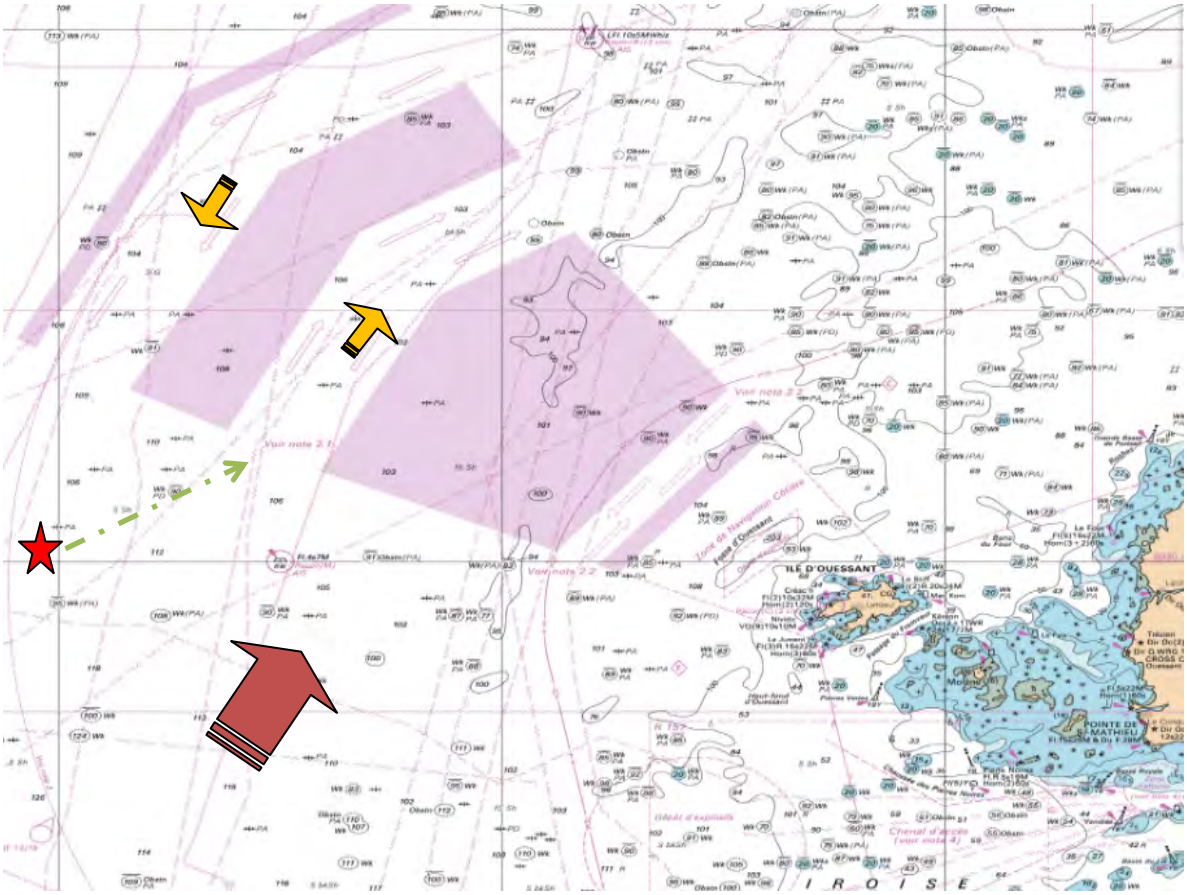


Chart showing approximate location of incident in relation to the coast of Brittany and "off Ushant" TSS, ship's course, traffic lane directions, and prevailing direction of weather[1]

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[1] *map from http://data.shom.fr/)*

4. ANALYSIS AND DISCUSSION

4.1. Voyage Planning

4.1.1. The planning of a voyage from berth to berth for safe navigation is a requirement under Regulation 34 of Chapter V of the International Convention on the Safety of Life at Sea (SOLAS) as follows:

> *1 Prior to proceeding to sea, the master shall ensure that the intended voyage has been planned using the appropriate nautical charts and nautical publications for the area concerned, taking into account the guidelines and recommendations developed by the Organization.*
>
> *2 The voyage plan shall identify a route which:*
>
> > *.1 takes into account any relevant ships' routeing systems;*
> > *.2 ensures sufficient sea room for the safe passage of the ship throughout the voyage;*
> > *.3 anticipates all known navigational hazards and adverse weather conditions; and*
> > *.4 takes into account the marine environmental protection measures that apply, and avoids as far as possible actions and activities which could cause damage to the environment.*
>
> *3 The owner, the charterer, or the company, as defined in regulation IX/1, operating the ship or any other person, shall not prevent or restrict the master of the ship from taking or executing any decision which, in the master's professional judgement, is necessary for safe navigation and protection of the marine environment.*

4.1.2. The Guidelines specified in sub-paragraph 1 of the Regulation are the International Maritime Organization's Assembly Resolution A.893(21) "Guidelines for Voyage Planning".

4.1.3. Voyage planning is also referenced in the mandatory standards contained in the Seafarers' Training, Certification and Watchkeeping (STCW) Code Part A-VIII/2 as follows:

> *PART 2 – VOYAGE PLANNING*
>
> *General requirements*

3 The intended voyage shall be planned in advance, taking into consideration all pertinent information, and any course laid down shall be checked before the voyage commences.

4 The chief engineer officer shall, in consultation with the master, determine in advance the needs of the intended voyage, taking into consideration the requirements for fuel, water, lubricants, chemicals, expendable and other spare parts, tools, supplies and any other requirements

Planning prior to each voyage

5 Prior to each voyage, the master of every ship shall ensure that the intended route from the port of departure to the first port of call is planned using adequate and appropriate charts and other nautical publications necessary for the intended voyage, containing accurate, complete and up-to-date information regarding those navigational limitations and hazards which are of a permanent or predictable nature and which are relevant to the safe navigation of the ship.

Verification and display of planned route

6 When the route planning is verified, taking into consideration all pertinent information, the planned route shall be clearly displayed on appropriate charts and shall be continuously available to the officer in charge of the watch, who shall verify each course to be followed prior to using it during the voyage.

Deviation from planned route

7 If a decision is made, during a voyage, to change the next port of call of the planned route, or if it is necessary for the ship to deviate substantially from the planned route for other reasons, then an amended route shall be planned prior to deviating substantially from the route originally planned.

4.1.4. The implementation of these requirements within the Company Safety Management System (SMS) is found in the Shipboard Operations Manual Vol II Rev.00 Section 2 “Preparing for Sea” Chapter 2 “Navigational Procedures (Departure)”. With regard to Voyage Planning the text of Appendix A “Departure Bridge Review” is relevant as it states that the passage plan must be ready, and approved by the Master, at least 12 hours prior to leaving port. Information which must be taken into account in passage planning is specified in the manual as: *“advice/recommendation in sailing directions; ship's draft effect of "squat" on under keel clearance in shallow water tides and currents; weather, particularly in areas renowned for poor visibility; available navigational aids and their accuracy; position/fixing methods to be used; daylight/night time passing of danger points; traffic likely to be*

encountered - flow, type, volume; any requirements for traffic separation/routing schemes."

4.1.5. Comparison of this section of the Shipboard Operations Manual with the Guidelines for Voyage Planning (A.893(21)) indicates that the author of the procedure did take account of the guidelines inasmuch as they include factors to be addressed both in the planning (Section 3 of the Guidelines) and the execution (Section 4 of the Guidelines).

4.1.6. There is a further reference to the Passage Plan in Section 3 "vessel at Sea" Chapter 1 "Navigational, VHF Communication and Bridge Procedures" paragraph 1.40 of which states "*Master must have a Passage Plan prepared by the Navigation Officer for every passage, which they must approve and make available for reference by all the Bridge watch keeping officers. (form VOY 1/1)*".

4.1.7. Such a form had been completed by the Navigating Officer for the voyage from Ponta Delgada to Tilbury. The form itself is undated and while information is provided regarding the identity of the preparer of the plan, and the fact that it has been approved by the Master, neither of these individuals are required under the Safety Management System to sign the form. Signatures of all the OOW are, however, included and the Navigating Officer has signed in the allocated place for the 4-8 watch.

4.1.8. Appended to the form VOY 1/1 is a Time Schedule printout from a Chartpilot 9320 Route Planning system showing a detailed set of 34 waypoints, tracks and distances. The printed notation shows the creation date as being 11.02.2014 while a signed hand-written note states "Created 10.02.14". The signature has been verified as that of the Navigating Officer.

4.1.9. The schedule from the previous voyage from Ponta Delgada to Tilbury, dated 28th January 2014 was also provided to the investigators. A similar number of waypoints are shown but a different track was taken for the two major components of the ocean passage (track distance 25.25 nm to "off Ushant" TSS). For the first 520 nautical miles the two passages maintained a similar planned course of 048.7º but at this point the passage plan for the voyage under investigation indicated a steering alteration to 51º whereas on the previous voyage passage the course alteration was to 55º. The difference in the plans was due to the fact that the previous voyage used the "off Ushant" TSS whereas the current voyage was planned to enter into the English Channel north of the TSS.

4.1.10. The existence of VOY 1/1 and the clear recording of course information and other navigational and communication requirements on navigation charts by the Navigating Officer and other OOW reflects active passage planning and monitoring. While interview data confirm this fact it was noted that the structure of the Shipboard Operations Manual is confused, and the content of the manual does not go into detail regarding all the

provisions contained in the IMO Guidelines. Some of the items contained in the guidelines which have not been transposed into the on-board procedures are: *draughts and under keel clearances; safe speeds and necessary alterations; areas of special environmental protection; positions where change in machinery status is required.*

4.1.11. In addition to the above there was no evidence that other IMO Guidance on navigating in heavy weather e.g. the "Revised Guidance to the Master for Avoiding Dangerous Situations in Adverse Weather and Sea Conditions" 11th January 2007 had been taken into account in the design of the procedures in respect of heavy weather operations.

4.2. Hours of rest and fatigue

4.2.1. Fatigue is widely acknowledged as a causal factor in maritime accidents and casualties. The requirements are set out in the 2010 Amendments to STCW Code under Section A-VIII/1 "Fitness for duty" as follows:

> *2 All persons who are assigned duty as officer in charge of a watch or as a rating forming part of a watch and those whose duties involve designated safety, prevention of pollution and security duties shall be provided with a rest period of not less than:*
>
> *.1 a minimum of 10 hours of rest in any 24-hour period; and*
>
> *.2 77 hours in any 7-day period.*

4.2.2. After examination of the required records, and from interviews with the OOW, the investigation found no evidence that fatigue was a contributory factor in this casualty. Up to the point of the incident all navigating watch-keepers met the requirements for hours of rest. The OOW were, for the whole passage, supported during their watches by a lookout, and when hand-steering was engaged two crew members took the helm on rotating short duty periods.

4.2.3. However, the Master undoubtedly attended on the bridge for time periods which exceeded the quoted requirements albeit that the application of A-VIII/1.2 appears to exclude the Master. While it is vital that the Master is properly rested this illustrates the difficulty of reconciling the need for rest with the Master's overriding authority and responsibility for safety – in particular when encountering extreme weather conditions.

4.2.4. The Master's decision to remain overtly available and present on the navigating bridge to support the more junior OOW is understandable and demonstrates the safety culture implemented on board.

4.3. Availability and use of meteorological information

It is indisputable that one of the critical aspects of voyage planning is the consideration of meteorological information. It was found that the ship

utilised two sources of information: PassageWeather.com and GMDSS (Inmarsat SafetyNET).

4.3.1. PassageWeather.com is a free marine weather resource which provides surface wind, barometric pressure and wave height forecasts for up to 180 hours ahead. For the first 48 hours ahead the forecasts are given in 3-hour intervals, for the next 24 hours ahead in 6-hour intervals and for the remaining 108 hours ahead in 12-hour intervals.

