Report on the investigation into

the structural failure and foundering

of the general cargo ship

Swanland

Irish Sea

27 November 2011

with the loss of six crew

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

3D	3-Dimensional
AB	Able bodied seaman
AIS	Automatic Information System
ALARP	As Low As Reasonably Practicable
AP	Aft Peak (tank)
BA	British Admiralty
BC Code	Bulk Cargoes Code
BIMCO	Baltic and International Maritime Council
BV	Bureau Veritas
CAD	Computer Aided Design
CERS	Consolidated European Reporting System
CO^2	Carbon dioxide
COG	course over the ground
CoC	Condition of Class
COLREGS	International Regulations for the Prevention of Collisions at Sea 1972, as amended
CPOMEM(L)	Chief Petty Officer Marine Engineer Mechanic (Electrical)
CSSCC	Cargo Ship Safety Construction Certificate
CU	cubic
d	load draught (as defined in Section 2505 of the 1976 LR Small Ship Rules)
DB	double bottom
DNV	Det Norske Veritas
DOC	Document of Compliance (a document issued to a Company that complies with the requirements of the ISM Code.)
DOT	Department of Transport (now known as Department for Transport (DfT))
DP	designated person
DSC	Digital Selective Calling

EEZ	-	Exclusive economic zone
EN	-	European Norm (standard)
EPIRB	-	Emergency Position Indicating Radio Beacon
ESP	-	Enhanced Survey Programme
FBA	-	Furnace Bottom Ash
FP	-	Fore Peak (tank)
FQMP	-	Fleet Quality Management Process
FSA	-	Formal Safety Assessment
FT	-	feet (an imperial or pre-metric measure of length; 1 foot equals 0.3048m)
GHz	-	Gigahertz (Hertz is the unit of frequency, defined as the number of cycles per second of a periodic phenomenon; Giga refers to 10 to the power of 9)
GISIS	-	Global Integrated Shipping Information System
GSB	-	Granular Sub Base
H&M	-	Hull & Machinery
HMAS	-	His Majesty’s Australian Ship
HSK	-	Hilfskreuzer (German for Auxiliary Cruiser/Raider)
HTCR	-	High Temperature Crushed Rock
IACS	-	International Association of Classification Societies
IMMARBE	-	International Merchant Marine Registry of Belize
IMO	-	International Maritime Organization
IMSBC Code	-	International Maritime Solid Bulk Cargoes Code
INSB	-	International Naval Surveys Bureau
ISM Code	-	International Safety Management Code (IMO Resolution A.741(18), as amended
ISO	-	International Organization for Standardization
ISPS Code	-	International Ship and Port Facility Security Code
kg	-	kilogram

lb	-	pound (an imperial or pre-metric measure of weight; 1lb is equal to 0.454kgs)
L	-	Electrical (an abbreviation used in the UK's Royal Navy)
LCG	-	longitudinal centre of gravity
LR	-	Lloyd's Register
LSA	-	Life-saving Appliance
m	-	metre
mm	-	millimetre
m^2	-	square metres (a measure of area)
m^3	-	cubic metres (a measure of volume)
MCA	-	Maritime and Coastguard Agency
MCI	-	Maritime Cook Islands
MEM	-	Marine Engineering Mechanic
MEPC	-	Marine Environment Protection Committee (a committee of the IMO)
MGN	-	Marine Guidance Note
MoC	-	Memoranda of Class
MOT	-	Ministry of Transport
MOU	-	Memorandum of Understanding
MRCC	-	Maritime Rescue Co-ordination Centre
MSC	-	Maritime Safety Committee (a committee of the IMO)
MTS	-	Marine Technical Services
N	-	Newton (a measure of force, equivalent to $kg.m/s^2$)
N/A	-	Not applicable
NDT	-	non-destructive test
NW	-	North West
P&I	-	Protection and Indemnity
PMA	-	Panama Maritime Authority

PR - Procedural Requirement

PSCI - Port State Control Inspection

PULS - Panel Ultimate Limit State

QACE - Entity for the Quality Assessment and Certification of Organisations Recognised by the European Union CIC

QIP - Quality Improvement Programme

QMS - Quality Management System

RAF - Royal Air Force

RAP 20 - Reclaimed Asphalt Pavement

RCO - risk control option

RN - Royal Navy

RNLI - Royal National Lifeboat Institution

RO - recognised organisation

RO Code - Code for Recognised Organizations

ROV - remotely operated vehicle

s - second

SART - Search and Rescue Transponder

SMC - Safety Management Certificate (a document issued to a ship signifying that the company and its shipboard management operate in accordance with the approved SMS.)

SMM - Safety Management Manual

SMS - Safety Management System

SOG - speed over the ground

SOLAS - International Convention on the Safety of Life at Sea

SRS - Standard Risk Ship

STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended

TSS - Traffic Separation Scheme

UK - United Kingdom

UR	-	Unified Requirement
USCG	-	United States Coastguard
UTC	-	Universal co-ordinated time
UTM	-	Ultrasound Thickness Measurement
UTS	-	ultimate tensile strength
VCG	-	vertical centre of gravity
VHF	-	Very High Frequency
WB	-	water ballast

TIMES: All times used in this report are utc unless otherwise stated

SYNOPSIS

At 0200 on 27 November 2011, the 34 year old Cook Islands-registered general cargo ship *Swanland* experienced a structural failure when heading directly into rough seas and gale force winds while on passage from Llanddulas, Wales to Cowes, Isle of Wight with a cargo of limestone. The vessel sank about 17 minutes later. Two of the vessel's eight crew managed to swim clear and were rescued from a liferaft. The body of the chief officer was recovered from the sea during an extensive air and sea search but the remaining crew were not found. There was no significant pollution.

The wreck of *Swanland* was subsequently found 12 miles off the Welsh coast in a depth of approximately 80m. Sonar and underwater surveys showed that the vessel was inverted on the seabed; the hull appeared to be in one piece. The upper part of the vessel's structure had failed in the midships region, on both the starboard and port sides. The investigation identified that the major factors contributing to the structural failure were:

- The limestone was a high density cargo that had been effectively loaded as a single pile within the central section of the hold. As a result, significant stresses were generated in the vessel's midships section.

- The stresses in the midships section were exacerbated by the rough seas in which the wavelength was similar to the length of the vessel.

- *Swanland*'s longitudinal strength had probably weakened significantly over the previous 2½ years through corrosion and wastage. The maintenance and repair of the vessel had lacked focus and oversight; no structural repairs had been undertaken since 2009.

Other contributing factors included: non-compliance with the International Maritime Solid Bulk Cargo Code, insufficient loading information, a lack of effective safety management, poor quality of survey and audit, lack of oversight of the classification society by the Flag State and the financial pressures of operating this type of vessel in the current economic downturn. The investigation also identified several safety issues concerning the immersion suits and lifejackets available on board the vessel.

Sadly, none of these factors are new. *Swanland* is one of 248 general cargo ships that are known to have foundered worldwide since 2002 with the loss of over 800 seafarers; 226 of the vessels were 15 years old or more, 139 of which were 27 years old or more. Concerns surrounding the safety and high loss rates of similar general cargo ships have been repeatedly raised at the International Maritime Organization. However, progress to address the problems appears to have been slow. It is hoped that the loss of *Swanland* and her six crew will be a catalyst for the work already being undertaken by the International Maritime Organization to tackle the global issue of general cargo ship safety.

The Cook Islands has undertaken to ensure that the findings of this investigation are taken into account at the International Maritime Organization when future measures to improve general cargo ship safety and the development of goal-based standards for life-saving appliances are decided. It has also started to take action aimed at improving the quality of the ships accepted onto its register and the oversight of the recognised organisations which are authorised to act on its behalf.

Action taken by the Maritime and Coastguard Agency and a recommendation made to Lloyds Register are intended, through the Paris Memorandum of Understanding on port state control and the International Association of Classification Societies respectively, to promote and improve the safe carriage of solid bulk cargoes on general cargo ships.

Recommendations have been made to the International Naval Surveys Bureau which seek to improve the quality of the classification society's survey, audit and training regimes. Recommendations have also been made to Torbulk Limited, *Swanland*'s ship manager, that are aimed at ensuring: solid bulk cargoes are safely carried on all its vessels and; crews are familiar with and well drilled in the use of life-saving appliances on board its vessels.

Image courtesy of Robert Smith (Robenco)

Swanland

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *SWANLAND* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	Swanland
Flag	Cook Islands
Classification society	International Naval Surveys Bureau
IMO number	7607431
Type	Self-discharging general cargo ship
Registered owner	Swanland Shipping Limited
Manager	Torbulk Limited
Construction	Steel
Length overall	81m
Gross tonnage	1978
Minimum safe manning	8
Authorised cargo	None
VOYAGE PARTICULARS	
Port of departure	Raynes Jetty, Llanddulas, North Wales
Planned port of arrival	Cowes, Isle of Wight
Type of voyage	Coastal
Cargo information	2730 tonnes of Limestone
Manning	8

MARINE CASUALTY INFORMATION	
Date and time	27 November 2011 at 0200
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	52° 52.3’N 005° 04.8’W
Place on board	Hull amidships
Fatalities	6
Damage/environmental impact	Vessel lost. No significant pollution
Ship operation	In passage
Voyage segment	Mid-water
External & internal environment	Wind: south-west between Beaufort force 8 and 9 Sea state: rough to very rough Visibility: moderate Sea temperature: 12°C Darkness Tidal stream: Predicted to be 2.2kts setting to the south-south-west
Persons on board	8

1.2 BACKGROUND

Swanland was built in the Netherlands in 1977 as the general cargo ship[1] *Carebeka IX*. A copy of the general arrangement of the vessel, as built, is at **Figure 1**, which confirms that her overall length was 81 metres and her deadweight was 3137 tonnes. The vessel underwent various changes of name during her 34 years in service and was finally renamed *Swanland* in 1996. The vessel had been operated under various Flag State administrations and classification societies[2]. In 2009, *Swanland*’s

[1] There is no specific definition for a general cargo ship in the 1974 Safety of Life at Sea (SOLAS) Convention, as amended. However, a circular issued as part of the work of the IMO Marine Environment Protection Committee, MEPC.1/Circ.681, defines a general cargo ship as having:

a multi-deck or single-deck hull designed primarily for the carriage of general cargo.

[2] A classification society is a commercial organisation that provides classification and statutory services to regulatory bodies regarding maritime safety. Classification societies achieve this objective through the development and application of their own published rules and by verifying compliance with international and/or national statutory regulations on behalf of flag Administrations. As such, they are often also referred to as recognised organisations. Vessels subject to a society’s classification are referred to as being “in class”.

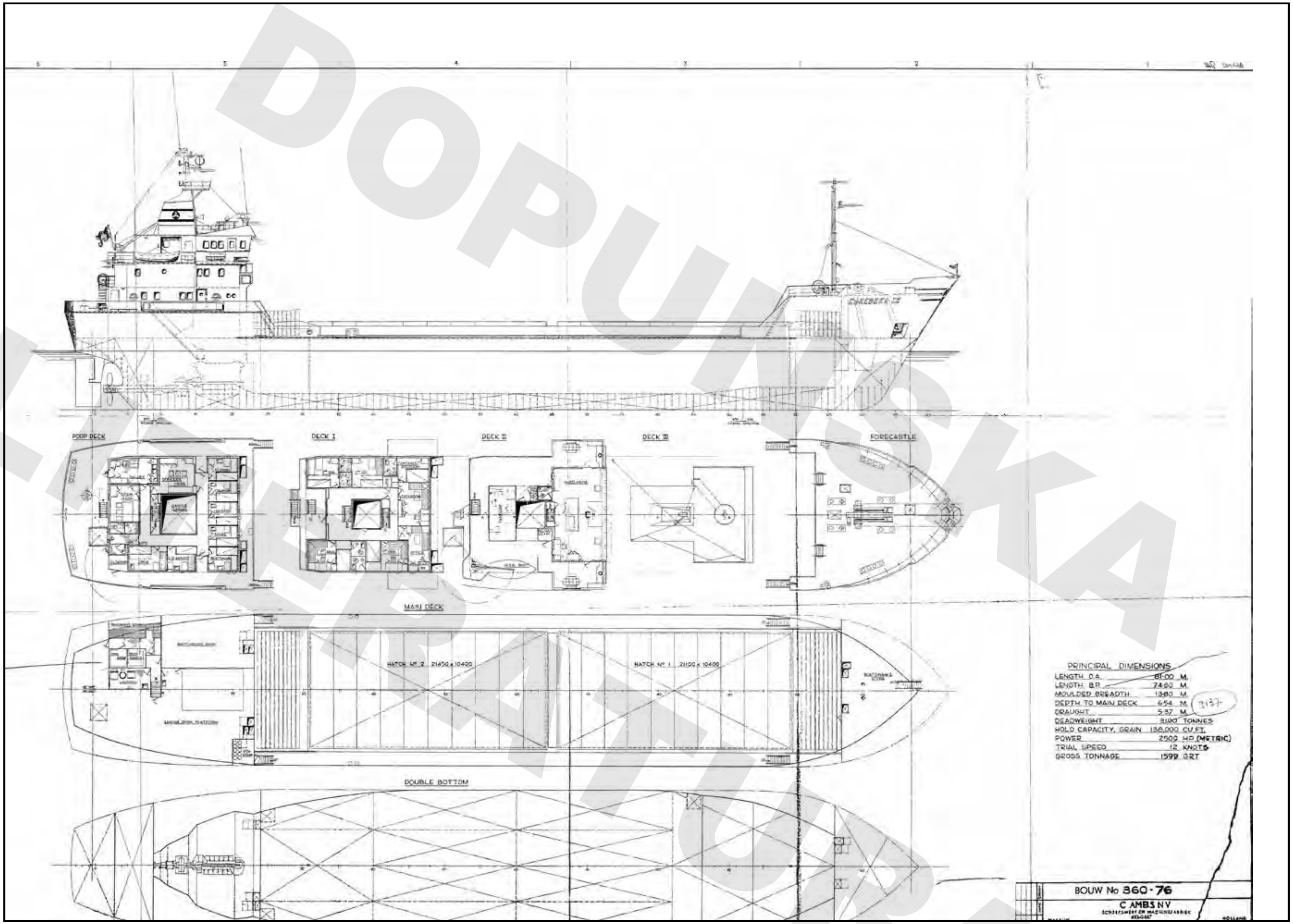


Figure 1: General arrangement of *Swanland*, as built

registration was transferred to the Cook Islands and she was entered into class with the International Naval Surveys Bureau (INSB); thereafter she remained registered in the Cook Islands and classed with INSB until the time of the accident.