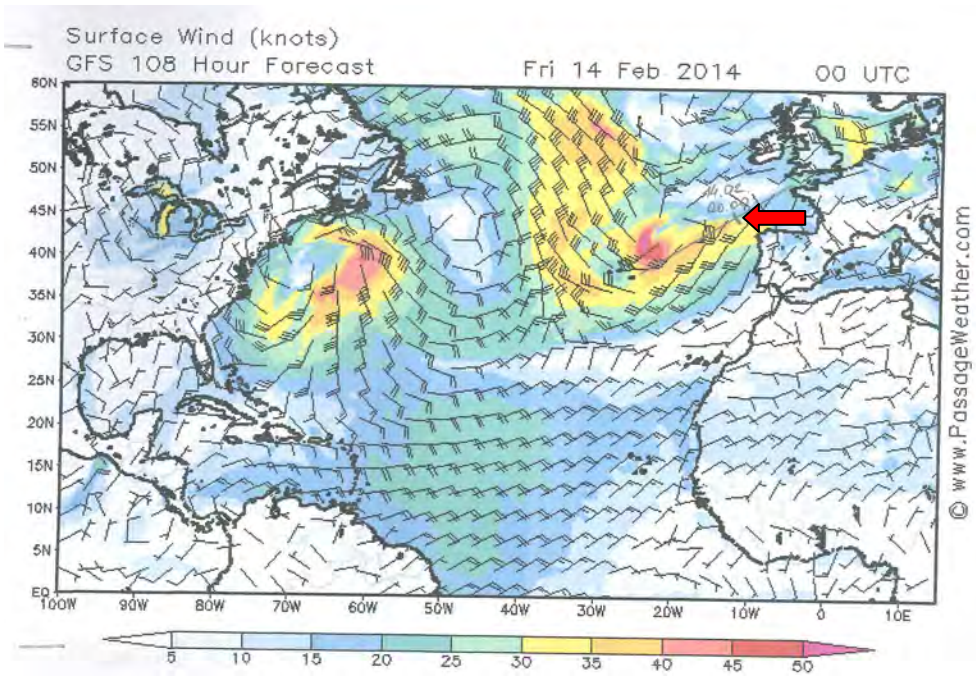
4.3.2. The website states that data used are obtained from official sources including the US National Weather Service (NWS), the National Oceanic and Atmospheric Administration (NOAA), the National Centers for Environmental Prediction (NCEP), the Marine Meteorology Division of the U.S. Naval Research Laboratory (NRL), Frivind AS and the Cyprus Oceanography Center.

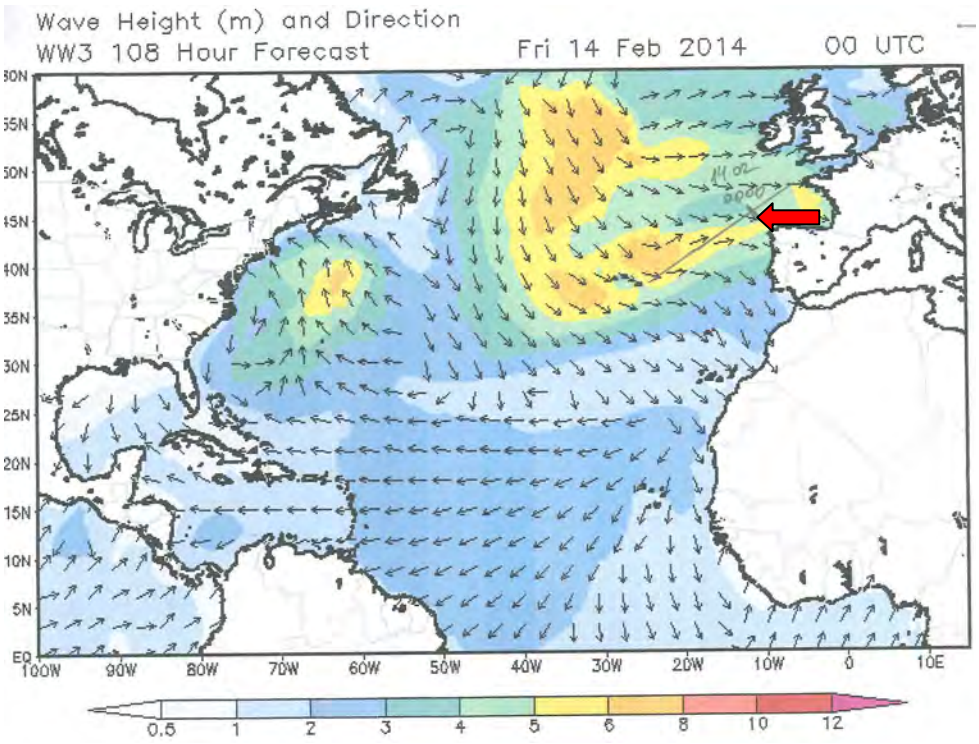
4.3.3. PassageWeather.com contains the following disclaimer regarding the use of its forecasts:

"These forecasts are produced from computer models and may not always reflect official forecasts, especially in the vicinity of weather fronts, tropical cyclones (tropical depressions, tropical storms, hurricanes, typhoons, etc.) or in rapidly changing conditions. As they contain no input from weather forecasters, it is important to check the official marine forecasts and warnings for your area when strong winds or tropical cyclones are forecast."

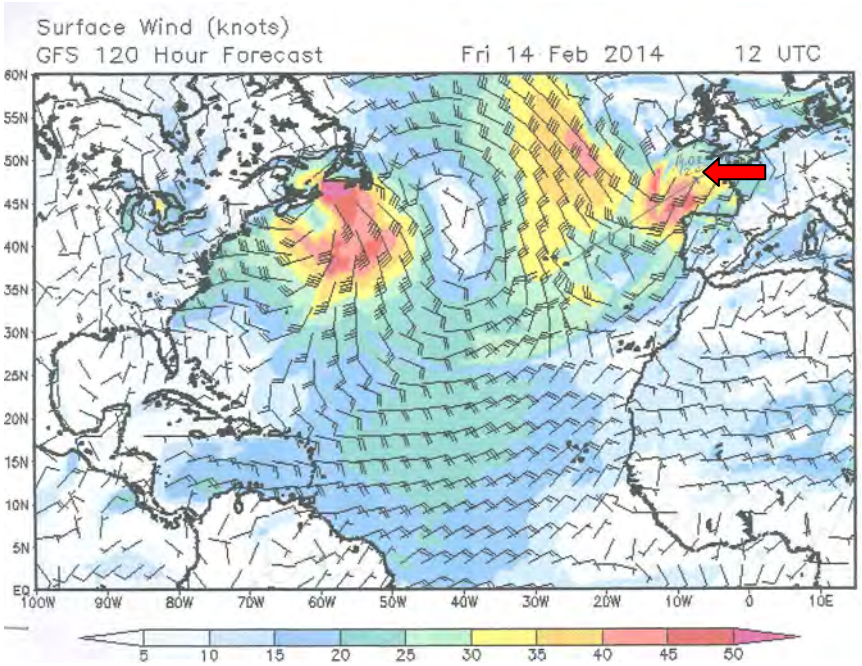
4.3.4. During interview the Master stated that he regularly used the PassageWeather.com website to obtain weather forecast information as it was, in his experience, usually very accurate and provided information in a very useable and practical form. Having made enquiries of other Companies operating passenger ships under the Bahamas flag it is noted that PassageWeather.com is a commonly used source of weather information and has a reputation as an authoritative source.

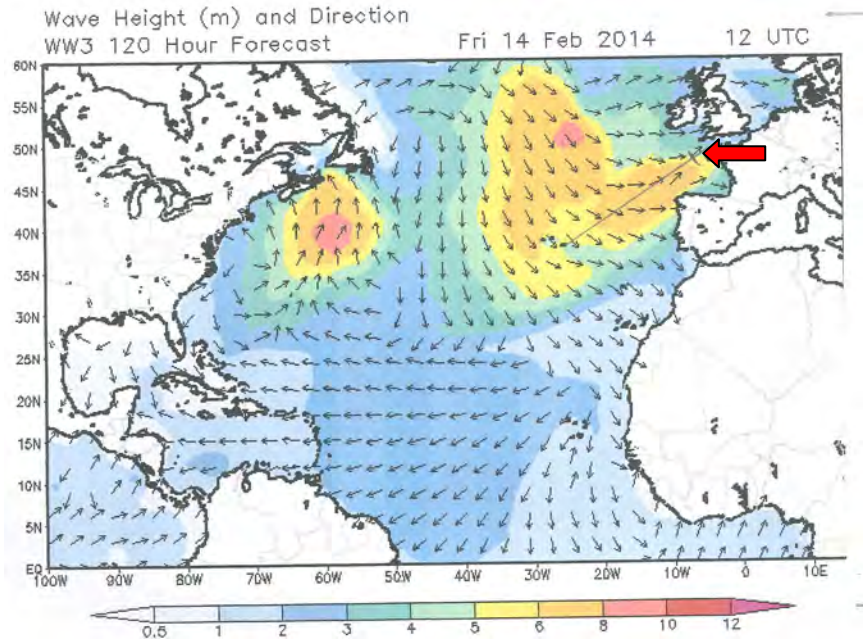
4.3.5. For the purpose of voyage planning the ship made use of the surface wind and wave forecasts issued by PassageWeather.com on the 9th February 2014. Hard copies were retained on board and had been marked with the approximate course and position at each 12 hour interval. The charts for the 14th February 2014 are shown below:





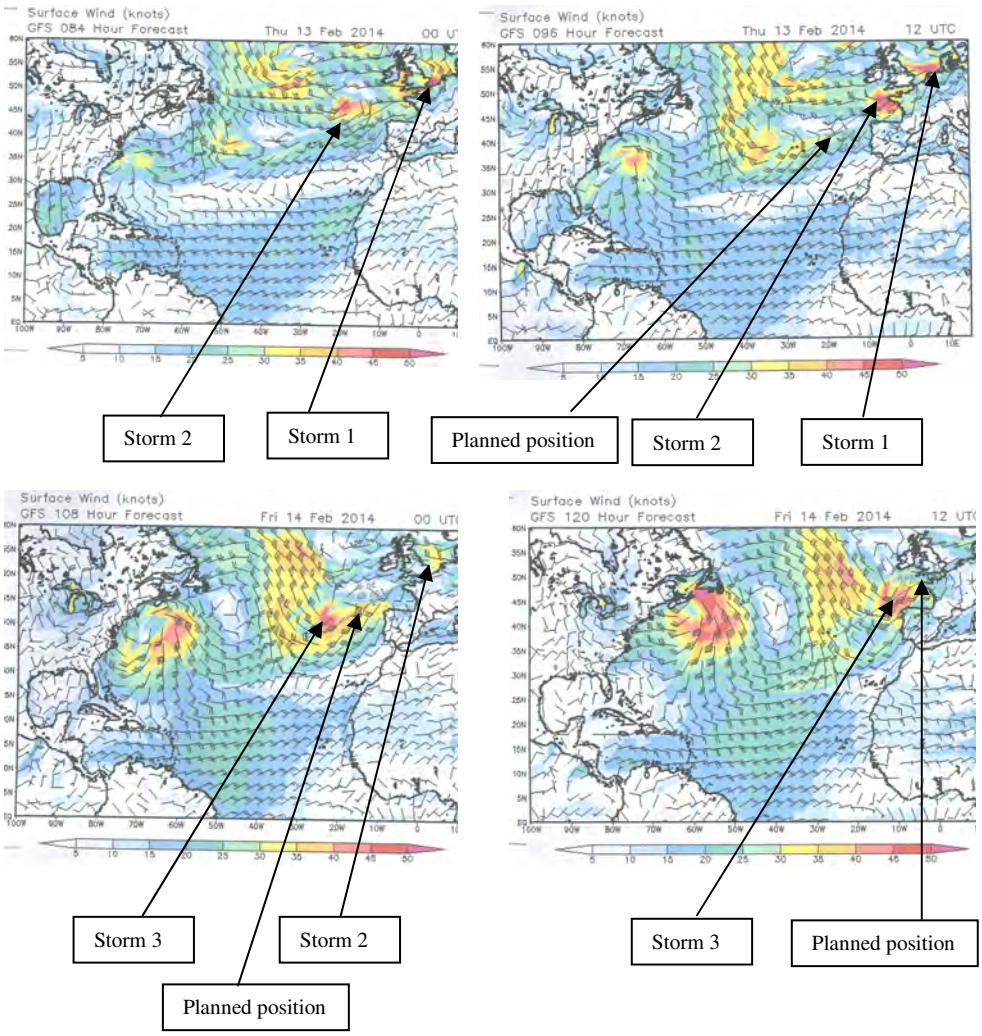
Wind and wave forecasts for 00:00 hours GMT 14th February 2014
(anticipated ship position indicated with arrow)