In 2003, *Swanland* was modified to allow her cargo to be self-discharged, as detailed in **paragraph 1.12.7** below. This involved the fitting of a conveyor system on the port side of the main deck and a movable carriage to support a tracked excavator. **Figure 2** shows the vessel in 2010 with the self-discharge equipment fitted.

Swanland's trading pattern was driven by the spot market and she predominantly operated around the UK coastline, as well as northern Europe and the Baltic, carrying various bulk dry cargoes including limestone, salt, sand, slag and grain. Her service speed was reported as 10 knots. At the time of the accident, the vessel had a crew of eight, all of whom were Russian.

1.3 NARRATIVE

1.3.1 Events prior to departure

At 0725 on 26 November 2011, *Swanland* arrived alongside at Raynes Jetty, Llanddulas, North Wales in a ballast condition with up to 680 tonnes of sea water in her water ballast (WB) tanks. It was routine practice for the ship's duty engineer to begin to pump out the ballast shortly after the vessel arrived alongside. The wind was light and the height of tide was 2.6m and rising.

Swanland's chief officer had prepared a loading plan **(Figure 3)** for the intended cargo of 2730 tonnes of Ministry of Transport (MOT) Type 1 Granular Sub Base (GSB) Limestone[3], and this plan was submitted to the jetty supervisor on arrival. To allow the cargo to be loaded, six or seven of the ten aft hatch covers of the hold were opened, along with five of the hatch covers on the hold's forward section.

Loading commenced at 0732 and was in accordance with the distribution and order of loading indicated in the loading plan. Two piles of limestone were loaded towards the centre of the cargo hold, one pile either side of a transverse cross beam at main deck level. The aft pile was loaded first using the jetty's moveable loading arm. The loading continued until 1780 tonnes of limestone had been loaded to form the aft pile; the top of the pile was approximately 300mm below the top of the cargo hold hatch coaming. The loading arm was then moved to a position forward of the vessel's transverse cross beam, and the same process repeated to form the forward pile of 930 tonnes of limestone. The final 20 tonnes of the cargo was then added to the aft pile to trim the vessel upright. The tops of both piles of limestone were reported to be level across the width of the hatch opening.

The loading of *Swanland* was completed at 1025 and draughts of 5.3m forward and 5.4m aft were reported. The agent completed the bill of lading, which was signed by the master **(Annex A)**.

[3] MOT Type 1 GSB Limestone is a crushed aggregate material **(**see **paragraph 1.19)**

Image courtesy of Richard Wisse/www.richard-photography.nl

Figure 2: *Swanland* underway in a ballast condition in 2010

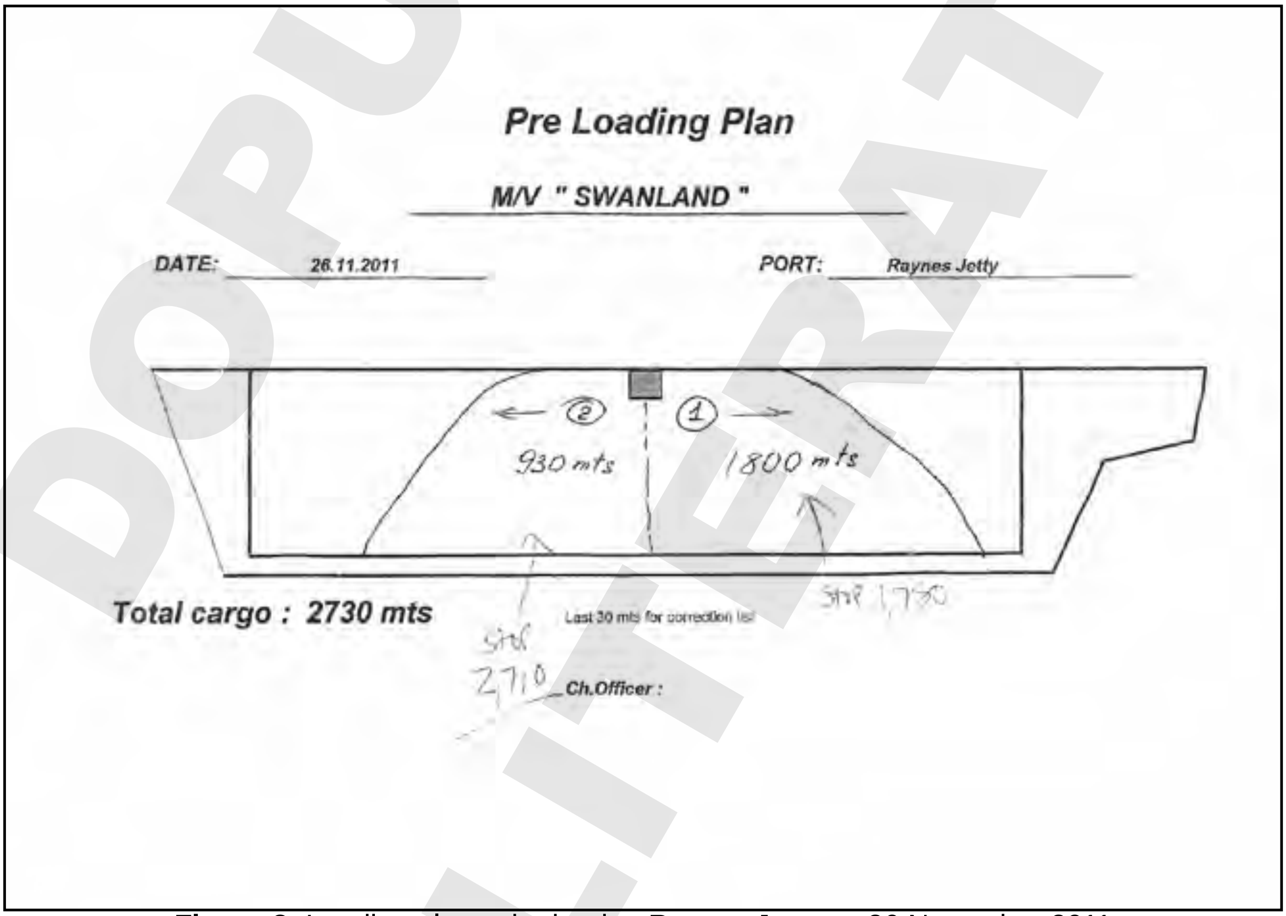


Figure 3: Loading plan submitted to Raynes Jetty on 26 November 2011

Before departing from Raynes Jetty, *Swanland*'s owner telephoned the master. The conversation included a discussion on the weather forecast, which predicted winds of up to Beaufort force 9. The master confirmed during the conversation that he was content to sail and proceed on passage as planned. The vessel was scheduled to arrive in Cowes, Isle of Wight at 1800 on 28 November 2011.

1.3.2 Foundering

At 1045, *Swanland* departed from Raynes Jetty with a minimum under keel clearance of 4m **(Figure 4)**. Once clear of the jetty, the crew closed and secured the hatch covers **(Figure 5)**. Although the weather conditions were good and the sea was calm, the crew were aware that worsening sea conditions were forecast. The crew therefore tidied up any loose equipment on the deck before returning into the accommodation. The ballast tanks were not dipped.

Figure 6 shows *Swanland*'s track, based on the Automatic Information System (AIS) data transmitted by the vessel. This confirms that the vessel's initial track was close to the coastline around the north of Wales and the island of Anglesey; the vessel did not transit through the Off Skerries Traffic Separation Scheme (TSS).

At 2000, the master took over the bridge watch from the chief officer. At this point, *Swanland* was rolling and pitching moderately but her movement was not uncomfortable. Autopilot was used to steer the vessel on a heading of 200°, and *Swanland* was averaging a speed over the ground (SOG) of about 2 knots with the engine at 'full ahead'. Although the vessel was being operated at full ahead, only 75% of the engine's power was reportedly available, due to a pre-existing problem.

From 2000, the force of the south-westerly wind increased and the sea conditions worsened, which caused the vessel's speed to fluctuate. At approximately 2345, the master altered the course set on the autopilot to starboard to approximately 210°.

At midnight, the second officer took over the bridge watch from the master. During the watch handover, the master explained to the second officer that everything was going to plan but that the wind was now force 8 and occasionally force 9. The master also advised that if the wind veered to the west, the second officer should adjust the vessel's heading to prevent the vessel from rolling excessively.

At the time of the watch handover, the sea and swell, which was approaching from fine off *Swanland*'s port bow, was estimated to be between 5m and 6m in height. The tidal stream was predicted to be setting to the south-south-west at a rate of around 2 knots and the vessel was making good a SOG of approximately 6 knots. No additional lookout was posted on the bridge.

During the second officer's watch, the master and the other crew members were asleep in their cabins. The wind remained from the south-west and *Swanland* was pitching into the oncoming seas, but she was not slamming[4]. The vessel was

[4] Slamming occurs when a vessel's bow or stern emerges from a wave in rough seas, then re-enters the wave with a heavy impact or "slam" as the hull structure comes into contact with the water surface. A vessel with such excessive motions is subject to very rapidly developed hydrodynamic loads and experiences impulse loads with high-pressure peaks during the impact.

Image courtesy of Jane Baker from Abergele

Figure 4: *Swanland* shortly after departing Raynes Jetty, 26 November 2011 (photo taken from Rhos-on-Sea, with Point of Ayr headland in background)

Image courtesy of INSB

Figure 5: View of open cargo hold hatch covers and cargo hold loaded on a previous occasion

Reproduced from Admiralty Charts: BA 1410, 1411, 1826, 1970, 1971 by permission of the Controller of HMSO and the UK Hydrographic Office

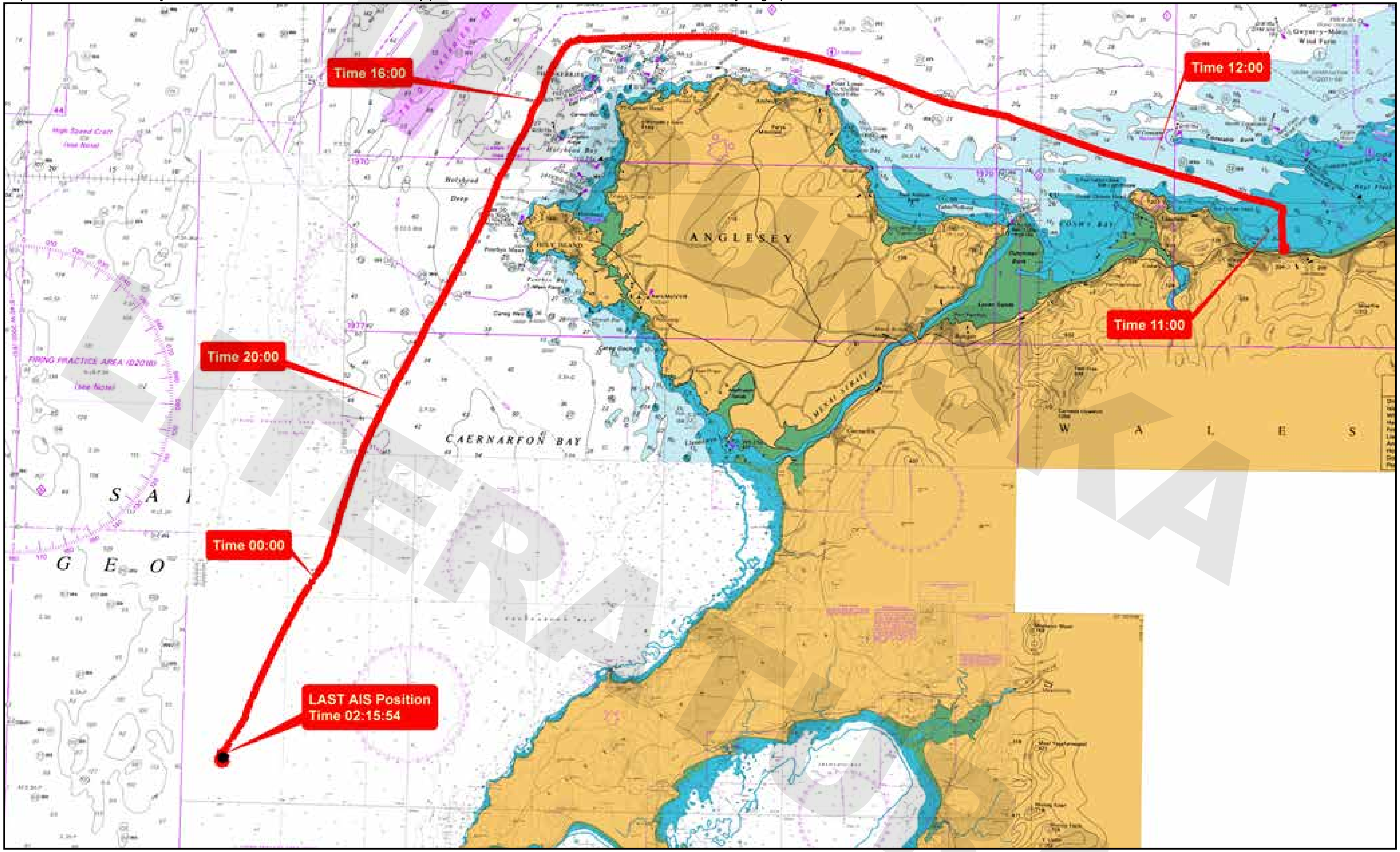


Figure 6: Chart showing track of *Swanland* on 26 to 27 November 2011

occasionally rolling up to an angle of approximately 6°, and also yawing between 10°and 15° either side of the autopilot heading. *Swanland*'s SOG and course over the ground (COG) continued to fluctuate in the conditions, as shown in **Table 1**.