Wind and wave forecasts for 1200 hours GMT 14th February 2014

4.3.6. The strategy adopted by the ship in light of the forecast can be illustrated by the wind forecast charts as shown below:

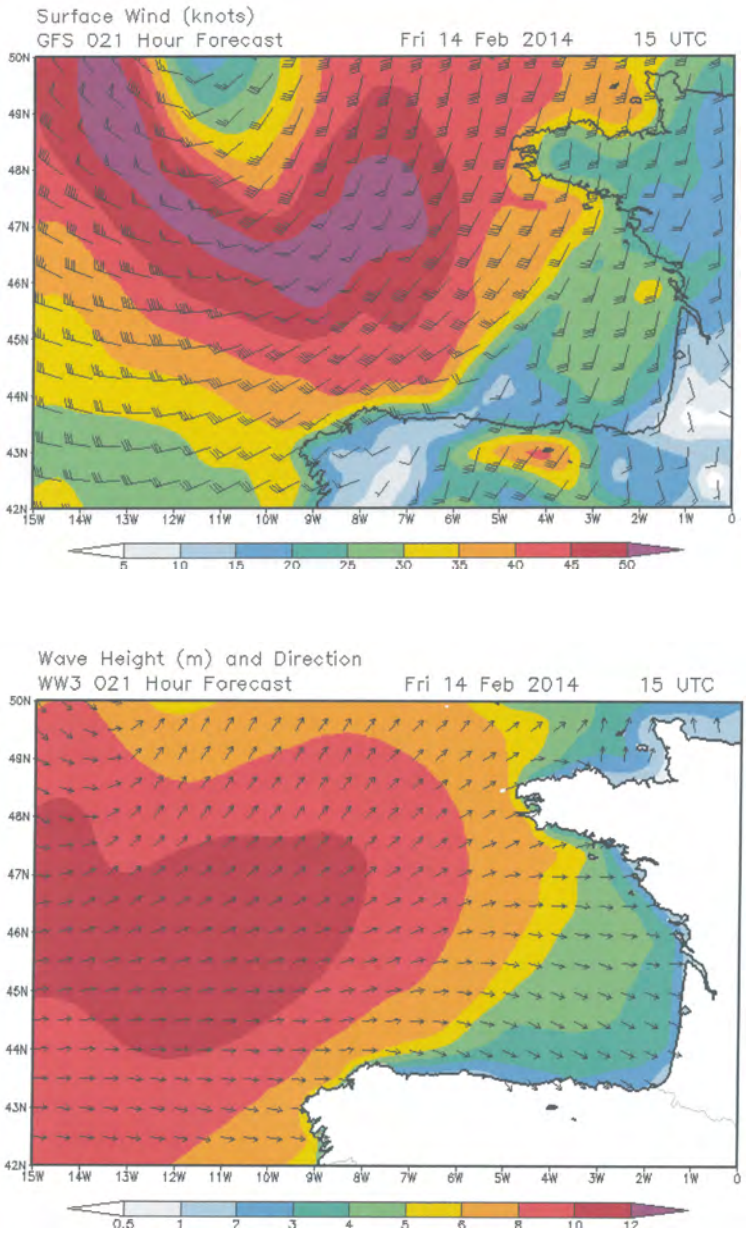


Wind forecast charts used in passage planning - 0000 GMT 13th February to 1200 GMT 14th February

4.3.7. The charts indicate the forecast transit of three storms through the region on the 13th and 14th. The strategy adopted by the ship was to proceed into the English Channel behind the high wind area associated with "Storm 2" and in advance of the high winds associated with "Storm 3" which were, at 1200 GMT on the 14th February, forecast to be centred to the northwest of Cape Finisterre, Spain. At this time the ship was anticipated to be in the more sheltered waters of the English Channel and clear of the areas of highest wind speeds.

4.3.8. At the position indicated on the planned course for 12:00 hours the forecast surface wind speed was in the range 35-40 knots from the SSW direction with wave heights 5-6m from the W or SW direction. By this time, due to the increase in speed which had been decided prior to departure from Ponta Delgada, the ship was actually further along its passage and into the area where forecast surface wind speed was 35-40 knots from the SSW direction with wave heights of 4-5 metres.

4.3.9. Changes in the weather forecast were monitored throughout the passage and the strategy decided upon prior to departure from Ponta Delgada was originally maintained except for the reduction in engine speed to protect the propulsion machinery. The Master remained confident that the ship could maintain its position ahead of the worst of the weather albeit the forecast conditions would be more difficult than originally forecast as shown in the following charts showing the 21 hour forecast for 1500 GMT on the 14th February:



21-hour wind and wave forecast charts for 1500 GMT 14th February 2014(note shelter effect of Brittany peninsula)

4.3.10. At the speed which the ship had been making prior to the incident the anticipated position at 15:00 on the 14th February would have been well into the mouth of the English Channel in more sheltered waters. The wind direction was, by this time, forecast to have backed (anticlockwise) to a more southerly direction with a similar shift in wave direction. Wave height in the area was forecast to be up to 6 metres.

4.3.11. Inmarsat (SafetyNet)

The provision of meteorological service and warnings to international shipping is set out in Regulation 5 of Chapter V of SOLAS which states, inter alia, that Contracting governments undertake to carry out meteorological arrangements [to]:

> *…issue, at least twice daily, by terrestrial and space radiocommunication services, as appropriate, weather information suitable for shipping containing data, analyses, warnings and forecasts of weather, waves and ice. Such information shall be transmitted in text and, as far as practicable, graphic form including meteorological analysis and prognosis charts transmitted by facsimile or in digital form for reconstitution on board the ship's data processing system.*

4.3.12. For the passage from Ponta Delgada to the "off Ushant" TSS the ship was operating in METAREA II in which the Issuing Service for meteorological information is Meteo-France. Forecasts are broadcast in English at 1015 and 2215 GMT.

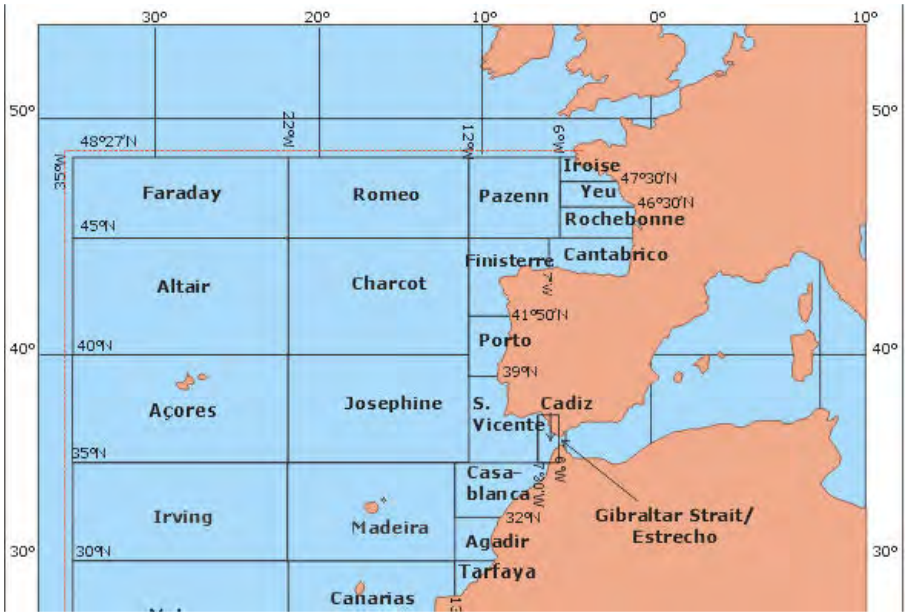


Illustration of METAREA II sea areas

4.3.13. Hard copies of the Meteo-France, Tolouse, broadcast at 10:15 hours and 22:15 hours GMT were retained on board and those from the period 10th to 14th February were examined. The issued forecasts comprise four parts: Part 1 containing Warnings; Part 2 containing the General Synopsis at midnight; Part 3 containing the Area forecasts up to mid-day on the following day (i.e. 24 hour forecast) and Part 4 outlook for the next 24 hours.

4.3.14. The forecast[2] contained in the 22:15 hours GMT broadcast on Monday 10th February to 00:00 GMT Wednesday 11th (i.e. mid-night on Tuesday) for the Açores sea area was for "*Southwest 6 or 7, locally 8 in north, decreasing south or southwest 5 or 6 soon. Gusts. Rough or very rough, crossed with NW swell. Rain in north.*"[3]. It should be noted that the use of the word "gusts" indicates that wind speeds may be up to 40% stronger than the given average. Furthermore maximum wave heights may be up to twice the significant wave height.

4.3.15. Forecast and conditions - 11th February 2014

By the time of the next forecast, at 10:15 GMT on Tuesday 11th February the forecast for the Açores sea area was for "*Southwest 5 or 6, at times 7 in north today. Gusts. Rough or very rough. W or NW swell 3m, slowly abating. Some rain*." Meanwhile the forecast for the Charcot sea area, which the ship would enter after leaving the Açores sea area, was "*Variable Clockwise 2 to 4, increasing Southwest 6 or 7 from west this evening, then veering Westerly at end. Gusts. Very rough, becoming cross by NW swell 3m. Rain and fog patches*."

4.3.16. The outlook for the next 24 hours was "*Persistence of West Near Gale over FARADAY, ALTAIR, ROMEO, CHARCOT, IROISE, YEU, ROCHEBONE, CANTABRICO, PAZENN, FINISTERRE. Threat of Southwest Near Gale from Wednesday night over ALTAIR, ACORES, JOSEPHINE and IRVING with threat of cyclonic Gale to Storm over ALTAIR and ACORES from Thursday midday*."

4.3.17. Interviews with navigating officers indicated that there was a wide awareness of the contents of the forecast which was used in the review of the passage plan during the meeting which was held on the morning of the 11th February.

4.3.18. The forecast (to Thursday 13 at 00 GMT) issued at 22:10 hours on Tuesday the 11th February, received just prior to departure from Ponta Delgada, found the forecast for the Açores sea area as "*Southwest 5 or 6. Gusts. Rough, locally very rough in far north. W or NW swell 3m. Some rain*." Meanwhile for Charcot, the sea area which the ship would enter

[2] In all cases where forecast text is quoted it is replicated exactly as it appears on the hard copy including capitalization and missing punctuation
[3] See Marine Forecasts terminology Appendix II for marine weather forecast terms

after leaving the Açores sea area (anticipated to be around 12:00 hours on the 12th February), the forecast was "*Southwest 6 or 7, at times 8 in the far north, veering West or Southwest 6 or 7 from west soon, increasing locally 8 in north later. Gusts. Very rough, locally rough in far north later, becoming cross by NW swell 3 or 4 m. Showers*."