Time (UTC)	Speed Over Ground (knots)	Course Over Ground (Degrees)	Heading (Degrees)
01:55:29	5.2	219.6	217
01:56:00	6.1	186.8	215
01:56:30	4.9	213.3	220
01:57:03	6.4	199.9	220
01:57:33	4.5	208.4	217
01:58:03	4.4	208.5	215
01:58:34	5.6	193.4	213
01:59:06	6	198.2	217
01:59:43	4.7	197.1	222
02:00:23	5.2	209.3	222
02:00:53	3.6	198.1	215
02:01:24	5.9	193.8	212
02:01:56	3.9	186.4	190
02:02:26	5.2	195.7	150
02:02:56	5.2	160.1	121

Table 1: AIS data between 0155 and 0203

At approximately 0200 **(Figure 7)**, *Swanland* struck a large wave forward. As her bow dipped into the trough behind the wave, it struck and was lifted by a second large wave. At the same time, the second officer saw the bulwark on the starboard side in the vicinity of the midships section fold outboard **(Figure 8)**; at least one of the hatch covers in the same area had also lifted. The second officer switched on the deck lights and saw that the bow was higher than normal. He immediately realised that *Swanland* had suffered a structural failure and alerted the vessel's crew by sounding seven short rings followed by one long ring on the general alarm. As the alarm was being sounded, another large wave broke over the bow and covered the main deck and hatch covers.

Following the sounding of the general alarm, the master telephoned the bridge to find out what was happening. The second officer informed him that there was '*a breakage in the middle of the vessel*'. The master, who was only half-dressed, immediately went to the bridge and saw the damage to the bulwark and hatch cover. At 0201, the master broadcast a 'Mayday' message via Very High Frequency (VHF) radio, channel 16 **(Table 2)**; he did not transmit a Digital Selective Calling (DSC) distress alert[5].

The 'Mayday' message was heard by the Maritime Rescue Co-ordination Centre (MRCC) Holyhead. A coastguard operator immediately contacted *Swanland.*

[5] DSC is part of the Global Maritime Distress and Safety System (GMDSS) and facilitates the transmission of pre-defined digital messages via several radio frequency bands.

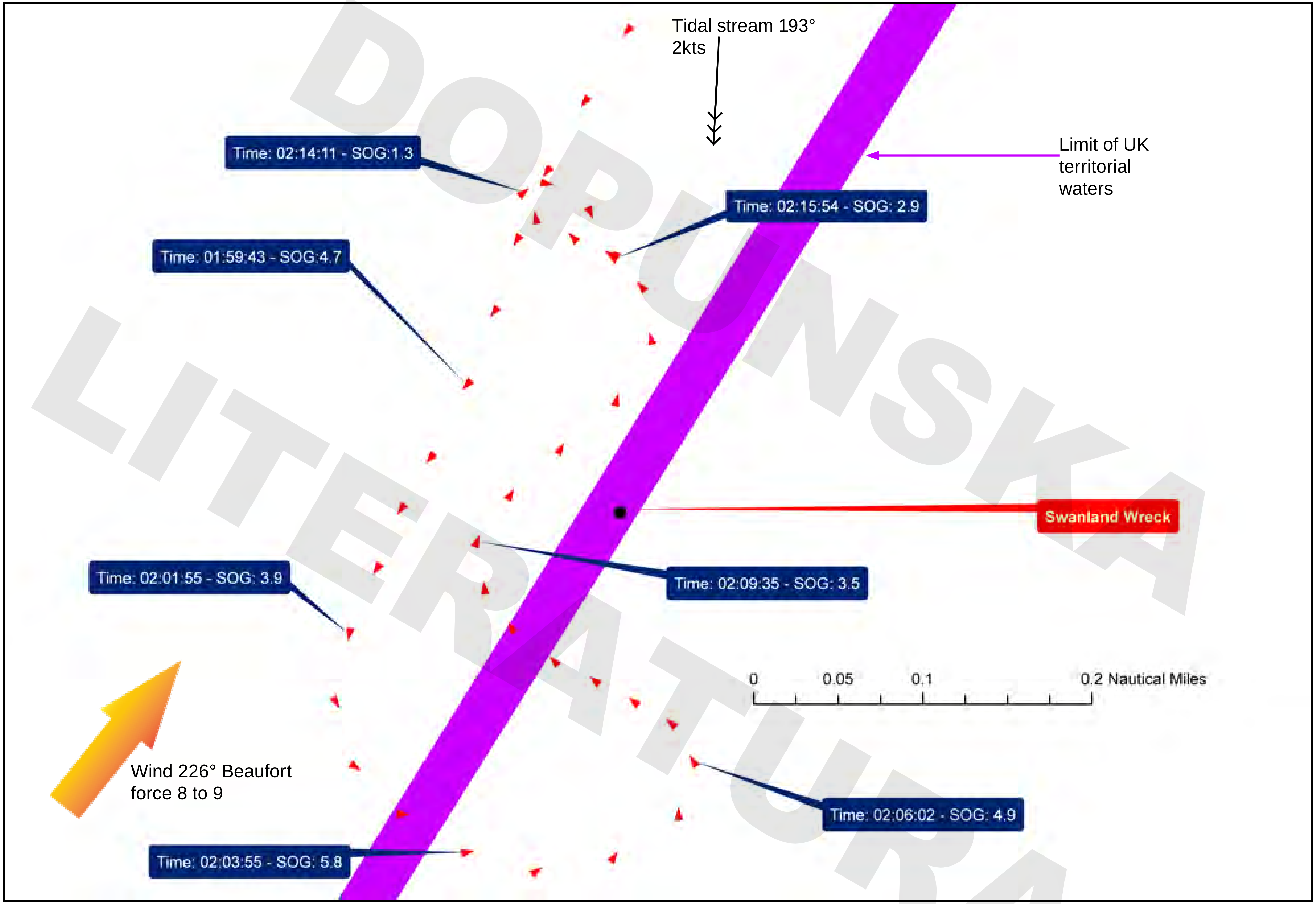


Figure 7: Chart showing track of *Swanland* prior to vessel foundering

Figure 8: View looking forward from wheelhouse, annotated to show approximate area of initial damage

Table 2: Transcript of communications between *Swanland*'s master and Holyhead MRCC from 0201 to 0206

Time	Transmission by	Transcript
02:01:33	*Swanland*	Mayday, Mayday, Mayday. Mayday, Mayday, Mayday. This is *Swanland*, *Swanland* over
02:01:57	Holyhead MRCC	Mayday.
02:02:03	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard over.
02:02:09	*Swanland*	Holyhead Coastguard. This is motor vessel *Swanland* Mayday. We are in position 052° 52.05 North 05° 055 East – West, sorry. We have a broken hull, it's a broken hull. It's ah, over.
02:02:41	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Can you confirm your position over?
02:02:49	*Swanland*	Our position 52° 52.006 North 005°05.03 West over.
02:03:07	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Can you tell me again your problem over? , with the vessel.
02:03:16	*Swanland*	Sorry, say again please.
02:03:18	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Can you tell me the problem with your vessel over?
02:03:27	*Swanland*	We are in closed condition and our hull is cracked. Our hull is cracked in the middle of the ship. Over.
02:03:42	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. How many persons are on board over?

Time	Transmission by	Transcript
02:03:50	*Swanland*	We have eight persons on board over.
02:03:54	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. And what type of vessel are you? Over.
02:04:01	*Swanland*	Dry cargo, vessel 81 metres long over.
02:04:09	Holyhead MRCC	Mayday *Swanland*. Holyhead Coastguard. Are you carrying any cargo over?
02:04:17	*Swanland*	Yes we have cargo of limestone, limestone almost three thousand tonnes over
02:04:37	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Can you tell if you have if you have an ingress of water? Over.
02:04:47	*Swanland*	I don't know for a moment but I think we have. I think we have because it's a …just a second.
02:05:02	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Yes, if you can get someone to check and to come back to us. Do you have a liferaft on board over?
02:05:15	*Swanland*	Yes, we have liferaft, we have liferaft ... and I, I think we have ingress cos its quite good damage of the ship over.
02:05:34	Holyhead MRCC	Mayday *Swanland*. This is Holyhead Coastguard. Do you believe you have hit something or have you been in collision with a vessel or is it weather related over?
02:05:48	*Swanland*	Holyhead it was not collision, just weather related damage cos its heavy swell and a good wave, good wind over.

In between the radio exchanges with the coastguard, the master ordered the second officer to turn the vessel around so that the waves would break over the stern. The second officer selected hand-steering, started the second steering pump and then began to turn *Swanland* hard to port. At about the same time, the chief officer, the bosun, the chief engineer, the second engineer, and the able bodied seaman (AB) arrived on the bridge. The chief engineer had already been down to the engine room to check the condition of the machinery.

As the vessel turned, the bow rose further and the damage to the hull appeared to worsen. At approximately 0203, by which time the vessel had been turned beam on to the sea **(Figure 7)**, large waves broke on top of the hatches and water entered the hold through the gaps where the hatch covers had lifted. There were no reports of any of *Swanland*'s automatic alarms, such as the bilge alarms fitted in the hold, sounding.

While the master was speaking with the coastguard, the crew who had assembled on the bridge returned below to collect warm clothing. On their return to the bridge, the chief officer and the AB collected six immersion suits from their stowage by the stairway, two decks below the bridge; they were unable to carry any more than six immersion suits between them.

The bosun, the AB and the chief officer donned immersion suits, then the latter took over from the second officer on the helm. The second officer went to his cabin, where he changed his footwear and collected a lifejacket. On returning to the bridge, the second officer also donned an immersion suit. He noticed that the suit being worn by the chief officer was of a different type to the other five immersion suits, as it required a lifejacket to be donned before entering the water. He therefore handed his lifejacket to the chief officer. The chief officer was seen to don the lifejacket, but it is not known if he fastened it.

Meanwhile, the master had collected a bag containing documents from his cabin and he too started to don an immersion suit. By this time, *Swanland* was moving very slowly, with the helm in the 'midships' position.

The second officer collected the two Search and Rescue Transponders (SART)[6] which were stowed on the port and starboard sides of the bridge. Due to the design of the gloves fitted on his immersion suit, the second officer had to use his teeth to pull the cord in order to activate the transponders.

After checking the radar display to ensure that the SARTs were operating, the second officer joined the chief officer, the bosun, and the AB on the port bridge wing. The master, who had only partially donned his immersion suit, remained on the bridge. The whereabouts of the chief engineer, the second engineer and the cook, at this stage were unknown; the latter was not seen at any stage during the emergency.

The second officer asked the master whether the crew should deploy the liferafts. The master confirmed that they should. Accordingly, the chief officer, assisted by the bosun and the AB, released the strap used to secure the liferaft on the port side of the bridge deck.

[6] A SART is a self-contained, waterproof radar transponder which is used to locate a survival craft or a distressed vessel by creating a series of dots on a rescuing ship's 9 GHz X-band (3 cm wavelength) radar.

The sea continued to enter the hold and, as the vessel's freeboard reduced, debris from the main deck floated towards the crew on the port side of the bridge deck. Before the crew were able to lower the liferaft into the water, a wave covered the bridge deck and knocked over the bosun and the chief officer, who fell on top of the second officer. The second officer hit his head on a handrail. The AB managed to hold on to part of the ship's structure but he quickly let go when he realised that *Swanland* was sinking.

The AB and the second officer soon surfaced, but they did not see or hear the vessel or any of the other crew. However, the second officer heard a liferaft inflating close by and swam towards it. He pulled himself into the liferaft and then helped the AB on board. The AB had swum approximately 5m to reach the liferaft. The men started shouting and whistling to try to attract the attention of any other survivors.

The second officer and the AB became increasingly distressed when none of the other crew responded to their calls. Their anxiety increased further when a rope, which they believed to be the liferaft's painter, became taut. The survivors were concerned that the liferaft was being pulled under the water so they searched the liferaft and eventually found a knife, which the second officer used to cut the rope. Shortly after, the two men saw the lights of a nearby vessel that had turned towards them.

The interior light inside the liferaft then extinguished. The second officer realised that the liferaft should have carried a torch and parachute flares, but he could not find them in the dark. He eventually found them with the aid of the light on his mobile telephone. The second officer switched on the torch and starting waving it outside the liferaft's opening while the AB, who had started to become seasick, released a red parachute flare. Both survivors had difficulty using the equipment supplied in the liferaft due to the design of the gloves fitted to the immersion suits.

1.3.3 Search and rescue

At 0209, MRCC Holyhead transmitted a 'Mayday' relay message. In response, a number of vessels volunteered to assist. The closest vessel was *Bro Gazelle*, a tanker, which had earlier overtaken *Swanland* and was within 4nm of the cargo ship. *Swanland*'s last transmission on AIS was at 0215.54 **(Figures 6** and **7)**, when her SOG was recorded as 2.9 knots, her COG was 143.3° and her heading was 193°. At 0217, *Bro Gazelle*'s master reported to MRCC Holyhead that he could no longer see the lights on board *Swanland* that he had seen 2 minutes earlier; her radar echo had also disappeared from the radar display. MRCC Holyhead immediately tried to contact *Swanland* via VHF radio but was unable to do so.

An extensive air and sea search was promptly commenced involving four Royal National Lifeboat Institution (RNLI) lifeboats and several search and rescue (SAR) helicopters. *Bro Gazelle* was quickly on the scene and at 0240 the vessel's crew located both of *Swanland*'s liferafts. *Bro Gazelle* was manoeuvred close to one of the liferafts to provide a lee. At 0255, the red flare fired by the AB was seen by the tanker's crew. It had been launched from the furthest liferaft, which was about 300m away.

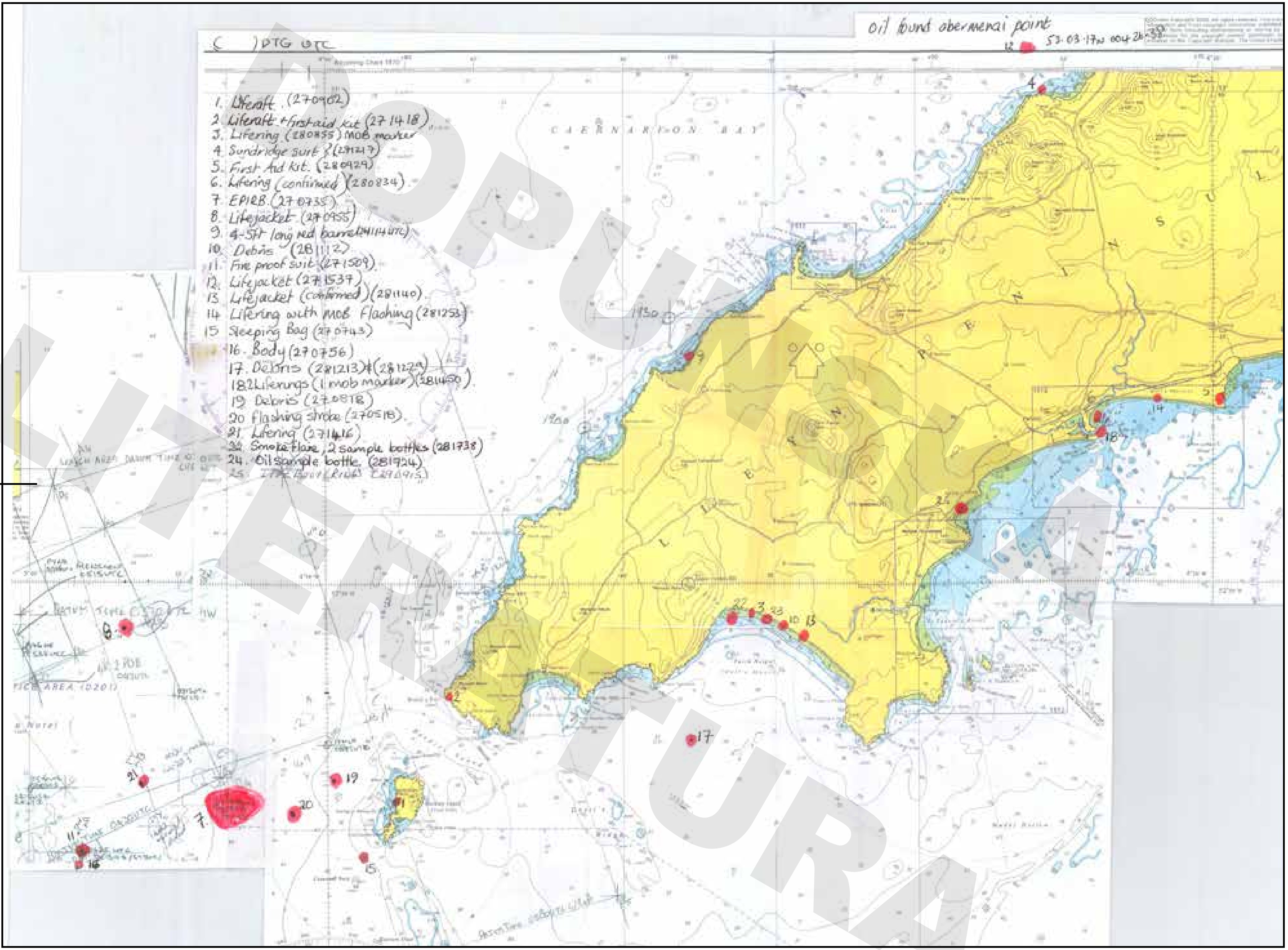
The sea conditions were too rough to launch *Bro Gazelle*'s rescue boat but at 0315, R122, the first of the rescue helicopters, arrived on scene and soon spotted the second officer and the AB in the liferaft **(Figure 9)**. Another vessel, *Monsoon*, also arrived on scene to assist with the search. Having seen that the second officer and AB did not appear to be in any imminent danger, R122 continued to search the immediate area for other survivors. A winchman was lowered down to the other liferaft, but this was found to be empty. The crew of R122 did not see any of the other members of *Swanland*'s crew and R122 returned to the liferaft containing the survivors. By 0406, the second officer and the AB had been winched on board R122, which then flew them to its base at Royal Air Force (RAF) Valley; both of the men were cold but uninjured.

The search for the six missing crewmen continued among a large amount of floating debris, the positions of which were plotted on chart British Admiralty (BA) 1971 by MRCC Holyhead **(Figure 10)**. At approximately 0810, the body of the deceased chief officer was sighted (item 16 on **Figure 10**) and was winched on board rescue helicopter, R117, based in Waterford, Ireland. The chief officer was found lying on his back in the water, wearing an immersion suit. The suit was fully zipped up but the chief officer was not wearing a lifejacket.

A postmortem examination later found that the chief officer had died due to drowning. Toxicology tests identified only small traces of two prescription drugs. The bodies of the master, chief engineer, second engineer, bosun, and the cook have not been found.

Figure 9: Survivor in the liferaft

Image courtesy of Maritime and Coastguard Agency/MRCC Holyhead and Reproduced from Admiralty Chart BA1971 by permission of the Controller of HMSO and the UK Hydrographic Office



Position of *Swanland*'s last AIS transmission is off the chart

Figure 10: MRCC Holyhead plot of debris field

Swanland's Emergency Position Indicating Radio Beacon (EPIRB), which had activated shortly after the vessel foundered, was also located (item 7 on **Figure 10**) and recovered by one of the rescue helicopters. The seaborne search for the missing crewmen was terminated at 1100 on 28 November.

1.4 ENVIRONMENTAL CONDITIONS

The surface analysis chart for 0000 on 27 November is shown at **Figure 11**. At 0620 on 26 November, the Meteorological Office (Met Office) issued its 24 hour shipping forecast which was received on board *Swanland* and included:

> *'Lundy, Fastnet, Irish Sea, W or NW 7 to sev gale 9, back S or SW 5 or 6. Mod or rough, occnl very rough, Shwrs, mod or good' ….. 'Outlook flw 24 hours: gales or sev gales exp in all areas'. [sic]*

In order to determine the actual environmental conditions, the MAIB commissioned a report from the Met Office, extracts of which are at **Annex B**. The report concluded that:

> *All the available evidence indicates a rough passage for the MV Swanland as she sailed southwards in the Irish Sea, west of Gwynedd at 0200 UTC on the 27th November 2011. She would have met a south westerly gale force wind with gusts of around 50 knots. Seas would have been rough, perhaps very rough with a significant wave height of around 4.0 metres. Waves would have been steeper than normal due to an opposing tidal current of around 2 knots. Maximum individual waves (crest to trough) within a 3 hour sampling period could have reached 7.6 metres.*

Table 5.1 from **Annex B** states that at 0200, the predicted waves would have had a height of 4m, a period of 8.2 seconds and a wavelength (from peak to peak) of 105m[7].

Visibility was moderate and the sea water temperature was about 12° Celsius.

1.5 UNDERWATER SURVEYS

1.5.1 Location and initial underwater survey

On 1 December 2011, the Commissioners of Irish Lights' vessel, *Granuaile*, established the location of *Swanland* in position 52° 52.15N 005° 04.78'W during a multi-beam sonar survey **(Figure 12)**. The sonar image appeared to indicate that the vessel was sitting upright on the seabed.

The following day, a VideoRay mini remotely operated vehicle (ROV) was deployed from *Granuaile* to inspect the wreck. The quality of the ROV footage was affected by the strong tidal currents and restricted visibility. However, the mini-ROV identified that *Swanland* was in fact inverted on the seabed and there appeared to be a significant structural failure on the starboard side of the main hull shell plating in way of the load line mark **(Figures 13a** and **13b)**. The mini-ROV was able to briefly enter

[7] Paragraph 4.9 at **Annex B** confirms that although Table 5.1 of the Met Office report includes predicted wave data for both waves generated by the wind and the swell, the wavelength of the wind wave is considered the most appropriate. This is because at the time and location of the accident, most of the wave energy was composed of the wind wave.

the cargo hold through the failed starboard shell plating and capture images of the internal structure. This included areas of the tank top plating (forming the bottom of the hold), which appeared to be largely intact **(Figure 14a)**, although a large crease was observed in the plating in one area **(Figure 14b)**, where the plating had been pushed up in the hold. Internal footage was also taken of the main structural failure on the starboard side of the hull **(Figure 15a)**. **Figure 15b** appeared to show a hold transverse frame detached from the buckled shell plating; **Figure 15c** showed a small area of the frame that appeared to be corroded or wasted in way of the connection to the shell plating. Approximately 14 minutes of video footage of the wreck was obtained prior to the mini-ROV's cable snagging and parting.

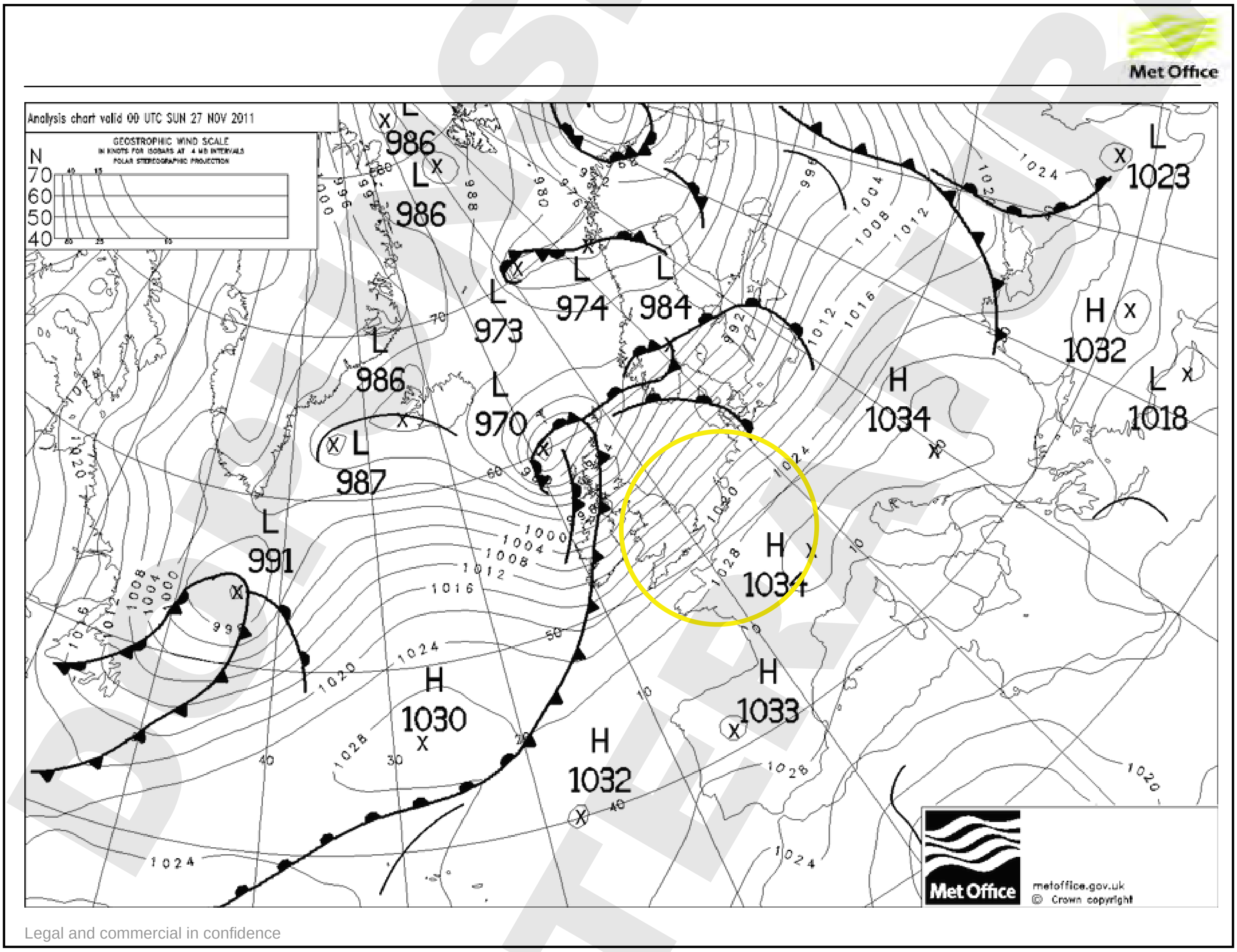
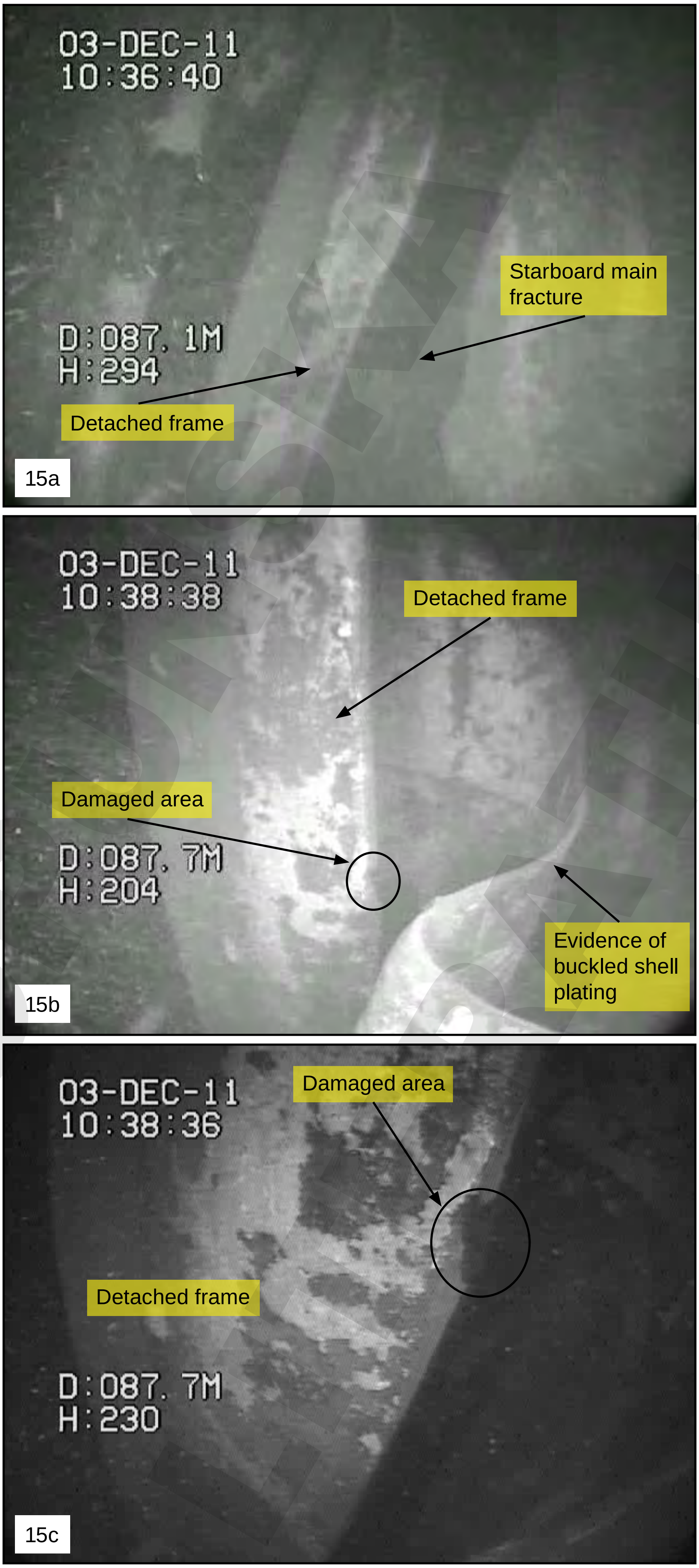


Figure 11: Surface Analysis Chart for 0000 on 27 November 2011



Figures 15a, 15b and **15c:** Stills from MiniROV showing the structural failure on starboard side (from inside cargo hold)

1.5.2 Detailed underwater survey

On 9 January and 6 February 2012, Subsea Vision Ltd conducted multi-beam sonar surveys of the wreck on behalf of the Marine Accident Investigation Branch (MAIB) and the Maritime Cook Islands (MCI). A copy of the Subsea Vision survey report is at **(Annex C)**.