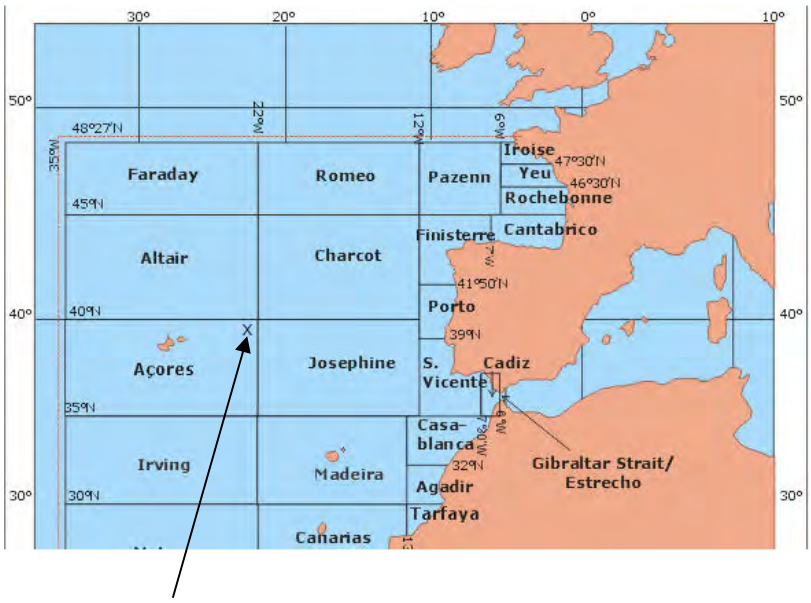
4.3.19. Therefore the weather which was anticipated to be encountered during the first day of the passage was wind speed of generally less than Beaufort Scale 8 ("gale"), but with some gusts above that. As the course of the ship was almost directly north-east the wind would be experienced as coming from astern. Since the islands of the Azores lie in the northern part of the sea area wave heights were anticipated to be generally 2.5m-4m with some local areas of 4m-6m. After crossing into Charcot the wind speeds were anticipated to be slightly higher, although remaining generally below Beaufort Scale 8. While the sea state would be initially very rough (4m-6m wave height) it is noted that in the north part of the area wave heights would be reducing within 12 hours.

4.3.20. It is also noted that the hard copy of this forecast has sea areas Pazenn and Iroise, Yeu highlighted. As the ship was not anticipated to enter into Pazenn until 20:00 hours on the 12th February this is indicative of an active process of looking ahead to further in the passage.

4.3.21. Forecast and conditions - 12th February 2014

At 11:00 on the Wednesday 12th February the ship had reached the north-eastern corner of the Açores sea area and was about to cross into sea area Charcot for a 26 hours traverse. The forecast for Charcot issued at 10:10 GMT to 12 GMT on Thursday 13th was "*West or Southwest 5 or 6, increasing 6 or 7 soon, locally 8 in north, decreasing Southwesterly 4 to 6 at end. Very rough, locally high in extreme north, cross by NW swell 4 to 5 m. Showers*."

4.3.22. The 24 hour outlook at this time noted "*Persistence of West or Southwest near gale or gale in all areas of the Bay of Biscay, decreasing temporarily, then threat of South or Southwest near gale or gale or storm in PAZENN and FINISTERRE at end. Threat of Cyclonic gale to storm over FARADAY, ROMEO, JOSEPHINE, ACORES; locally violent storm over ALTARI, CHARCOT and north of ACORES*."



Ship position 12:00 hrs GMT 12th February 2014 (north east corner of sea area Açores)

4.3.23. Forecast and conditions - 13th February 2014

The forecast from the 13th February at 10:10 GMT for the Pazenn sea area was "*West or Southwest 5 or 6, locally 7 at first, increasing Southwest 8 or 9 from southwest later, increasing 9 or 10 at end occasionally Cyclonic in northwest. Violent gusts. Very rough or high decreasing, becoming high then very high later and cross with NW swell. Rain and thundery showers*." By this stage the ship had reached the north-eastern corner of Charcot and would soon enter Pazenn.

Ship position 11:00 hrs GMT 13th February (north east corner of sea area Charcot)

4.3.24. In looking at weather behind the ship it is also noted that the forecast for Charcot at this time showed a significant deterioration in conditions "*Southwest 8 or 9 from west, increasing 9 to 11 soon locally Cyclonic in northwest, becoming Westerly 8 to 10 from south at end. Violent gusts. Very rough, becoming high later then very high and cross. Rain and thundery showers*."

4.3.25. The outlook for the next 24 hours at this time also showed a marked deterioration in the forecast: "*Southwesterly gale or severe gale over south of Bay of Biscay and severe gale in north. Cyclonic storm or violent storm over East of ROMEO, PAZENN. Northwest gale or severe gale over FARADAY, ROMEO, ALTAIR, CHARCOT. Southwest gale or severe gale over FINISTERRE, PONTO. Northerly near gale over ACORES, JOSEPHINE, IRVING, MADEIRA, METEOR, CANARIAS*."

4.3.26. The ship had, meanwhile, altered course from 049º to 051º at 06:00 hours as scheduled in the voyage plan. While the weather had generally been as anticipated through the previous 24 hours, perhaps slightly less stormy, the view of interviewees was that the ship was riding the weather safely and well – albeit that the motion of the ship was not entirely comfortable for passengers.

4.3.27. However, through the evening of the 13th February, and into the early morning of the 14th February weather conditions deteriorated significantly to the extent that the Master spent much of the period on the navigating bridge. The Official logbook shows that the recorded wind speed increased from Beaufort Scale 5 to Beaufort Scale 8 between 18:00 and 20:00 hours although the direction was maintained at Southwesterly to Southerly.

4.3.28. At 20:00 hours on the 13th February the course of the ship was altered to steer 059º, as marked on chart BA 4103 in use. This was an unplanned change from the original voyage plan which specified a course of 051º. There is no comment in the logbook associated with this deviation from the planned route but the conclusion drawn is that it was done to reduce the exposure to the prevailing conditions at the time when the original course alteration from 051º to 076º to enter the English Channel was planned.

4.3.29. The forecast issued at 22:10 GMT on the 13th February for Pazenn was "*Southwesterly increasing 8 or 9 at first, 9 or 10 soon, locally 11 in northeast later, then gradually decreasing 6 to 8 from west at end. Violent gusts. Very rough becoming high then very high soon. Rain then thundery showers*."

4.3.30. Forecast on 14th February

By the time of the next forecast, 10:15 hours GMT on the 14th February, the ship had reached a point at the very extreme north-east corner of the Pazenn sea area and was about to cross into the extreme south west corner of UK Met Office sea area Plymouth. At this stage the navigating officers were still taking the forecast for the Pazenn area into account while also looking at areas Iroise and Yeu directly to the east.

4.3.31. The METAREA 2 forecast for Pazenn at 10:15 GMT was "*Southwesterly 9 or 10, veering Westerly 8 to 10 soon, then decreasing gradually west 6 or 7 at end. Severe gusts. Very high becoming high later. Thundery showers." For Iroise and Yeu the forecast was "Southwesterly 8 or 9, temporarily 10 soon, decreasing 7 or 8 later, then 6 or 7 at end. Severe to violent gusts. High, becoming very high. Rain or showers, locally thundersqualls*."

4.3.32. Meanwhile the broadcast Shipping Forecast, issued by the UK Met Office at 0015 GMT on the 14th February contained the forecast for Plymouth sea area as being "*South-westerly 5 to 7 backing south-easterly 6 to gale 8 then veering south-westerly gale 8 to storm 10. Rain, moderate or poor." By the 0505 forecast this had become "South-easterly 6 to gale 8 veering south west gale 8 to storm 10 perhaps violent storm 11 later. Rain then squally showers. Moderate to poor*."

4.3.33. At 09:45 GMT the UK Met Office released a gale warning for a very large number of sea areas including that for Plymouth[4] which read "*Southerly severe gale force 9 veering southwesterly and increasing storm Beaufort Scale 10 imminent, increasing violent storm force 11 soon*". It is noted that a gale warning issued by the UK Met Office 24 hours previously contained no warnings for sea areas Sole, Fitzroy or Plymouth.

4.3.34. It is clear that the ship was actively monitoring the anticipated weather conditions from detailed area forecasts and from the general synopsis data for the sea area it was in and surrounding areas and was also monitoring actual weather data. This is evidenced by the fact that the positions and movements of a number of low pressure areas are marked on the large-scale navigation map in use for the voyage (4103 English Channel to the Strait of Gibraltar and the Arquipélago dos Açores - French Hydrographic and Oceanographic Service).

4.4. Training and competence requirements relating to meteorology

4.4.1. The STCW Code, Table A-II/2 sets out the "Knowledge, understanding and proficiency" requirements relating to the competence "Forecast weather and oceanographic conditions" as follows:

[4] Retrieved from http://home.weatheronline.co.uk/marine/weather

Ability to understand and interpret a synoptic chart and to forecast area weather, taking into account local weather conditions and information received by weather fax.
Knowledge of the characteristics of various weather systems, including tropical revolving storms and avoidance of storm centres and dangerous quadrants
Knowledge of ocean current systems
Ability to calculate tidal conditions
Use all appropriate nautical publications on tides and currents

4.4.2. The analogous requirements in STCW Code, Table A-II/1 are set at a less extensive level:

Ability to use and interpret information obtained from shipborne meteorological instruments
Knowledge of the characteristics of the various weather systems, reporting procedures and recording systems
Ability to apply the meteorological information available

4.4.3. While the Convention and STCW Code provide no guidance on instruction in meteorological matters two IMO Model Courses – 7.01 "Master and Chief Mate" and 7.03 "Officer In Charge Of A Navigational Watch" – do provide the expectation placed on training institutions and examiners regarding the range and level of competence.

4.4.4. The syllabus for Model Course 7.03 sets out the subject matters, and the recommended tile allocation) which should be covered at the OOW level as follows:

- *Shipborne Meteorological Instruments (5 hours)*
- *The Atmosphere, its Composition and Physical Properties (4 hours)*
- *Atmospheric Pressure (4 hours)*
- *Wind (8 hours)*
- *Cloud and Precipitation (4 hours)*
- *Visibility (5 hours)*
- *The Wind and Pressure Systems over the Oceans (10 hours)*
- *Structure of Depressions (12 hours)*
- *Anticyclones and Other Pressure Systems (6 hours)*
- *Weather Services for Shipping (5 hours)*
- *Recording and Reporting Weather Observations (6 hours)*
- *Application of Meteorological Information (10 hours)*

4.4.5. Model Course 7.01 builds on the fundamental knowledge delivered by Model Course 7.03 as follows:

Synoptic and Prognostic Charts and Forecasts From Any Source (6 hours)

- *interprets the isobaric patterns of a synoptic weather chart with interpolation and extrapolation as necessary*
- *determines the geostrophic and approximate surface wind speeds from the chart by use of the geostrophic wind scale*
- *determines the weather associated with specific places within the plots*
- *determines the likely movement of pressure systems,*
- *evaluates the use of prognostic charts*
- *evaluates the information given in shipping forecasts*
- *evaluates the information received from internet and email*

The Range of Information Available (3 hours)

- *lists the information available to the mariner in fax transmissions*
- *discusses the source of information relating to radio stations, and their transmissions*
- *evaluates the information given in surface synoptic and prognostic fax charts*
- *interprets the information given in wave charts*
- *evaluates the information given in ice charts*
- *evaluates the use of 500 hPa charts in forecasting the progress of depressions*
- *evaluates the value of personal observations of weather signs, in evaluating weather trends*
- *lists the information available to the mariner via internet and email*
- *evaluates the information received from internet and email*

Weather Forecasting (15 hours)

- *forecasts anticipated local weather from synopsis and prognosis information received, the movement of meteorological systems, knowledge of local influences, observation of local conditions and movement of own ship*

4.4.6. While the syllabi for these courses are comprehensive the delivery of the training, and its quality, depends upon the training institution. However, the proper delivery of the specified theoretical knowledge, and its assimilation, is supported by the experience, professionalism and performance of the officers on board. Two of the OOW and the Master had been examined for competence at the II/2 level and the other OOW at the II/1 level. All were considered to have a high level of understanding of the issue.