The multi-beam surveys confirmed that the wreck was lying in a north to south orientation **(Figure 16)** and was inverted in one piece **(Figures 17a** and **17b)**. A fold was evident in the double bottom plating near to midships with the previously straight keel rising upwards from the fold towards the vessel's stern and bow. A large item of debris was also seen on the seabed, 145m to the north of the main wreck.

On 6 and 7 February 2012, Subsea Vision Ltd conducted three underwater surveys of the wreck using a Seaeye Falcon ROV in a depth of approximately 80 metres of water. Strong tidal currents were again experienced, resulting in each ROV survey being restricted to around 1 hour's duration at slack water. However, even then, the ROV's manoeuvrability was affected by the current. Visibility was impaired by suspension in the water column, and at times was reduced to approximately 0.5m.

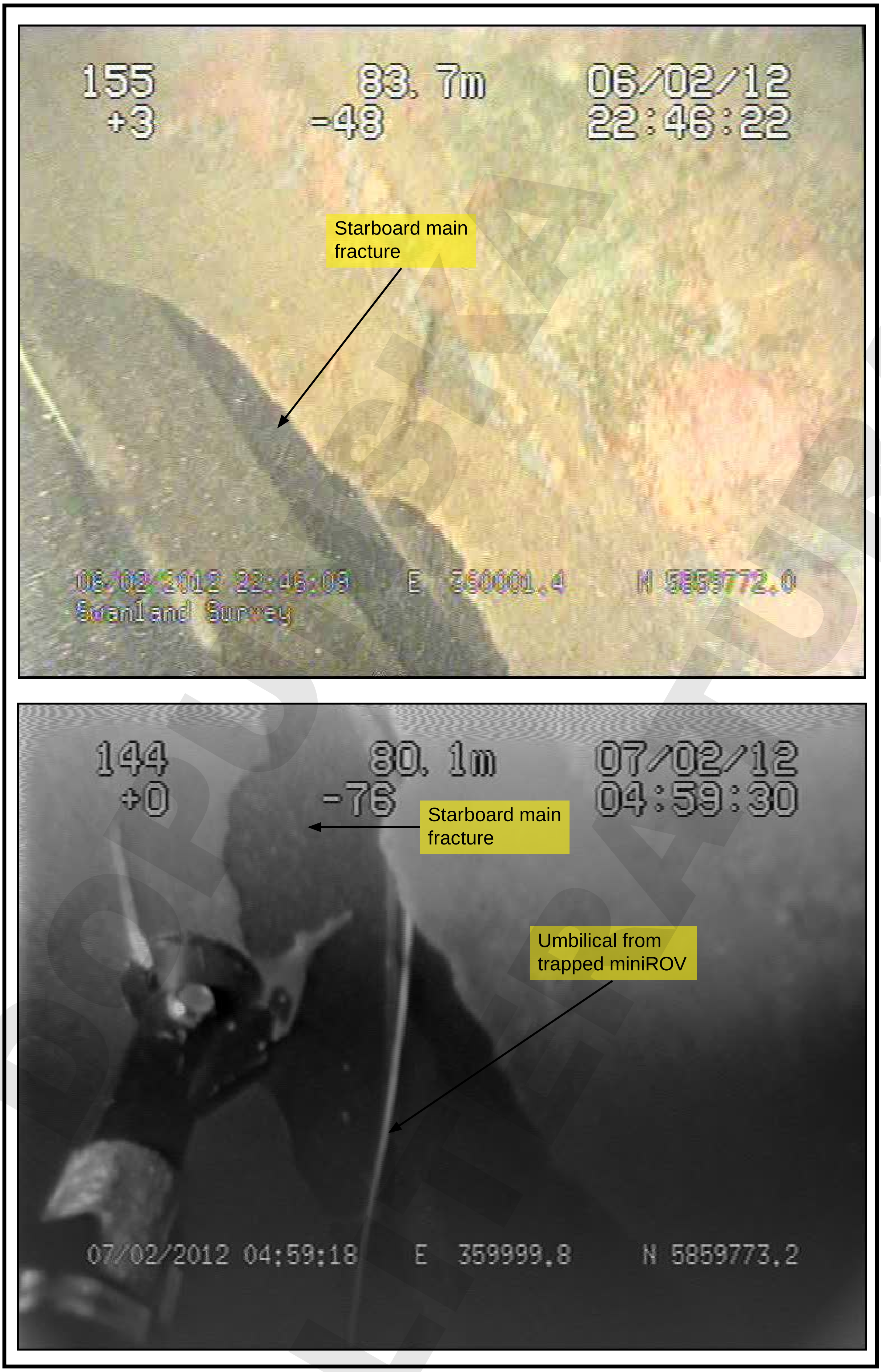
Given the visibility, tidal conditions, and the length of the ROV umbilical in the water column, it was not possible to view all areas of the wreck. In addition, as the wreck was inverted, the main deck plating was inaccessible, with sections either embedded in the seabed or missing due to the damage sustained when *Swanland* sank. It was also not possible to recover any samples of evidence from the wreck due to the limited capability of the ROV.

The ROV obtained detailed footage of the main fracture in the starboard shell plating near to the load line mark **(Figures 18a** and **18b)**. The fracture appeared be largely in the shape of an inverted "V", with the vertex in way of a rubbing bar above the bilge keel **(Figures 19a**, **19b** and **20)**. Areas of the shell plating in way of the fracture appeared to be severely folded or buckled **(Figures 21a**, **21b** and **21c)**, while there appeared to be evidence of frames within the hold having become detached from the shell plating **(Figures 22a** and **22b)**. A section of distorted bulwark plating **(Figures 23a** and **23b)** was on the seabed, close to the starboard fracture.

Footage was also obtained during the surveys of a corresponding fracture on the port side of the vessel's hull, again near to the load line mark **(Figures 24a**, **24b**, **24c** and **24d)**. This fracture also appeared to be in the form of an inverted "V", with the vertex approximately in way of the rubbing bar above the bilge keel **(Figure 25)**. The shell plating adjacent to the port side fracture was generally less folded than on the starboard side.

As suggested by the multi-beam sonar images at **Figures 16a** and **16b**, the vessel's bottom plating was found to be largely intact, albeit with a significant crease running transversely across the vessel between the two main areas of structural failure **(Figures 26a**, **26b** and **26c)**. Two structural members were observed protruding from the wreck in way of this crease **(Figures 27a** and **27b)**; the structural members appeared to be uncoated.

The only other significant damage observed to the hull was near to the vessel's bow in two specific areas. A small hole was observed on the port side in way of No.1 Port WB double bottom (DB) tank, where a section of the shell plating had appeared



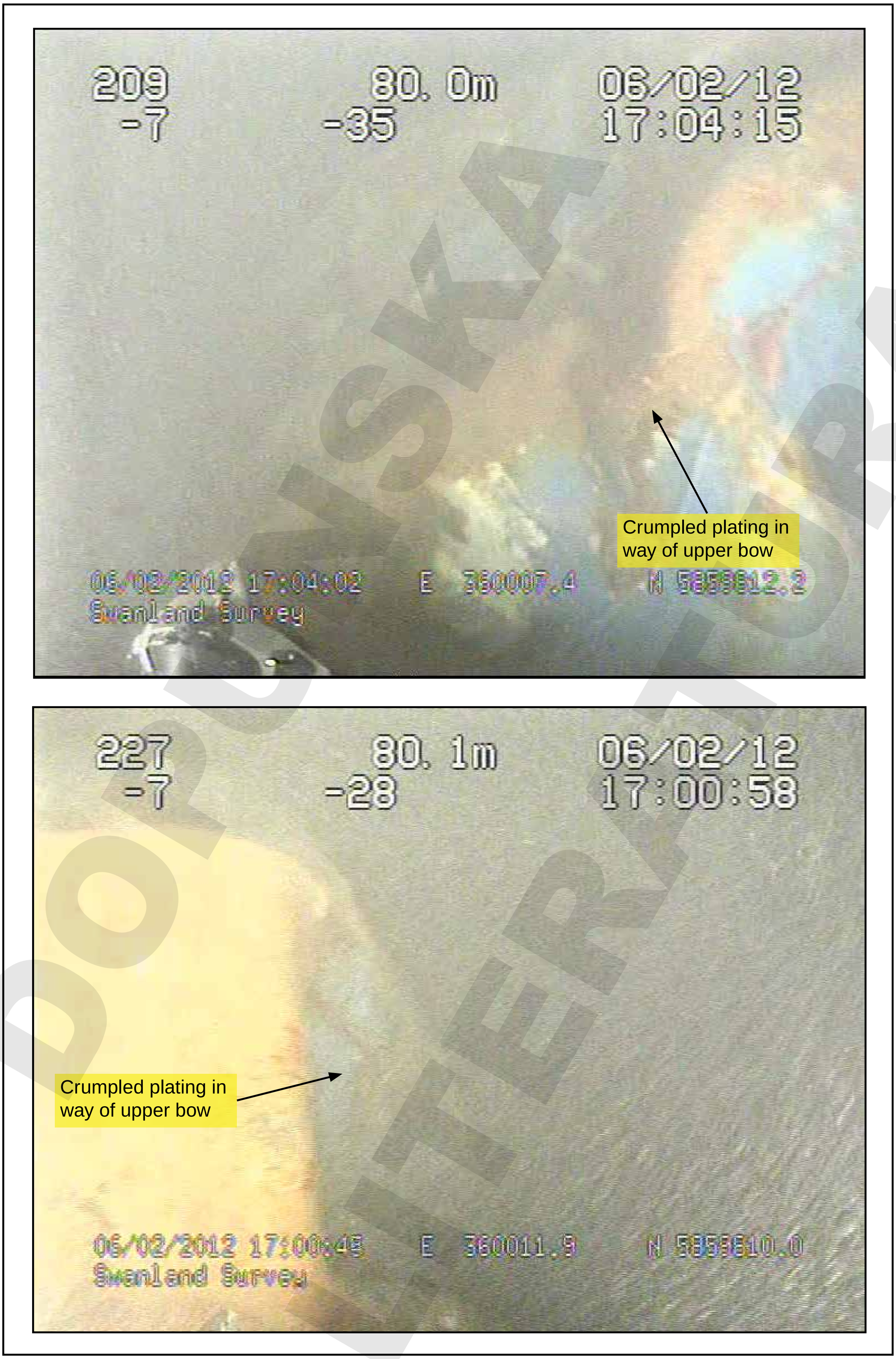
Figures 18a and **18b:** Stills from ROV footage showing damage close to the starboard load line mark

Image courtesy of Dennis Shaddick

Figures 19a and **19b:** *Swanland* in 2002 showing location of rubbing bar above bilge keel

Image courtesy of Subsea Vision for MAIB

Figure 20: Still from ROV footage showing ‘V’ shaped fracture in way of the rubbing bar above the starboard bilge keel



Figures 30a and **30b:** Stills from ROV footage showing crumpling of the top of the stem and bulwarks

1.6 THE CREW

1.6.1 General

Swanland's crew were all Russian nationals and were employed via the Liepaja Trading and Shipping Agency Limited (Ltd) based in Latvia. They were employed on 4-month contracts, but this duration could be varied.

1.6.2 The deceased

The master, Yury Shmelev, was 44 years old and had sailed on *Swanland* since 2006 as the chief officer. Recently promoted, this was his first contract as master and he had joined the vessel on 29 June 2011. He held a STCW[8] II/2 Certificate of Competency endorsed by MCI and had gained practical ship-handling experience on board *Swanland* under the guidance of previous masters. He spoke good English.

The chief officer, Leonid Safonov, was 50 years old and had sailed on board *Swanland* as an AB in 2006. In 2010, he joined the vessel as chief officer for the first time; he joined *Swanland* for the last time on 29 June 2011.

The chief engineer, Gennadiy Meshkov, was 52 years old and had joined the vessel to start his 11th contract on board since 2004 on 19 March 2011.

The second engineer, Mikhail Starchevoy, was 60 years old and had joined the vessel to start his sixth contract on board since 2006 on 20 September 2011.

The bosun, Sergey Kharchenko, was 51 years old and had joined the vessel to start his ninth contract on board since 2004 on 15 October 2011.