4.5. Weather aspects of the Safety Management System

4.5.1. In respect of the adherence of the OOW to the requirements contained in the Shipboard Operations Manual there is no evidence to suggest that this was anything other than complete. The voyage planning process clearly took into account available forecast information as is evidenced by the proposal to proceed at higher speed than originally planned. The unplanned course change also indicates a flexibility to react to the anticipated conditions and minimise the exposure of the ship to beam seas.

4.5.2. While it is the responsibility of the Master, inter alia, to ensure that a ship meets its operating schedule this must not over-ride safety considerations. The investigation found no evidence that the voyage-planning was anything other than safety-based, and no evidence was found of any pressure being placed on the Master to arrive at Tilbury at any particular time. In this respect the Company provided the Master with the appropriate support for his professional judgement in respect of commencing the voyage.

4.5.3. However, while the officers were very experienced and the Company supported the Master's decision to leave Ponta Delgada earlier than planned and at a higher speed, there was no evidence that the Company had a proactive weather management approach ashore. The Shipboard Operations Manual Vol II section 1.16 titled "Ocean Routing" describes actions to be taken <u>when</u> an ocean routing company has been appointed. Section 3.2 "Weather Forecasts Planning and Routing" states:

"During winter months your vessel may be offered the facility of weather routing on an advisory basis either at the request of the Master or at the discretion of the managing company."

4.5.4. No request was made in this case, and no assistance was offered. However, following enquiries of other passenger ship operators is was found that weather routing is generally utilised for trans-ocean crossings at high latitudes where weather conditions are anticipated to be poor but where the worst conditions may be avoided by route alterations. For the voyage in question route alteration options are more limited than would be the case with a trans-ocean voyage.

4.5.5. In no case in any other Company was the use of weather routing stated to be mandatory and, even when weather routing advice was given to a ship, Companies emphasised that the Master retained the overall responsibility and authority to safely navigate the ship.

4.5.6. In some larger passenger ship companies a more proactive approach is taken in monitoring developing weather situations – even, in some cases, when ships are alongside – but this is not common through the industry

sector. A small, but significant, number of passenger cruise companies operate out of northern European ports in winter months when bad weather can not only be anticipated but assured.

4.5.7. The Safety Management System should exist to support safe operations and on-board decision making. Accordingly the provision of active and authoritative weather information provisions, such as subscription services offered by Meteo France and the UK Met Office amongst others, may provide useful support to the Master and Officers.

4.5.8. While not a causal factor in this accident the investigation team noted what it considered to be fundamental weaknesses in the documented Safety Management System. In fact the conclusion was drawn that in some respects the documented procedures interfered with the professional management of safety and pollution prevention on board the ship by providing conflicting, irrelevant or inaccurate information. These concerns were immediately drawn to the attention of the flag State for action.

4.6. Weather conditions experienced on the 14th February 2014

4.6.1. The Master and the OOW involved in navigating the ship during the voyage were very experienced seafarers and watchkeepers. However, they all commented that the conditions on the evening of the 13th February through to the evening of the 14th February were the worst they had experienced in the course of their sea-going careers.

4.6.2. This perception is supported by the Master of the Bahamas ship "Fri Star" which encountered the "Marco Polo" on the 14th February during the period when it was manoeuvring for helicopter operations. His words paint a vivid picture:

"Weather condition this day: Wind increasing around from 10:30 lt. Gale 11 VIOLENT STORM direction SW, when come darkness is look more. Is real hell waves, in sea I twenty seven years Biscay cross app 30 times in my life I see this first time. And is very hard for "Fri Star", what we feeling all day and night unspeakable. We do not have any way[5] and we had passing waves all time. Wind decreasing only next day early morning"

4.6.3. During the same day the Danish-flagged container ship Svendborg Maersk lost 520 containers overboard at a position reported to be 48º 43 N, 05 58.8º W inside the southwestbound lane of the "off Ushant" TSS. Initial reports of the conditions from this ship placed the wind speed at Beaufort Scale 12 with 10m waves. The ship was also reported to be rolling 35°- 40° to each side. The World Shipping Council estimates that

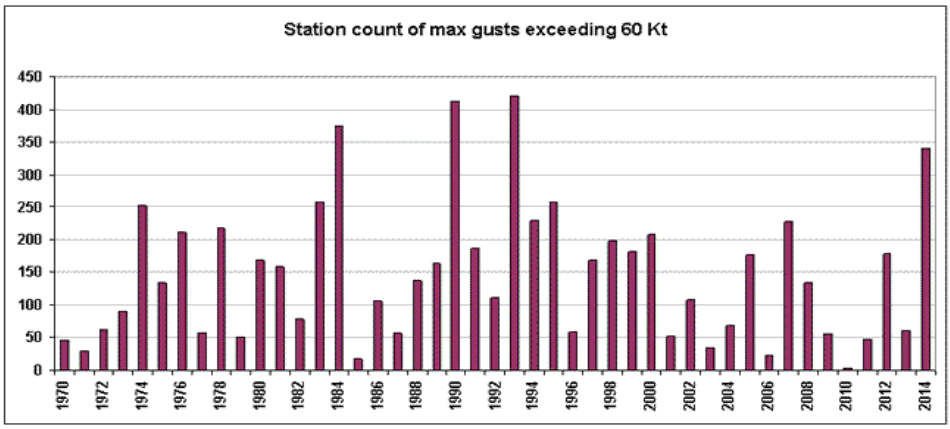
[5] "way" meaning that the ship was unable to maintain steering on its desired course due to the speed of overtaking waves exceeding the speed of the ship

the average annual figure for containers lost overboard is 350 so the loss of over 500 in a single incident is an extraordinary event.

4.6.4. The overall weather conditions during the winter of 2013-2014 were exceptionally poor. The UK Met Office determined that "*the period from mid-December to mid-February saw at least 12 major winter storms and, when considered overall, this was the stormiest period of weather the UK has experienced for at least 20 years*" and from late January to mid-February "*Around 6 major storms hit through this period, separated by intervals of 2 to 3 days*"[6].

4.6.5. The World Meteorological Organization also wrote: "*Between 1 and 13 February, six depressions developed over the Atlantic, impacting particularly on the UK and Ireland*"[7]. This weather has been attributed to an unusually strong jet stream which also followed a path much further to the south than usual. This meant that "*storms fell at a relatively low latitude, giving severe gales along the south and west coasts and pushing the bulk of the ocean wave energy toward the southwest of Ireland and England. Peak wave periods were exceptionally long; each wave carried a lot of energy and was able to inflict significant damage on coastal infrastructure*."[8]

4.6.6. While the period was the worst for 20 years it was also assessed as the fourth-worst since 1970 as shown by the following graphic[6]:



Count of stations recording maximum gust speeds exceeding 60 knotst for Winters from 1969/70 to 2013/14

4.6.7. The same publication notes that a wind gust of 95 knots (109 miles per hour) was recorded at the Isle of Wight during the 14th – 15th February, while other coastal stations facing the English Channel recorded maxima in the range of 69-72 knots.

[6] http://www.metoffice.gov.uk/climate/uk/interesting/2014-janwind
[7] http://wmo.int/pages/mediacentre/news/ExtremeWeatherinpartsoftheworld.html
[8] http://www.metoffice.gov.uk/media/pdf/1/2/Recent_Storms_Briefing_Final_SLR_20140211.pdf

4.6.8. The broadcast weather forecast for this area (sea area Plymouth) issued by the UK Met Office at 0505 hours on the 14th February indicated that expected conditions were *"…southeast force 6 to gale 8 veering southwest gale 8 to storm 10, perhaps violent storm 11 later*."

4.6.9. It is interesting to note the use of the word "*later*" and to understand that the meaning given by the Met Office[9] is "*Expected more than 12 hours from time of issue*". The conditions experienced by the Marco Polo and other ships in the area during the middle of the day, when taken against the forecast broadcast, indicates that that the storm moved in an easterly direction much more quickly than anticipated.

4.6.10. The broadcast does not indicate expected wave heights by quoting Douglas Sea State but these can be inferred by comparison of the Beaufort Scale with Met Office terminology. In this case storm 10 is associated with "*very high waves*" which the glossary gives as being wave height in the range of 9.0 to 14.0m.

4.6.11. Evidence points to the fact that the storm encountered by ships in the Atlantic approaches to the English Channel on the 14th February 2014 was one of extraordinary violence and energy. The ship seemed to be coping with the 70 knot winds and 10 metre seas being experienced. Comments received from passengers or found on social media indicate that individuals who were in the Waldorf Restaurant prior to the wave strike noted waves "rolling along the side of the ship". One passenger has advised that one wave broke over Deck 6 immediately prior to the wave strike. However, no concern was relayed to the bridge from the crew working in the Restaurant or from the crew mess room.

4.6.12. However, the ship was struck by a large wave which broke over the bridge deck resulting in a small volume of water entering through the starboard bridge wing door. The bridge doors are not designed to be watertight but the construction of the doors is such as to make any water entry difficult. This implies a strike by a wave crest of around 15 metres (49 feet) with the ship on an even keel. However, with a roll of 15° it is possible that the wave crest could have been up to 19m (62 feet).

4.6.13. Although this wave impacted on an area of the side of the ship which features numerous windows of various dimensions no other damage was reported except from the four windows in the Waldorf Restaurant. When the investigation on board commenced at 08:30 hours on Sunday 16th February a significant amount of work to repair the damage had already been done including clear-up of debris and damaged window retaining strips and insertion of replacement of window glass including two spare panes.

[9] http://www.metoffice.gov.uk/weather/marine/guide/glossary.html

4.6.14. As a result of the collection and removal of debris, the initial activities to secure the openings and the repair work in progress it was not possible to establish definitively which two of the four panes had been shattered and which two had been displaced whole. From the nature of the injuries described by the ship's doctor it is concluded that the deceased passenger was struck by one of these complete panes.

4.6.15. The force with which the wave struck the windows was evidenced by the fact that glass fragments from the shattered were found some 10 m into the restaurant and impact scratch marks were found to the mirrors mounted on the transverse bulkhead aft of the windows and the longitudinal half-height partition located 3m inboard, which was itself dislodged.

4.7. Window construction

4.7.1. The ship underwent significant alteration in 1991-1993 and it is believed that the rectangular windows were installed at this time. Unfortunately Bureau Veritas, the Classification Society at that time, advised the investigation that almost all contemporary records regarding the re-fit had been destroyed in a warehouse fire. Consequently the identity of the manufacturer of the window and approval documentation was unavailable. However, an examination of photographs of the ship prior to 1991 indicates that there were no rectangular windows on Deck 6 before the alterations – only circular portholes.

4.7.2. Bureau Veritas has also confirmed that its Class Rules in effect at the time of installation contained no strength requirements for windows and that the calculations that were made were in respect of hull strength to compensate for the area of side shell which was cropped out to make the transition from round portholes to rectangular windows.

4.7.3. Insofar as the Load Line Convention is concerned there are no strength requirements specified for windows. Regulation 23 refers only to side scuttles ("portholes"), and it is only within an Unified Interpretation that windows are addressed:

Side scuttles and windows together with their glasses, deadlights and storm covers, if fitted, should be of approved design and substantial construction in accordance with, or equivalent to, recognized national or international standards. Non-metallic frames should not be acceptable.

4.7.4. The requirements of SOLAS at the time of the installation of the windows were contained within the 1981 Amendments to Chapter II-2 Regulation 33 "Windows and side scuttles" as follows:

33.3 …Windows located in the ship's side below the lifeboat embarkation areas shall have the fire integrity at least equal to "A-0" class.