The cook, Oleg Andriets, was 49 years old and had joined the vessel on 19 May 2011. He had previously sailed on other ships managed by Torbulk Limited (Torbulk) since 2006. However, this was his first contract on board *Swanland*.

1.6.3 The survivors

The second officer was 27 years old and joined *Swanland* for his second contract on board on 15 October 2011. The AB was 48 years old and joined the vessel on 5 August 2011.

1.7 VESSEL OVERVIEW

Swanland's keel was laid on 27 July 1976, and she entered service on 2 March 1977 as *Carebeka IX*. The vessel was built by Scheepswerf Amels B.V. in the Netherlands as hull number 360. **Table 3** (overleaf) summarises the vessel's various names, Flag State administrations and classification societies during her 34-year service life.

Swanland had only one sister vessel, *Carebeka VIII,* which was built in 1975 at the same shipyard as hull number 352. In December 1982, *Carebeka VIII* grounded and was subsequently lost off the west coast of Spain.

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[8] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended.

Year	Name	Flag State	Classification Society
1977	*Carebeka IX*	Netherlands	Lloyd's Register
1983	*Elsborg*	–//–	–//–
1987	–//–	–//–	Bureau Veritas
1988	*Artemis*	Malta	–//–
1990	–//–	Cyprus	–//–
1994	*Elsborg*	–//–	–//–
1996	*Swanland*	Barbados	–//–
1997	–//–	–//–	Lloyd's Register
2009	–//–	Cook Islands	International Naval Surveys Bureau

Table 3: Summary of names, Flag States and classification societies

1.8 VESSEL OWNERSHIP

1.8.1 Swanland Shipping Limited

In 1996, *Swanland* was purchased by Swanland Shipping Limited. The company was operated by two shareholders with 72 and 28 percentage stakes respectively. The majority shareholder also owned the general cargo vessel, *Swan Diana* **(Figure 32)**, which had also been fitted with self-discharge equipment similar to that fitted on board *Swanland*. The concept and design of this equipment was developed by the majority shareholder to provide additional operational flexibility for both vessels.

Since *Swanland*'s modification in 2003, the majority shareholder had taken responsibility for arranging the vessel's cargoes and planning the vessel's movements, as well as acting as the agent in some ports (but not Raynes Jetty). He was also regularly involved in arranging repairs to the self-discharging equipment, including sourcing spare parts for the conveyor and excavator. The majority shareholder frequently visited *Swanland* and was in almost daily contact with both her master and her technical managers, Torbulk Limited (Torbulk).

The majority shareholder monitored the weather and sea forecasts and liaised closely with *Swanland*'s masters in this respect. Although feedback from one of *Swanland*'s previous masters indicates that the majority shareholder expected him to 'try and sail' if bad weather was forecast, *Swanland* is reported to have either remained in port or sought shelter during a voyage on several occasions because of bad weather, including at least once in 2011.

Image courtesy of Wil Weijsters

Figure 32: *Swan Diana* in 2009

The minority shareholder had served as a relief master on board *Swanland* both before and after the fitting of the self-discharging equipment. He provided shore-based oversight of the vessel when the majority shareholder was unavailable and also visited the vessel during her docking periods.

The majority shareholder considered that *Swanland* was suitable for the trade she was operating, but he was aware that she was nearing the end of her working life. Although he was content with the vessel's condition, he did not expect her to operate beyond the next scheduled special survey[9], which was due to be conducted by INSB in March 2012.

1.8.2 Financial arrangements

Swanland was purchased by Swanland Shipping Ltd using a mortgage provided by the London-based ship broker Ivanovic & Company Limited, which also financed the 2003 modifications. Any profits from the vessel's operation were divided equally between Swanland Shipping Limited and Ivanovic & Co. Ltd. Although Swanland Shipping Ltd had paid off the mortgage, *Swanland* had not made any profit since 2006, and the company had lost over £1,000,000 up to the time of her loss. Swanland Shipping Ltd had only managed to keep trading due to the financial support provided by Ivanovic & Co. Ltd.

The principal reason for the owners' decision to change the vessel's classification society from Lloyd's Register (LR) to INSB in 2009 was to reduce the fees paid to the classification society by about 30%.

1.9 TECHNICAL AND SAFETY MANAGEMENT

1.9.1 Torbulk Limited

Swanland had been managed by Torbulk since 1996 under a standard Baltic and International Maritime Council (BIMCO) ship management agreement. The agreement did not include chartering services, or sale or purchase.

Torbulk was established in 1986 and is based in Grimsby. The company also managed 10 other general cargo vessels, including *Swan Diana*, and a dredger. The company was owned by its managing director, who was also the designated person (DP). The managing director was assisted by a company director, who acted as the deputy DP and managed much of the daily running of the company's vessels and the administration of the International Maritime Organization's (IMO) International Safety Management Code (ISM Code) requirements. Two technical superintendents provided technical management, including the compilation of docking work packages. Since 2009, following the introduction of a fleet improvement programme by LR, Torbulk had employed a marine superintendent primarily to conduct ship visits and internal audits with the aim of raising safety awareness across its fleet.

The company periodically circulated safety bulletins to its vessels in order to highlight safety issues. The last bulletin to be issued prior to *Swanland*'s loss was in the summer of 2011 and included issues such as transiting the Dover Strait TSS and defect reporting.

[9] An overview of the periodic structural survey regime for a general cargo vessel such as *Swanland* is provided in **paragraphs 1.13.1** and **1.17**.

1.9.2 Safety management system

As required by the ISM Code, Torbulk had developed a Safety Management System (SMS) to ensure that its safety and environmental protection policy was being implemented. The onboard implementation of the SMS was achieved by a Safety Management Manual (SMM), which defined onboard responsibilities and procedures to ensure each vessel's safety. The SMM was not ship-specific; it provided generic procedures for vessels across Torbulk's fleet. Relevant extracts from the SMM are referred to during the remainder of this report.

1.9.3 Ship visits

Swanland was last visited by one of Torbulk's technical superintendents on 15 February 2011 while the ship was loading grain in Boston, UK. The technical superintendent recorded nine defects following the inspection of the ship. These were in relation to cabin portholes and deadlights, chain locker covers, rescue boat rowlocks, hawspipe securing arrangements, fire lines and fire flaps, the greasing of the boat davit and battery maintenance. Most of the defects were rectified within 1 week and all had been rectified by 10 May 2011.

Swanland's last internal audit was completed by Torbulk's marine superintendent on 30 June 2011 using a 'certificates and maintenance checklist' as a guide. No serious defects or deficiencies were identified. The marine superintendent's last visit to the ship was on 18 October 2011 when he assessed the vessel to be in a reasonable condition.

During ship visits, the marine superintendent usually conducted fire and boat drills and checked the condition of safety equipment, including immersion suits. The superintendent last conducted fire and abandon ship drills on board *Swanland* in January 2011. He also occasionally checked the loading and cargo information available. He did not see a loading manual on board *Swanland* or visit the vessel's hold.

1.10 SAFETY MANAGEMENT CERTIFICATION

1.10.1 ISM Code requirements

The ISM Code requires that a Flag State administration or Recognised Organisation (RO) acting on behalf of the administration should issue a Document of Compliance (DOC) to a company operating a vessel. The DOC is only valid for the ship types explicitly indicated in the document and confirms that the company is capable of complying with the requirements of the Code. The vessel itself should likewise be issued with a Safety Management Certificate (SMC). The validity of both the DOC and SMC should not exceed 5 years. A DOC requires annual verification by the administration or RO, while the validity of an SMC requires an intermediate verification.

1.10.2 Document of Compliance

On *Swanland*'s transfer of class and flag in 2009, an interim DOC was issued by INSB on behalf of the Cook Islands administration on 30 May 2009, valid until 29 October 2009 pending an office verification audit. This audit was subsequently carried out by INSB on 23 July 2009 as part of the annual verification audit carried out on behalf of the Comoros Flag State administration; no non-conformities or observations were recorded. The audit was used as the basis for the issue of the full term DOC on behalf of the Cook Islands on 24 September 2009 by INSB's head office in Piraeus, Greece. The DOC was valid until 23 May 2012.

INSB subsequently carried out annual DOC audits of Torbulk on behalf of The Cook Islands, Comoros and Panama administrations on 23 July 2010 and 19 July 2011. No non-conformities or observations were recorded at either audit.

1.10.3 Other DOC audits

In August 2009, DOC audits of Torbulk were undertaken by the Cayman Islands administration and LR. The Cayman Islands audit identified two non-conformities related to masters' standing orders and maintenance. The audit report also made five observations. The LR audit report recorded four non-conformities related to defect reporting, understanding of defect recognition, masters' standing orders and the availability of documentation. The non-conformities relating to defect reporting and masters' standing orders reflected the non-conformities raised by the Cayman Islands. The LR audit report also made six observations.

In August 2010, the Cayman Islands and LR annual DOC audits of Torbulk identified four non-conformities related to defect reporting and rectification and records of deficiencies. The Cayman Islands audit report also made four observations. These included the minimal feedback received from masters' reviews and ships' safety meetings, the potential impact of a reported TSS infringement by *Swan Diana*, and the possible lack of crew training with onboard Life-saving appliances (LSA) and fire-fighting equipment.

In August 2011, the Cayman Islands and LR annual DOC audits of Torbulk identified three non-conformities related to the procedures for the recording of the hours of work and rest, the failure to provide an additional bridge lookout during the hours of darkness, and the auditing of external crewing agencies. The audits also made a total of nine observations.

On 15 February 2012, after the loss of *Swanland*, INSB conducted an additional audit of Torbulk which identified eight non-conformities. The non-conformities were connected with: the lack of risk assessments; the failure to assign a technical manager resulting in a lack of control of technical matters; the lack of specificity in the procedure and periodicity of masters' reviews; the lack of review of SMS reports and returns; the lack of a procedure for the evaluation of crew and the lack of a crew training program; the lack of definition and development of cargo operation procedures, including forms and checklists; the drill programme not being properly developed; and, the failure to keep planned maintenance records at the company's offices. The corrective actions taken by Torbulk in response to these non-conformities were verified by INSB on 17 May 2012.

1.10.4 Safety Management Certificate

On 30 May 2009, an interim SMC for *Swanland* was issued by INSB on behalf of the Cook Islands during the transfer of class in Kaliningrad. The interim SMC was valid until 29 October 2009, pending a verification audit.

On 23 September 2009, an initial verification audit was conducted while *Swanland* was in Middlesbrough, UK. No non-conformities were identified or any observations made. A short-term SMC was then issued, valid until 1 March 2010 pending the issue of the full term certificate by INSB's head office. A full term SMC was subsequently issued by INSB's Piraeus office on 24 February 2010 which was valid until 22 September 2014.

1.11 ASSESSMENT OF STRUCTURAL DESIGN, AND SURVEY AND REPAIR HISTORY

As part of this investigation, the MAIB contracted the marine consultancy firm Braemar Technical Services Limited (Braemar) to assess *Swanland*'s structural design, and her survey and repair history. Braemar's report **(Annex D)** was based on a detailed review and assessment of the available structural records for the vessel, including surveys, modifications, repairs, voyages and cargoes.

1.12 DESIGN AND CONSTRUCTION

1.12.1 Overview

Swanland was of steel construction and transversely framed. The vessel's single cargo hold was accessed via a hatch opening either side of a central transverse cross beam **(Figure 33)** at Frames 64 to 66 between the two hatch coamings. The accommodation and engine room were located aft, while there was a raised foc'sle forward, incorporating an enclosed store. Section 5 of **Annex D** provides a more detailed description of the vessel's structural design, which was considered by Braemar to be "*normal for a vessel of her size, type and trade*".

1.12.2 Cargo hold

As shown in **Figure 34**, the side shell in way of the hold was transversely framed with a series of exposed flanged plate frames, spaced 650mm apart in the central section. The frames alternated between deep frames and intermediate frames, the latter being half the depth of the deep frames. The upper ends of the deep frames were connected both to the main deck plating and the deck beam **(Figure 35)**. The upper ends of the intermediate frames were terminated below the main deck plating, and were connected to the deck beam by a welded bracket.

As **Figure 36** shows, deep frames replaced the expected intermediate frames at Frames 47, 65 and 83 respectively. Frames 64 to 66, in way of the central transverse beam above were also plated-in to form a vertical box section. Two removable small access covers were incorporated into the plating at Frames 64 to 66, which also featured a fuller connection to the DB structure beneath. Braemar's report **(Annex D)** concluded that the box section at Frames 64 to 66 would have been provided to create a "strong portal frame", which, assisted by the additional deep frames at Frames 47 and 83, would have acted to counter racking loads[10].

[10] Racking is the tendency for the main deck (which in the case of *Swanland* was formed by the relatively narrow strips either side of the hatch coaming) to move laterally with respect to the tank-top.