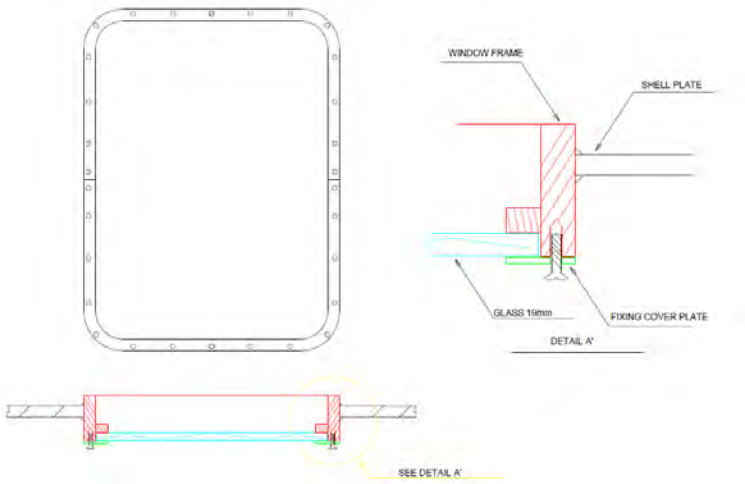
4.7.5. While the manufacturer of the window unit is unknown, the glass was identified as Pyroswiss – formerly manufactured by Temperit AG, Hinwil, Switzerland (now a trademark of Vetrotech Saint-Gobain). From photographic evidence of the inverted triangle manufacturer's mark the glass was identified as 19mm thick monolithic and fire-resistant. Furthermore the glass was stated to be able to withstand pressure corresponding to ISO 614 "Shipbuilding - Toughened safety glass panes for ships' side scuttles and ships' rectangular windows -- Punch method of non-destructive strength testing". While this standard has been revised in 1989 and 2012 the original edition of 1976 is of relevance.

4.7.6. In respect of the strength of the glass ISO 614 states that the proof load of a 19mm thick glass under the standard test procedure is 33 000 N (3 363 kg). However, this standard does not describe an impact test since the load is applied to the glass at a low value and increased gradually to the required value.

4.7.7. In the absence of any definitive evidence it is probable that the manufacture of the window unit was at least based on, if not in compliance with, the ISO Standard 3903:1977 "Shipbuilding - Ships' ordinary rectangular windows" and ISO 3254:1989 "Shipbuilding and marine structures - Toughened safety glass panes for rectangular windows"

4.7.8. In examination of ISO 3903:1977 it is noted that the principal height and width dimensions of the windows installed on the Marco Polo do not align with the designated dimensions set out in the standard.

4.7.9. No thickness is given in the standard for the retaining flat bar which is estimated as being 3-5mm and, consequently, having a very limited resistance to external force. It is concluded that the strip is to retain the glass in place in normal conditions rather than to resist any significant direct external impact.



Schematic of window assembly

4.8. Maintenance and condition of windows

4.8.1. The maintenance of the condition of side scuttles and windows is the responsibility of the ship operator and the water- or weather-tightness of these items is a verifiable item at Load Line Surveys. As recorded earlier in this report the ship carried a valid International Convention on Load Lines Certificate which was endorsed for Annual Survey at Antwerp on 12th December 2013.

4.8.2. The conduct of the Load Line Annual survey in respect of the actions required of the Surveyor is set out in the IMO "Survey Guidelines under the Harmonized System of Survey and Certification" which states the requirement only as "examining the side scuttles and deadlights (LLC 66/88 reg.23)" and it may be noted that there is no reference to windows under the Load Line survey requirement.

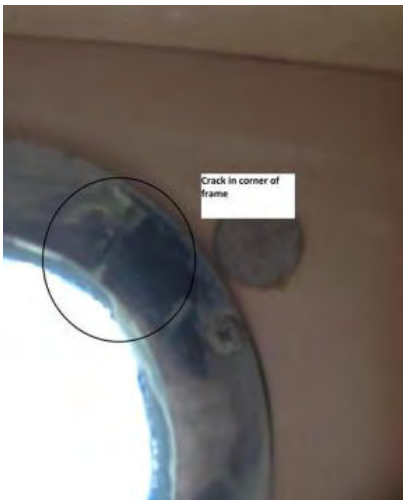
4.8.3. The examination of such items, which is invariably an in-situ visual inspection without dismantling, under the Load Line specific survey requirements is augmented by general advice contained elsewhere in the guidelines in respect of Annual surveys: *"…should any doubt arise as to the maintenance of the condition of the ship or its equipment, further examination and testing should be conducted as considered necessary."*

4.8.4. In respect of Load Line surveys this could entail water-tightness testing using a directed fire hose water jet. However, the report of the survey held in Antwerp in 2013 contains no comments regarding the survey from which it is concluded that the attending Surveyor noted nothing of concern regarding the condition of side scuttles and windows.

4.8.5. Information provided by some passengers who were on the voyage indicated that a number of windows in cabins and public areas were seen

with leaks or rust stains. A subsequent Load Line survey carried out in March 2014 by DNV and the Bahamas Maritime Authority discovered cracks in some window frames and unidentified glass in use. A small number of windows in other locations were using non-glass glazing material. While no windows were recorded as leaking when subjected to a hose test, this was not the case with side scuttles as some of these were found with signs of leaks, corrosion and missing sealing gaskets.

Side scuttle showing internal tide mark, poor sealing and general corrosion



Crack in corner of window frame

4.8.6. The repair of the four damaged windows was well progressed when the investigator arrived on board in the morning of the 16th February. Some cleaning up of the area had been completed and taken together with the activity associated with the efforts to close the openings in the immediate aftermath of the incident and the repair work overnight there had been some disposal or movement of damaged materials. It was therefore not possible to make a full in-situ assessment of the effects of the wave strike.

4.8.7. It is not possible to say whether the condition of the windows shattered or displaced was substantially worse than any other of the windows on the starboard side of the Waldorf Restaurant or whether the strength of the windows retaining frame was substantially reduced. Neither could it be established whether corrosion of the side shell material had led to compressive stress being set up in window panes.

4.8.8. As post-accident inspection of other windows in the Waldorf Restaurant, and in other locations around the ship, by DNV and BMA reported damages to windows and portholes the adequacy of the survey by the Classification Society in the context of the Annual Load Line survey in December 2013 must be called into question.

4.8.9. With respect to on-board maintenance of windows and portholes the Owner provided a copy of inspection records for the windows and portholes for Deck 6 for the period 30.05.2003 to 26.08.2014. These records indicate monthly inspections of windows and portholes; six-monthly inspections of portholes and six-monthly lubrication of portholes. The records do not indicate any other maintenance nor are there any adverse or notable results of inspections. However, there was evidence that some maintenance was ongoing from the presence of "red lead" primer application at some window frames on Deck 8.

4.8.10. In noting the difficulty of carrying out maintenance in the winter in Northern Europe it is therefore of critical importance that all necessary preventative maintenance, and not just inspection, is carried out during annual docking periods.

4.9. International Convention on Load Lines (ICLL)

4.9.1. The International Load Line Certificate held by the ship at the time of the incident was issued by DNV under the authority of the Government of the Commonwealth of the Bahamas in February 2013. The certificate was valid until January 2018 subject to the necessary annual surveys the most recent of which was carried out by DNV in December 2013.

4.9.2. Examination of DNV Records showed that a short term Loadline Certificate was issued at Class entry in October 2001 based on a survey concluded in Lisbon. However, at the subsequent survey in Barcelona in October 2002 the surveyor noted that the Record of Conditions of Assignment could not be located on board.

4.9.3. The Record of Conditions of Assignment (form 44.401a) found on board was issued by DNV on the 19th October 2004. The RCA, page 12, identified those side scuttles and windows subject to Regulation 23 of the Convention "Between Decks 6&7, forw. and aft" as 350mm diameter openings with bronze frames and inside hinged deadlights. However, the form is incomplete regarding the number fitted, type of glass and thickness, standard used and Type No. and deadlight material. The incomplete nature of the RCA was immediately drawn to the attention of the flag State for investigation and action.

4.9.4. The fact that the RCA has been in an incomplete form since 2004 is indicative of the fact that a heavy reliance has been placed on the Class Society by the ship operator. While it is the responsibility of the Class Society to ensure the quality of the survey and issued documents it is also incumbent upon a ship operator to do its own checks of documentation to ensure that it is complete, valid and up to date.

4.9.5. ICLL Regulation 23 requires "*sidescuttles to … spaces within enclosed superstructures shall be fitted with efficient hinged inside deadlights arranged so that they can be effectively closed and secured watertight.*"

4.9.6. This requirement is modified by the Unified Interpretation:

Side scuttles to the following spaces should be fitted with efficient hinged inside deadlights:

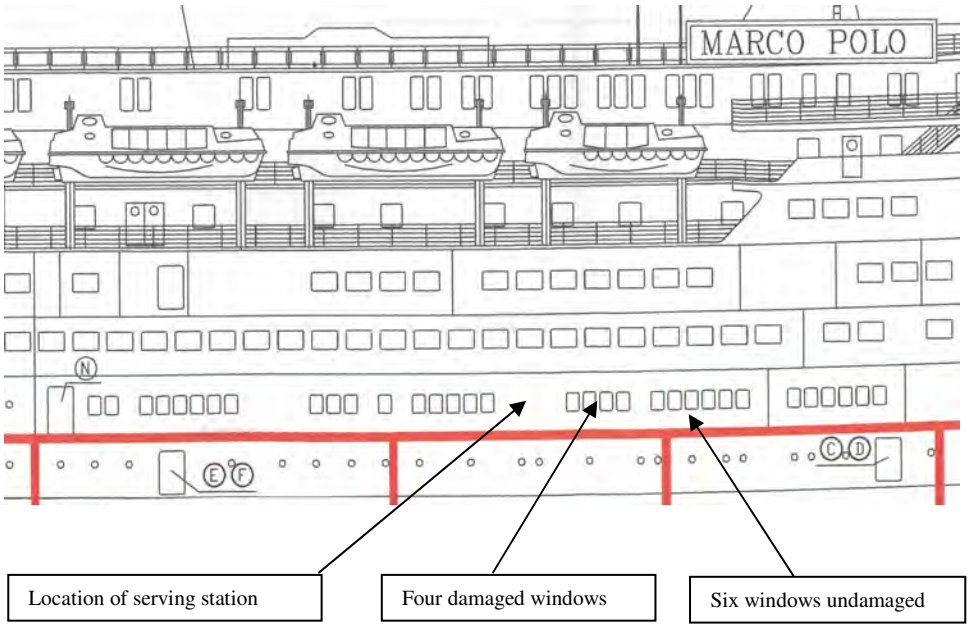
(a) spaces below freeboard deck;
(b) spaces within the first tier of enclosed superstructures; and
(c) first tier deckhouses on the freeboard deck protecting openings leading below or considered buoyant in stability calculations.

It may be noted at this point that no reference is made to windows within the Regulation.

4.9.7. The Waldorf Restaurant is located on Deck 6, the freeboard deck, and extends from Frame 87 to Frame 137 forward. There are 28 windows on the starboard side, each of nominal dimension 87cm high by 57cm wide.

4.9.8. The window disposition shown is, from forward: a group of six windows which lead into a space which is physically separate from the restaurant; another group of six which are the most forward of the windows in the restaurant and the group of four which were damaged in this incident. Aft of the group of four is located a windowless serving station and further windows are again arranged in groups with another serving station forward of the final eight windows.

4.9.9. The windows are not evenly spaced along the length of the restaurant space as can be seen in the following illustration:



Side elevation of Marco Polo – Deck 6 windows

4.9.10. The windows which were affected in this incident are located between Frame 116 and Frame 120 i.e. from 67 m to 70 m from the forward end of the ship (i.e. within approximately 2/5 of length from forward.) The lower edge of the windows is approximately 6.5 m above the waterline.

4.9.11. All other spaces on deck 6, forty four (44) two person passenger cabins aft of the restaurant and various service spaces and crew dining rooms forward of the restaurant, are provided with 350 mm diameter round side scuttles (portholes). Each side scuttle is fitted with a hinged steel deadlight which is permanently fixed to the structure to be closed in the event of heavy weather.

4.9.12. The windows in the restaurant are not provided with permanently attached closing plates. However, portable closing plates were available and were brought to Deck 6 as the crew worked to make the openings weather-tight. In the absence of information in the Conditions of Assignment it is suggested that these closing plates are the "storm-covers" which are referenced in the Unified Interpretation to Regulation 23 as follows:

"Side scuttles and windows together with their glasses, deadlights and storm covers, if fitted, should be of approved design and substantial construction in accordance with, or equivalent to, recognized national or international standards. Non-metallic frames should not be acceptable."

4.9.13. The Shipboard Operations Manual Vol II Section 03.03 (Vessel at Sea – Heavy Weather) Appendix "A" contains a "Heavy Weather Review". Within the review, which comprises a checklist of issues to be considered, there is a reference to securing of "*Port. dead-lights*". It is clear from interviews and bridge records that the dead-lights on Deck 6 and below had all been proactively closed in preparation for the anticipated conditions.

4.9.14. The checklist made no reference to windows on Deck 6 which, in light of the existence of deadlights on side scuttles on that same deck, may be viewed as a weakness in the risk assessment process. The absence of any mention of closing plates in the Record of Conditions of Assignment of Load Lines and the fact that these plates were not permanently fixed in place it is debatable whether the plates are intended to close an opening after damage or to offer protection against damage.

4.9.15. In fact this problem was pointed out by the UK Marine accident Investigation Branch in its report on wave damage to windows on the UK-flagged ship "Oriana" in September 2000 (report published November 2002).

"The MAIB considers that the intended use of storm covers requires clarification and, if storm covers are to be fitted to the inside of windows as a precaution against heavy weather, more detailed guidance on strength requirements needs to be issued…therefore, these covers are to be considered suitable for use following a window breach when the spaces they are protecting can be left unoccupied; they are not suitable to act as a precaution in heavy weather"

4.9.16. It is noted that the UK Maritime and Coastguard Agency issued Marine Guidance Notice MGN271(M) "The Protection of Windows and Side Scuttles of Passenger Ships by Deadlights and Storm Covers" in response to this report. This Note also contains the text of Regulation 23 of the ICLL (entry into force 2005) which records the fact that storm covers are intended to be fitted to the outside of a window.

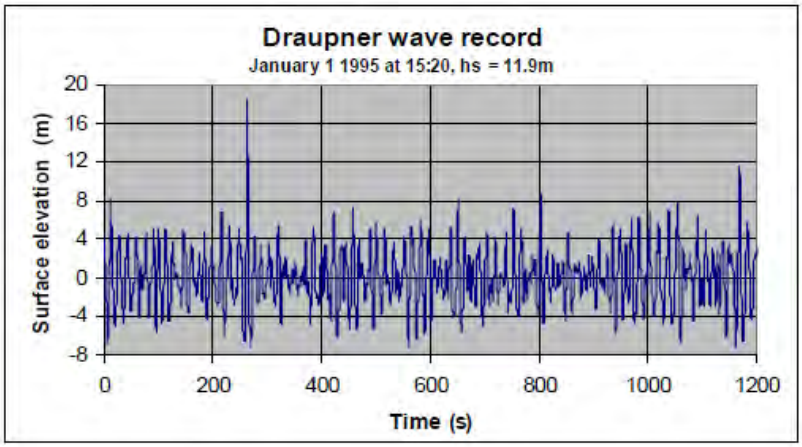
4.9.17. It is concluded that the portable closing plates provided on the Marco Polo are intended to close an opening following damage to a window and are not intended to protect windows against weather damage. It is possible that had they been installed as a protective measure they could have prevented the injuries to passengers. However, it is also possible that the force of the wave strike could have dislodged the aluminium plates causing equal, if not greater, damage.

4.9.18. Whatever the intended purpose of the closing plates, and this should be clarified, it is clear that the storage location of the closing plates was well understood by crew members as they were retrieved and fitted within a very short time of the incident.

4.10. Was this an example of a rogue wave?

4.10.1. In its press release immediately following the incident the ship operator made reference to the ship having been hit by a "rogue wave". This claim has been challenged by a number of different commentators and articles and it is appropriate that the investigation addresses the issue.

4.10.2. The issue of rogue waves, or waves which are extreme in height when the taken in the context of a wave spectrum has been under discussion and study for many decades. Originally dismissed as exaggeration, the existence of such extreme waves was substantiated by the wave which struck the Draupner E oil platform in the North Sea on 1st January 1995. In order to monitor the behaviour of the structure a downward-looking laser wave sensor had been installed. Over a period of 12 hours when the significant wave height was 11.9m one wave with a maximum height of 26m was recorded.



4.10.3. The "Draupner Wave" has stimulated an enormous amount of research activity including the European Union project "Maxwave[10]," which was commenced in 2000. This project used two radar satellites and, over a short three week period, analysis of the images taken revealed ten waves having a maximum height of 25m or over[11].

4.10.4. In their paper "Rogue waves in 2006–2010" published in Natural Hazards and Earth System Sciences[12] (European Geosciences Union) Nikolkina and Didenkulova discuss the phenomenon of rogue waves (which they define as being twice H_s) and tabulate examples.

4.10.5. The study of rogue waves has entire conferences and workshops dedicated to its further understanding of the phenomenon. Of particular relevance to this point are the quadrennial events in 2000, 2004 and 2008 held by IFREMER (Institut français de recherche pour l'exploitation de la mer) in Brest. The 2008 event[13] attracted 38 papers from contributors from around the world.

4.10.6. It is clear from the ongoing scientific interest and evidence that rogue waves (i.e. waves with a significantly greater height than the significant wave height in a spectrum) do exist. While the investigation cannot rule out the possibility that this was a rogue wave event it is noted that a "very high" sea state as linked to Storm 10 in the Beaufort Scale and the Met Office glossary indicates an a wave height of 9.0 to 14.0 m. Above this height a the sea state is termed "phenomenal".

4.10.7. The UK Met Office also publishes its guide to the Beaufort Scale[14] which indicates that the probable[15] wave height under Storm 10 conditions is 9 m with a probable maximum height of 12.5 m. These

[10] http://ec.europa.eu/research/infocentre/export/success/article_707_en.html
[11] www.esa.int/Our_Activities/Observing_the_Earth/Ship-sinking_monster_waves_revealed_by_ESA_satellites
[12] www.nat-hazards-earth-syst-sci.net/11/2913/2011/doi:10.5194/nhess-11-2913-2011
[13] http://www.ifremer.fr/web-com/stw2008/rw/papers.html
[14] http://www.metoffice.gov.uk/weather/marine/guide/beaufortscale.html
[15] "well-developed wind waves of the open sea"

values rise to 11.5 m and 16 m respectively under Violent Storm 11 conditions.

4.10.8. Based on this information it may be more probable that the wave which caused the damage to the Marco Polo – even at the maximum estimated height of 18.4 m – was "phenomenal" but not "rogue". Evidence given by the OOW that the heading of the ship had rotated from the desired 059º to 087º despite using a full port helm indicates that the ship was being turned more beam-on to the prevailing weather. In that light this event may have been an unfortunate combination of the roll to starboard meeting an oncoming wave which was at the extreme end of the expected height range for the conditions being experienced.

4.10.9. There is a further possibility: that of some form of waterborne debris striking the windows. However, in the absence of any evidence of impact damage, including to paintwork, on the side shell and noting that two window glass panes shattered while two remained intact this is purely speculative.

4.11. Other miscellaneous window breakage events affecting passenger ships

4.11.1. The Marco Polo is by no means the first passenger ship to suffer window breakage in bad weather. A review of incidents has been carried out using the International Maritime Organization's GISIS database and internet sources such as cruisejunkie.com. It should be noted that investigations should be carried out on very serious marine casualties, as defined in the Casualty Investigation Code.

4.11.2. The review has revealed that there have been sixteen reported incidences of window breakages on passenger ships in heavy weather events since the year 2000. Passenger fatalities were experienced in one of these – the Louis Majesty accident in 2010 when two passengers suffered fatal injuries and eighteen other passengers were injured. This event took place in the Mediterranean Sea but despite enquiries made to the Administration in question no marine safety investigation report appears to be available. However, photographs on various websites indicate that both forward-facing and side windows were broken.

4.11.3. In 2000 the UK-registered ship Oriana suffered window damage during heavy weather in the North Atlantic – side-facing windows in six cabins were damaged (three on deck 5 and three on deck 6); one crew member and six passengers suffered cuts and bruises[16].

4.11.4. In 2005 two Bahamas-registered ships the "Voyager" and the "Explorer" suffered almost identical damage to forward-facing navigating bridge windows while in the Pacific Ocean and the Mediterranean Sea

[16] http://www.maib.gov.uk/cms_resources.cfm?file=/oriana.pdf

respectively. These incidents led to serious consequences in respect of temporary loss of power and navigational capability due to water damage[17].

4.11.5. In 2005 the United States' National Transportation Safety carried out an investigation on window breakages to the cruise ship Norwegian Dawn. Windows into two forward-facing cabins were damaged and four passengers injured[18].

4.11.6. In 2007 the Pacific Star suffered damage to a number of windows after encountering wind speeds in excess of 90 knots after departing from Auckland, New Zealand. These wind speeds were higher than had been forecast and the ship was placed on a heading to keep wind and sea fine on the starboard bow.

4.11.7. In 2010 the Netherlands-registered passenger ship Prinsendam suffered wave damage to forty-four (44) windows although none appears to have broken and no injuries were reported. No investigation was carried out into this incident which occurred in waters off the northern coast of Scotland.

4.11.8. Investigation reports for the other incidents have proven difficult to obtain and it appears that these incidents have generally not been investigated. However, from review of the reports which are available it can be seen that damage to forward-facing windows generally results in more extreme consequences in respect of the impact on the ability of a ship to continue to navigate safely. This does run counter to the generally-held view that the best way to meet heavy weather is head-on to ride out a storm. While this is an option the lesson learned is that if damage is suffered it may lead to more serious consequences if navigating bridge windows are breached

4.12. Actions taken after the event

4.12.1. Actions taken by the Bahamas Maritime Authority

4.12.1.1. Following the initial visit by the investigation team the Bahamas Maritime Authority instructed its Recognised Organization (DNV) to attend on board to survey the temporary repairs made to the affected windows while the ship was at Tilbury.

4.12.1.2. The Bahamas Maritime Authority instructed its Recognised Organisation to carry out a full Initial Load Line Survey and draw up a complete Record of Conditions of Assignment of Load Lines. This

[17] http://www.bahamasmaritime.com/downloads/Casualty%20Reports%202001%20onwards/Explorer%20_%20Voyager%20-%20Jan%202005.pdf)

[18] https://www.ntsb.gov/investigations/fulltext/MAB0503.htm

survey was commenced by DNV at Tilbury on the 2nd of March 2014 with the Bahamas Maritime Authority in attendance.

4.12.1.3. The Bahamas Maritime Authority instructed its Recognised Organisation to carry out a full extraordinary Safety Management Certificate audit on board to verify the adequacy of the documented procedures and their implementation. It also required a full Document of Compliance audit to be carried out at the Company's headquarters in Piraeus, Greece.

4.12.1.4. The Bahamas Maritime Authority has arranged a meeting with DNV-GL to discuss further the survey and audit issues raised by the investigators.

4.12.2. Actions taken by Det Norske Veritas

4.12.2.1. A full Initial Load Line Survey has been completed and a new Record of Conditions of Assignment of Load Lines has been issued. A new Full Term International Load Lines Certificate valid to 31st January 2018 has been issued to the ship.

4.12.2.2. Repairs to all identified non-compliances with Load Line requirements have been surveyed and found satisfactory.