Image courtesy of Roman Savin

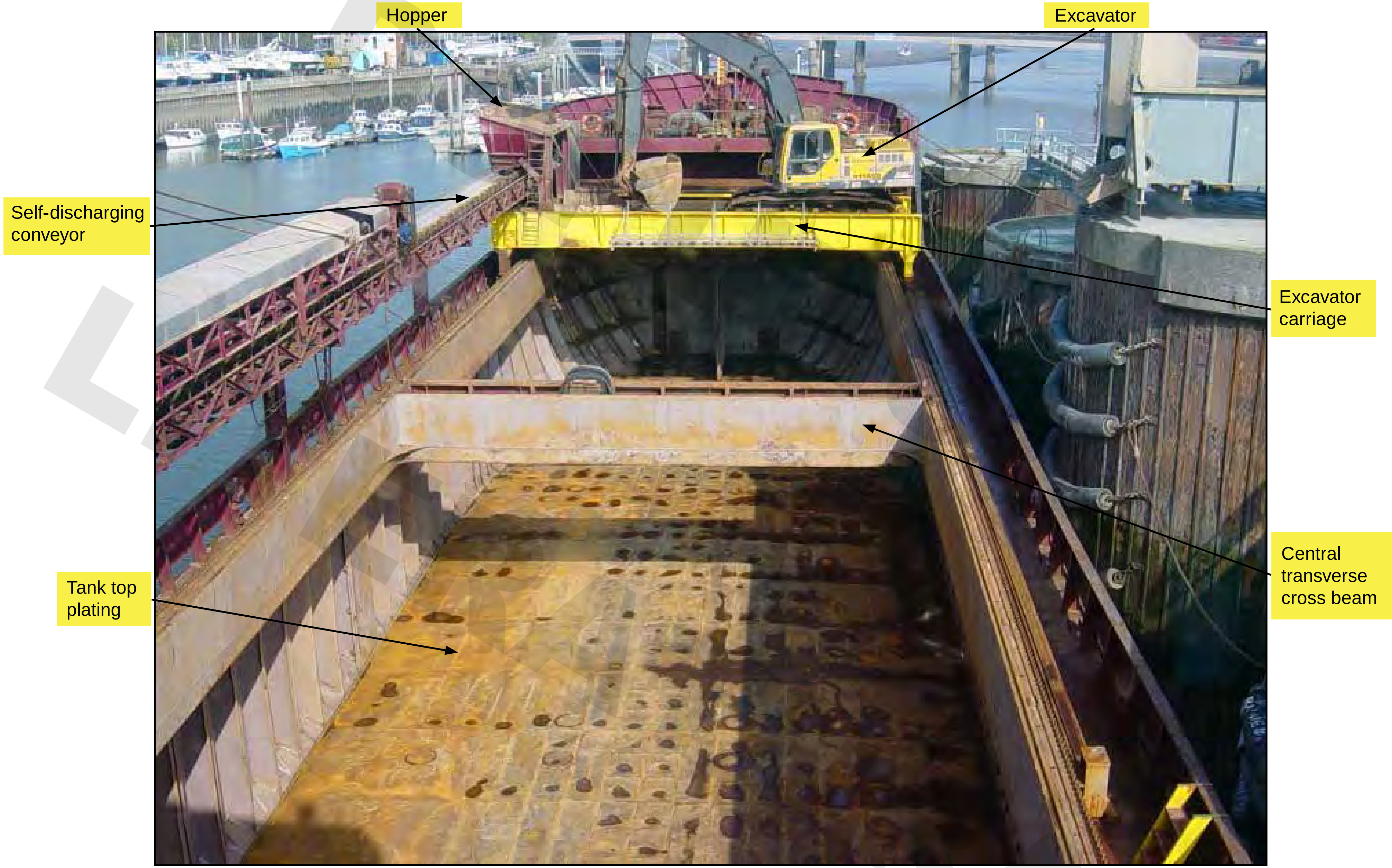

Figure 33: Looking forward from bridge showing cargo hold and central transverse cross beam

Figure 34: Looking forward on starboard side of cargo hold in 2002

The deck of the hold was formed by the DB tank top plating, which sloped gently up at the forward end. The height of the main deck from the tank top plating was 5.06m. A 4.5m long centreline longitudinal bulkhead was fitted at either end of the hold. A small "bobcat" bulldozer was stowed adjacent to the forward centreline bulkhead, and was used during cargo discharge.

In 2009, the cargo hold was fitted with a 'Bulksafe' water ingress detection system, as required by Chapter II-1, Regulation 25 of the 1974 Safety of Life at Sea (SOLAS) Convention, as amended. The system incorporated a float-level type switch, which would activate an audible and visual alarm on the bridge when flooding was detected. The system was required to be tested monthly and the results of the test forwarded to Torbulk. Torbulk's records indicated that the system was last tested successfully on 24 September 2011. Torbulk advised all its vessels in August 2011 that the Bulksafe sensors required a filter change every 12 months.

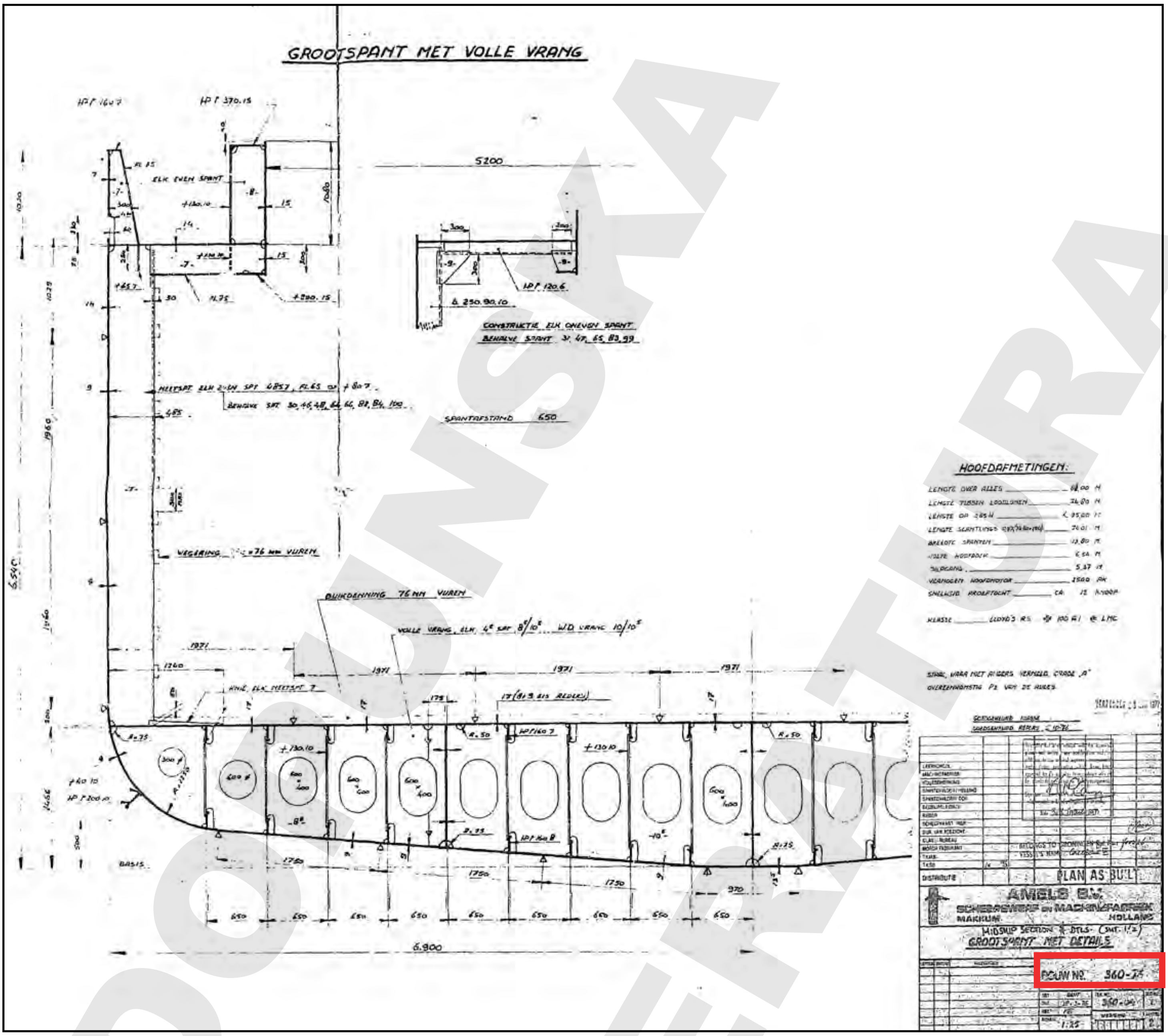

Figure 35: Extract from the as-built Midship Section & Details drawing for *Carebeka IX* showing the upper end connections of the frames in the cargo hold

Figure 36: View of cargo hold looking aft, showing additional deep frames at Frames 47, 65 and 83

1.12.3 Cargo hold hatches

Each hatch opening was fitted with a sliding steel MacGregor-Comarain chain pull operated folding hatch cover divided into ten sections, which allowed the covers to either be fully or partially opened as required. The removed sections were stowed either at the forward or aft end of the 1.08m high hatch coaming, as shown in outline at **Figure 1**. The hatch covers could be made watertight by securing each of the sections using 'dog-clips'; these were reported to be in good condition. When water intolerant cargoes were carried in the hold, any small gaps in the vicinity of the hatch covers were filled using high expansion foam. The vessel's as-built capacity plan **(Annex E)** stated that the hatch covers could support an evenly distributed load of 1735kg/m^2.

1.12.4 DB tanks

Swanland was fitted with a series of DB tanks along her full length **(Figure 1)**, the configuration and capacity of which are detailed at **Annex E**. The majority of the DB tanks beneath the cargo hold were used for sea WB, as were the aft peak (AP) and fore peak (FP) tanks at the aft and forward extremities of the vessel respectively. The DB tanks beneath the cargo hold incorporated longitudinal and transverse floors, which provided additional strength and rigidity in the bottom area.

The WB tanks were emptied and filled by the duty engineer. The ballast water pump was rated at 160m^3 per hour, and the duty engineer monitored the state of the ballast by monitoring the pump pressure. Tank soundings were generally taken at sea. It was reported that number 4 port WB tank, located beneath the aft end of the cargo hold, had a defective tank valve.

1.12.5 LR construction rules

During a vessel's design and construction, a classification society will verify that the technical requirements in its rules have been complied with, including those intended to ensure a vessel's structural strength. This allows a Certificate of Class and a Cargo Ship Safety Construction Certificate (CSSCC) to be issued to the vessel, as required by SOLAS.

As indicated in **Table 3**, the vessel's design and construction was approved by LR during 1976 and 1977. LR was unable to confirm which version of its Rules and Regulations was used to approve the vessel's design. The LR Rules and Regulations for the Construction and Classification of Steel Ships 1976 (hereafter referred to as the "full" 1976 LR Rules) were extant when the vessel's keel was laid. However, a note preceding Chapter D of the 'full' 1976 LR Rules, titled – *Hull Construction*, stated that the chapter only applied to ships of 90m and over in length and that:

> *For ships under 90 m in length, see the Rules for the Hull Construction of Steel Ships Under 90 m in Length.*

The extant version of these latter rules was titled Small Ships Rules for the Hull Construction of Steel Ships Under 90m in Length 1976 (hereafter referred to as the 1976 LR Small Ship Rules).

Extracts of the 'full' 1976 LR Rules and the 1976 LR Small Ship Rules are at **Annexes F** and **G** respectively.

1.12.6 LR entry class notation

Swanland entered service in 1977 with the class notation:

✠100A1 ✠LMC

The ✠ notation indicated that the vessel had been constructed under LR survey, while 100 confirmed that the vessel was considered suitable for seagoing service; A1 denoted that the vessel had been accepted into LR class and maintained in good and efficient condition. The LMC notation indicated that the machinery had been constructed, installed and tested under LR survey.

The class notation did not include "(cc)", which would have indicated that an approved system of corrosion control had been fitted in the tanks in association with reduced scantlings[11]. There was also no reference in the notation to the scantlings having been approved as 'strengthened for heavy cargoes' or of the thickness of the plating having been increased or 'strengthened for regular discharge by heavy grabs'.

1.12.7 Design modifications

The only reported significant alteration to *Swanland*'s design during her service life was the fitting of the self-discharge equipment at Reimerswaal in the Netherlands in early 2003.

The modifications included the addition of a discharging conveyor system, fitted on a pedestal with a slewing bearing on the port side of the main deck. The main deck was also reinforced in way of the conveyor supports, with the pedestal integrated into the vessel's structure and the sides of the deckhouse reinforced to withstand the extra loads.

A derrick-post was fitted to the port side of the superstructure, while a diesel-hydraulic tracked excavator was provided to dig cargo out of the hold using its articulated grab. The excavator was stowed on a carriage, which could be moved on rails that were welded to the main deck along the length of the cargo hold hatch coamings. The rails consisted of a heavy H-beam with flat bar on top **(Figure 37)**. The carriage and excavator were normally stowed forward of the cargo hatch when the vessel was at sea **(Figure 4)**, as was the case at the time of the accident.

The design and the installation of the equipment were approved by a local LR surveyor. At the time of this accident, all documentary records of the approval of the modifications had been destroyed in accordance with LR's records retention policy. However, a general description of the modification was recorded on LR's survey database. This noted that several deck beams and frames in the cargo hold had been identified as severely wasted at their connections. Accordingly, 26 and 22 deep frames on the port and starboard sides of the cargo hold respectively were cropped, along with the accompanying deck beams. For each of the 48 frames, a new internal radius section was installed, as shown at item 2 on the contemporaneous sketch at **Figure 38**. Two further deck beams on the port side were also modified as shown at item 3 on **Figure 38**, as were six deck beams on the starboard side.

[11] Scantlings is the general term describing the dimensions of a ship's structural members such as girders, stiffeners and plates.