4.12.2.3. A team of senior DNV auditors has carried out a full Safety Management Certificate audit on board to the extent of an initial audit.

4.12.2.4. A team of senior DNV auditors has carried out a full Document of Compliance audit at the head office of the operating Company.

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5. CONCLUSIONS

5.1. The execution of the voyage planning process for the passage from Ponta Delgada, Azores, to Tilbury, London, was carried out in accordance with regulatory requirements with a high degree of professionalism. The process on board took full account of the International Maritime Organization's Guidelines for Voyage Planning.

5.2. The meteorological information used for planning included both official INMARSAT C – SafetyNET and unofficial internet sources. While the latter offer an enhanced level of detail, and cannot be dismissed, there was no proactive weather management system implemented by the Company to support the Master.

5.3. During the voyage the navigating officers continued to closely monitor developing weather systems and the ship's course and speed were actively managed, including an unplanned change to the original voyage plan, for safety and passenger comfort reasons.

5.4. The ship had intended to run in advance of a low pressure area into the English Channel but the speed of travel of that depression was significantly greater than forecast, and storm conditions were significantly more intense and vigorous than forecast.

5.5. The wind and sea conditions experienced made maintaining the desired course extremely difficult and exposed the propulsion engines to damage from "racing" i.e. rapid over-speeding due to emergence of the propellers from the water into the air. The reduction of speed to protect the engines exacerbated the yawing effect of wind and waves and increased the exposure of the ship to beam seas.

5.6. The windows in the Waldorf Restaurant were not fitted with external storm covers or internal deadlights - but these are not required under Load Line Regulations. The standards of the windows installed in 1991 could not be established but International Standards available at the time contained no impact resistance requirements for window glass or window assemblies.

5.7. In the aftermath of the incident the crew displayed professionalism and knowledge in closing the window openings with portable closing plates. However, on board procedures made no reference to the use of the closing plates including whether or not they could be used as protective devices.

5.8. There is strong evidence to suggest that the wave which caused the damage was extremely large when taken against the wave height which may reasonably have been expected in the conditions being experienced at the time. Whether or not this was a "rogue wave" event remains open to interpretation but it is suggested that it was not of a size (twice H_s) which would qualify as such.

5.9. While not a causal factor in this event it is the opinion of the investigators that there were long-standing weaknesses in the survey regime performed by the Classification Society in respect of the International Convention on Load Lines.

5.10. While not specifically relevant to the event, the damage suffered or the on-board planning and response, it was the opinion of the investigators that the documented Safety Management System requires comprehensive review and, consequently, that the effectiveness of the ISM audit regime should be reviewed.

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6. RECOMMENDATIONS

Recommendations for the Operator:

6.1. The operator should ensure that the planning process for the scheduling of preventative maintenance at docking periods takes into account the difficulty of in-service maintenance when operating in winter conditions.

6.2. The operator should consider a review of the provision of meteorological information to the Master and the adoption of a more proactive approach to weather management by incorporating the service of a dedicated provider of such information.

6.3. The operator should review the Safety Management System to improve plans and procedures to be adopted in anticipation of, and when encountering, heavy weather and other conditions anticipated for scheduled voyages.

6.4. Notwithstanding recommendations made to the flag State the operator should consider issuing guidance and instructions for the use of the lightweight portable window covers for windows in the Waldorf Restaurant.

6.5. The operator should consider establishing procedures to review, on receipt, all statutory certification and other associated documents issued by the Administration or the Classification Society for completeness and accuracy.

Recommendations for the Flag State

6.6. The Bahamas should consider the purpose and use of portable closing plates in the context of the Load Line Convention definition of "storm covers" and establish a national policy for clarity

6.7. The Bahamas should consider a review of the contents of MGN 271(M) "The Protection of Windows and Side Scuttles of Passenger Ships by Deadlights and Storm Covers" and promulgation of relevant information to passenger ships under its flag.

6.8. The Bahamas should consider a review of the effectiveness of Load Line Surveys and ISM audits carried out by the Recognised Organisation.

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LIST OF APPENDICES

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Appendix I

BEAUFORT SCALE OF WIND FORCE

Beaufort number	*Descriptive term*	*Wind speed equivalents*		*Specifications for observations on board ship (open sea)*
		Metres/ second	*Knots*	
0	Calm	0–0.2	<1	Sea like a mirror
1	Light air	0.3–1.5	1–3	Ripples with the appearance of scales are formed, but without foam crests
2	Light breeze	1.6–3.3	4–6	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break
3	Gentle breeze	3.4–5.4	7–10	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses
4	Moderate breeze	5.5–7.9	11–16	Small waves, becoming longer; fairly frequent white horses
5	Fresh breeze	8.0–10.7	17–21	Moderate waves, taking a more pronounced long form; many white horses are formed (chance of some spray)
6	Strong breeze	10.8–13.8	22–27	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray)
7	Near gale	13.9–17.1	28–33	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind
8	Gale	17.2–20.7	34–40	Moderately high waves of greater length; edges of crests begin to break into the spindrift; the foam is blown in well-marked streaks along the direction of the wind
9	Strong gale	20.8–24.4	41–47	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble and roll over; spray may affect visibility
10	Storm	24.5–28.4	48–55	Very high waves with long overhanging crests; the resulting foam, in great patches, is blown in dense white streaks along the direction of the wind; on the whole, the surface of the sea takes a white appearance; the tumbling of the sea becomes heavy and shock-like; visibility affected
11	Violent storm	28.5–32.6	56–63	Exceptionally high waves (small and medium-sized ships might be for a time lost to view behind the waves); the sea is completely covered with long white patches of foam lying along the direction of the wind; everywhere the edges of the wave crests are blown into front; visibility affected
12	Hurricane	32.7 and over	64 and over	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected

Obtained from Manual on Marine Meteorological Services
Volume I – Global Aspects
WMO-No. 558
2012 edition

http://library.wmo.int/pmb_ged/wmo_558_en-v1.pdf

Appendix II - Marine forecasts terminology[19]

Gale warnings	Gale - Winds of at least Beaufort Beaufort Scale 8 (34–40 knots) or gusts reaching 43–51 knots
	Severe gale - Winds of Beaufort Scale 9 (41–47 knots) or gusts reaching 52–60 knots
	Storm - Winds of Beaufort Scale 10 (48–55 knots) or gusts reaching 61–68 knots
	Violent storm - Winds of Beaufort Scale 11 (56–63 knots) or gusts of 69 knots or more
	Hurricane Beaufort Scale - Winds of Beaufort Scale 12 (64 knots or more)
	Note: The term used is 'hurricane Beaufort Scale'; the term 'hurricane' on its own means a true tropical cyclone, not experienced in British waters
Time	Imminent- Expected within six hours of time of issue
	Soon - Expected within six to 12 hours of time of issue
	Later - Expected more than 12 hours from time of issue
Visibility	Very poor - Visibility less than 1,000 metres
	Poor - Visibility between 1,000 metres and 2 nautical miles
	Moderate - Visibility between 2 and 5 nautical miles
	Good - Visibility more than 5 nautical miles
Movement of pressure systems	Slowly - Moving at less than 15 knots
	Steadily - Moving at 15 to 25 knots
	Rather quickly - Moving at 25 to 35 knots
	Rapidly - Moving at 35 to 45 knots
	Very rapidly - Moving at more than 45 knots
Pressure tendency in station reports	Rising (or falling) more slowly - Pressure rising (or falling) at a progressively slower rate through the preceding three hours
	Rising (or falling) slowly - Pressure change of 0.1 to 1.5 hPa in the preceding three hours

[19] Obtained from http://www.metoffice.gov.uk/weather/marine/guide/glossary.html

	Rising (or falling) - Pressure change of 1.6 to 3.5 hPa in the preceding three hours
	Rising (or falling) quickly - Pressure change of 3.6 to 6.0 hPa in the preceding three hours
	Rising (or falling) v. rapidly - Pressure change of more than 6.0 hPa in the preceding three hours
	Now rising (or falling) - Pressure has been falling (rising) or steady in the preceding three hours, but at the time of observation was definitely rising (falling)
Wind	Wind direction - Indicates the direction from which the wind is blowing
	Becoming cyclonic - Indicates that there will be considerable change in wind direction across the path of a depression within the forecast area
	Veering - The changing of the wind direction clockwise, e.g. SW to W
	Backing - The changing of the wind in the opposite direction to veering (anticlockwise), e.g. SE to NE
Sea state	Smooth - Wave height less than 0.5 m
	Slight - Wave height of 0.5 to 1.25 m
	Moderate - Wave height of 1.25 to 2.5 m
	Rough - Wave height of 2.5 to 4.0 m
	Very rough - Wave height of 4.0 to 6.0 m
	High - Wave height of 6.0 to 9.0 m
	Very high - Wave height of 9.0 to 14.0 m
	Phenomenal - Wave height more than 14.0 m

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Appendix III

Illustration of sea area relationships between UK Met office and MeteoFrance

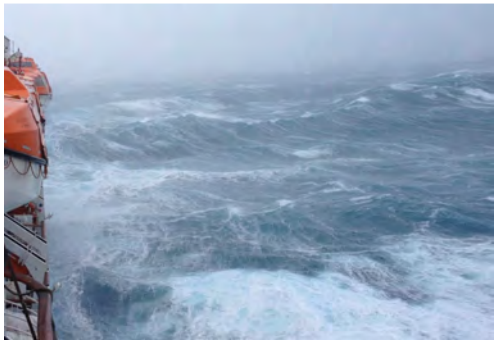
Appendix IV - Additional photographs

Photographs 1-3

Damage in Waldorf Restaurant

Photographs 4-10

Sea conditions through the afternoon of 14th February 2014

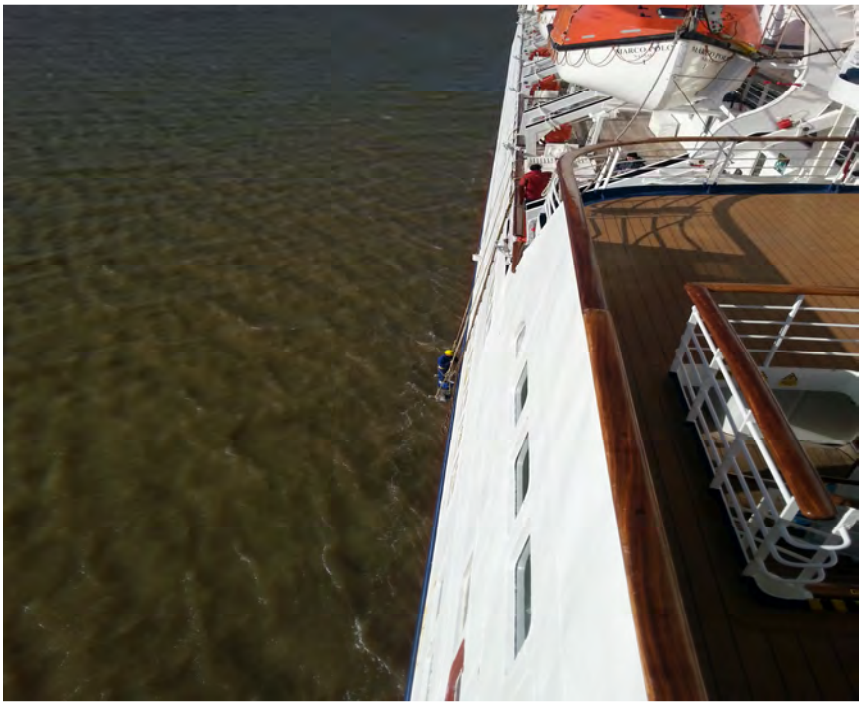




Photographs 11-13

Waldorf Restaurant – repairs underway 0830 Sunday 16th February 2014

Repairs underway at Tilbury – view from navigating bridge deck towards the waterline



Window glass fragment (19mm thickness)

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