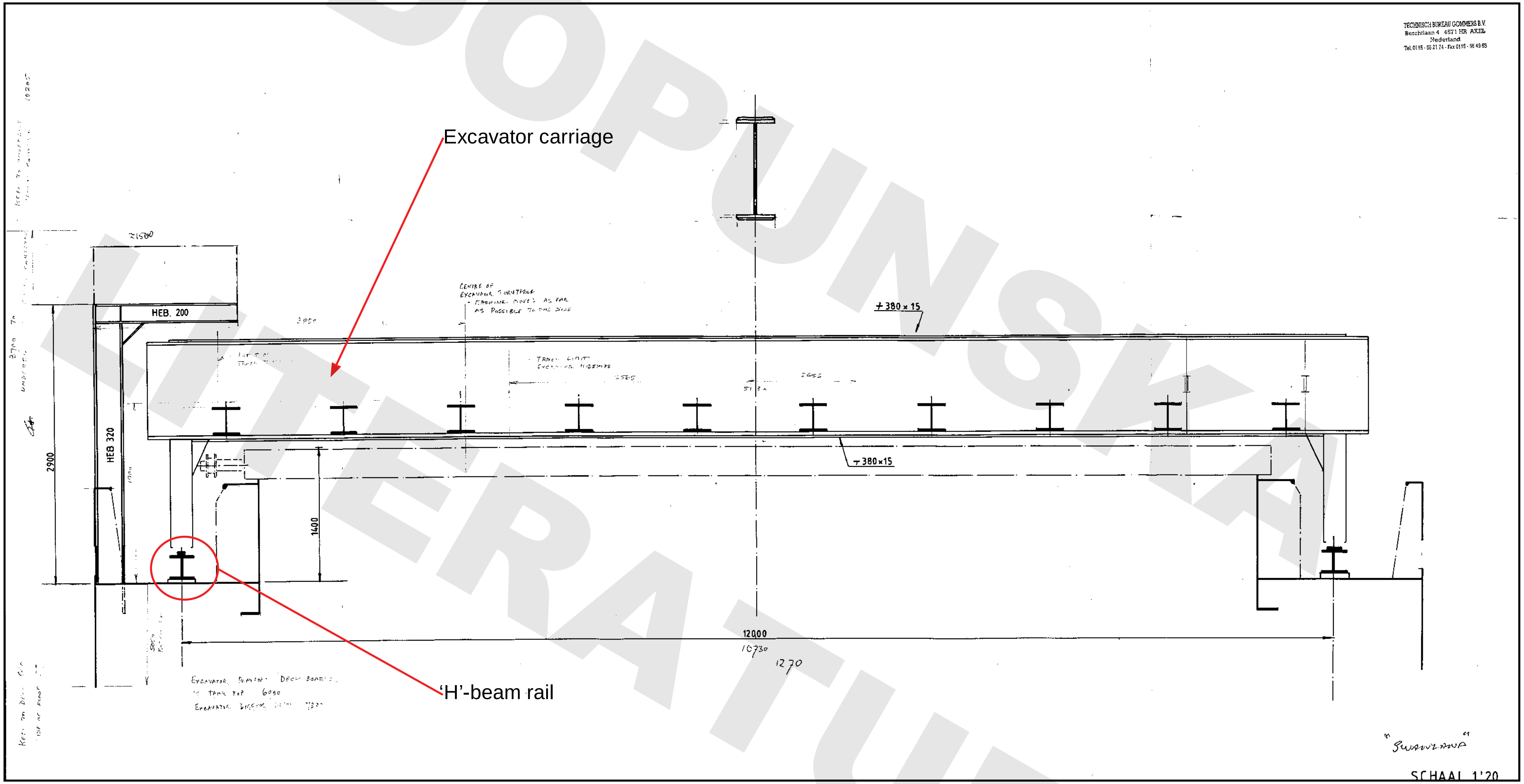

Figure 37: Design drawing for excavator carriage and carriage 'H'-beam rails

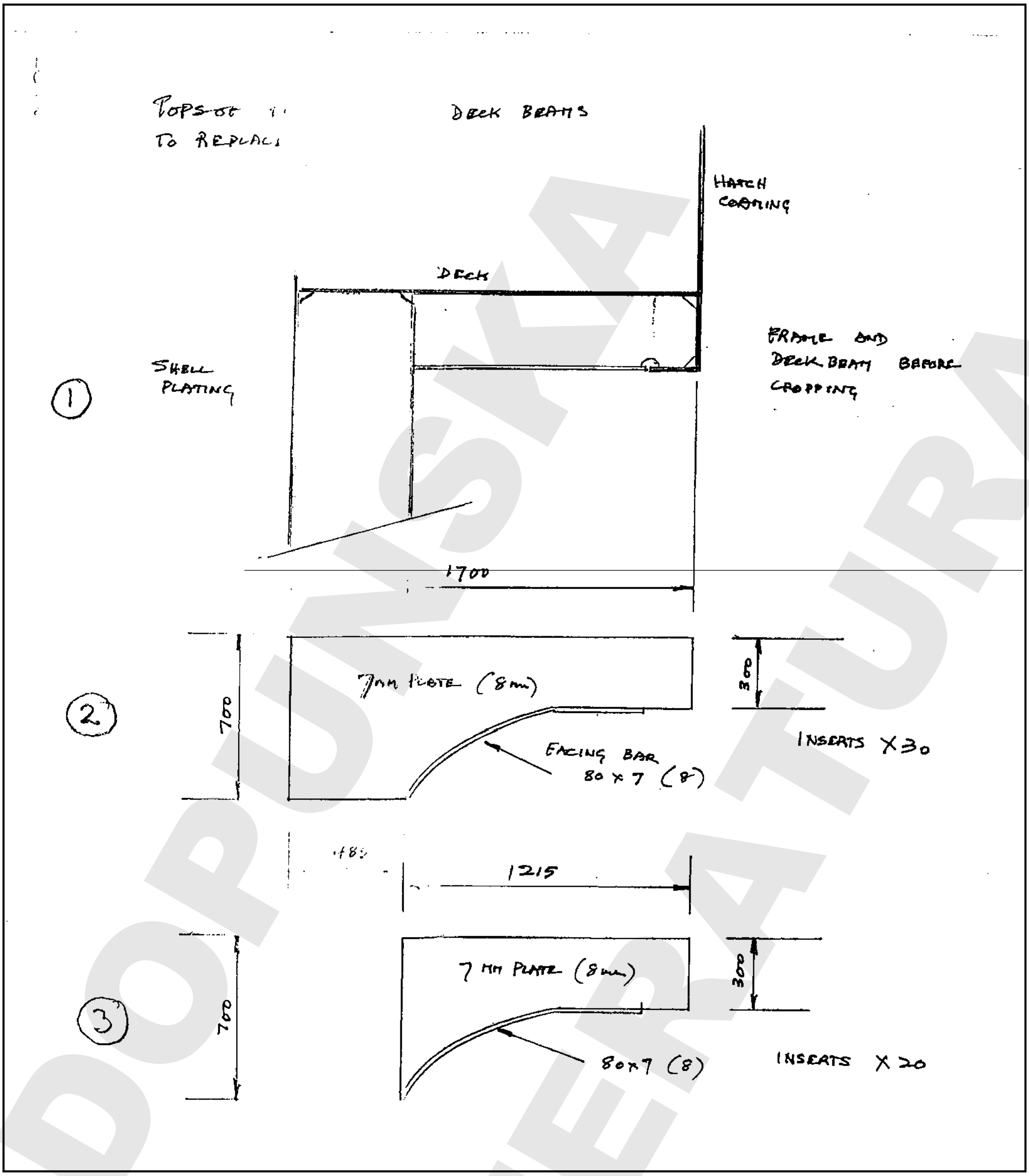

Figure 38: Contemporaneous sketch of modifications to cargo hold deck beams carried out in 2003

As part of its analysis **(Annex D)**, Braemar commented that the addition of the self-discharging equipment would have had an overall beneficial effect on the structural capacity of *Swanland*, given the alterations to the transverse frames. However, Braemar also noted that the installation of the rails either side of the hatch coamings would have created a water ‘trap’ area where corrosion would have been more likely to develop, as shown at **Figures 39a** and **39b**.

Figures 39a and **39b:** Water trap area between excavator carriage rail and cargo hold hatch coaming on *Swanland*

1.13 RECENT STRUCTURAL SURVEYS AND REPAIRS

1.13.1 Background

As for all other vessels entered “in class”, *Swanland* was subjected to a 5-year cycle of periodic classification society surveys to verify that the requirements for issuing the CSSCC and a Certificate of Class remained valid. The surveys consisted of annual surveys, an intermediate survey[12] and a 5-yearly renewal survey, referred to as a special survey.

The scope of each survey, in particular the intermediate and special surveys, increases with the age of the vessel in accordance with the requirements stipulated in a classification society’s rules. This generally includes increased requirements for the inspection and thickness measurement of certain structural areas of the vessel. Based on the findings of a survey, a classification society may also impose additional inspection or measurement requirements on subsequent surveys.

1.13.2 Overview of significant surveys and repairs

A detailed overview of the available structural history of *Swanland* was compiled by Braemar and is summarised in detail at sections 4.4 and 5.2 at **Annex D**. Table 1 of **Annex D** provides a detailed summary of the specific significant structural repairs between 1987 and 2011, while the nature and extent of these repairs is illustrated in its Figures A.2(a) to A.2(k) and Figures A.3(a) to A.3(d).

Table 4 overleaf provides a further summary of the structural surveys and repairs conducted between 2003 and the time of the accident. This includes the cost of the repairs, where known.

Annex D and **Table 4** confirm that the periodic classification surveys conducted on *Swanland* up until 2009 identified the need for regular structural repairs, often relatively soon after previous repairs had been completed. The scope and frequency of the repairs increased from 2000 onwards, and repairs were required on an almost annual basis from 2002 to 2009. Particular areas of the vessel’s structure requiring repeated repairs included the:

- exposed transverse frames in the cargo hold;
- side shell and main deck plating, including under deck stiffeners;
- tank top plating;
- hatch coamings and bulwarks;
- double bottom structure.

Various factors were identified as the trigger for these repairs. These included thickness measurement readings for areas of the structure being below the stated allowable diminution tolerances in LR’s rules, and the cracking and buckling of certain structural members.

[12] An intermediate survey is to be carried out within the window from three months before the second anniversary date of the Certificate of Class being issued, to three months after the third anniversary date.

LR had imposed a number of Memoranda of Class[13] (MoC) requiring additional inspections and thickness measurements to be conducted during *Swanland*'s annual surveys. These included all DB WB tanks from 2005 onwards; and, since 2006, both the AP and FP tanks, and various transverse frames in the cargo hold, particularly towards the midships area.

Date	Survey Type	Location	Class	Repairs	Cost of Repairs (if available)	Comments
Jan 2003	Annual	Reimerswaal	LR	Extensive repairs undertaken, incl. shell plating & hold frames; deck plating iwo hatch coaming; under deck stiffeners; DB structure	Not Known	Self-discharge eqpt fitted
June 2004	Annual	Warrenpoint	LR	None	N/A	Substantial corrosion in AP & FP tanks; Water penetration of fwd hatch cover
Feb-March 2005	Intermediate	Great Yarmouth	LR	Repairs to various frames iwo hold; Excessive diminution in AP & FP tanks.	**£30k**	Various WB tanks require repairs - coatings POOR; All WB tanks to be examined internally & gauged, as necessary annually.
June-July 2006	Annual	King's Lynn/Great Yarmouth	LR	↓	N/A	Corrosion iwo cargo hatches; Corrosion iwo of various WB tanks, in particular AP & FP; Repairs deferred to scheduled dry-docking, March 2007.
Sep-Oct 2006	Special	Leipaja	LR	Extensive repairs to hatch coaming, hatch lids, DB structure, hold frames (58 port, 31 stbd)	**£307k**	Dry-docking brought forward; UTM carried out;
March 2007	Annual	Warrenpoint/ Barrow	LR	Structural repairs to WB tanks (Corrosion) & various hold frames.	Not Known	
June 2008	Annual	Ipswich/Great Yarmouth	LR	Repairs conducted to WB tanks & hold frames.	**£13k**	WB tanks in satisfactory condition, coatings POOR; Doubler plate on side shell iwo hold. No record of repair or evidence that class informed; Various side shell frames in poor condition; No record of ship staff inspection; CoC imposed. Evidence of possible failures in shipboard SMS -> PR17.
April 2009	Occasional/ Annual	Warrenpoint	LR	↓	N/A	WB tanks - excessive wastage requiring repair; Maintenance records not up to date & not reflecting condition; CoC imposed. Evidence of possible failures in shipboard SMS -> PR17.
May 2009	Intermediate & Initial	Kallingrad	INSB	Extensive repairs to DB structure, hold plating & frames, hatch coamings, bulwarks, under deck stiffeners.	**£149k**	UTM conducted; INSB survey report - cargo hold GOOD condition; WB tanks in GOOD condition (although uncoated)
June 2010	Annual	Great Yarmouth	INSB	None	N/A	Cargo hold in FAIR condition; WB tanks in GOOD condition with FAIR coating;
June 2011	Annual	Londonderry	INSB	None	N/A	Cargo hold in FAIR condition; WB tanks in GOOD condition with FAIR coating;

Table 4: Summary of structural surveys and repairs between 2003 and 2011

[13] A Memoranda of Class (MoC) defines either: a condition that, although deviating from a technical standard, does not affect the vessel's classification; or, a recurring survey requirement, such as a specific annual survey activity. In the latter context, an MoC therefore has the same effect as a Condition of Class (CoC), which is a requirement for a certain activity, such as a repair, to be carried out within a specific timescale in order to maintain a vessel "in class".

1.13.3 Summary of repairs in 2006

In June 2006, an annual survey identified corrosion in a number of areas of *Swanland*'s structure, including the hatch covers, DB, AP and FP tanks and various frames within the cargo hold. The structural condition of the DB WB tanks was described as 'satisfactory', but the protective coating as being "poor"[14]. Although some repairs were subsequently conducted to the cargo hold frames in July 2006, it was evident that the extent of the required repairs would need the vessel to enter a dry dock. The vessel's next scheduled dry dock period, in March 2007, was therefore brought forward and permission granted by LR for the vessel to proceed to Latvia for repairs.

During September to October 2006, *Swanland* was in dry dock at Liepaja. This period coincided with a special survey, again conducted by LR. Ultrasound Thickness Measurements (UTMs) were taken in accordance with the LR rule requirements, and extensive repairs were carried out to the areas previously identified, in particular the DB, AP and FP structure and cargo hold frames. **Figure 40** shows the repair work underway, while **Figure 41** (taken from **Annex D)** illustrates the various repairs undertaken. **Table 4** confirms that the repairs cost around £307,000.

1.13.4 Summary of surveys in 2007 and 2008

The annual survey conducted in March 2007 identified wastage in various tanks and the need for further repairs to a number of damaged cargo hold frames.

During the 2008 annual survey, further damage was noted to the cargo hold frames, one of which had been cut out to facilitate the fitting of a doubler plate repair on the shell plating; there were no associated records for this repair or of LR being informed about it. The structural condition of the DB WB tanks was again described as 'satisfactory' and the protective coating as 'poor'. The hull, main deck and various cargo hold frames were described as being in 'poor condition', with no record of any ship's staff inspections having been carried out.

Given the vessel's condition, and the crew not being able to satisfactorily conduct practical demonstrations of various shipboard activities, the LR surveyor submitted a PR 17[15] report, due to his concerns about possible failings of the shipboard safety management system.

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[14] The International Association of Classification Societies (IACS) Unified Requirement (UR) Z7.1 defines the various coating condition descriptions as:

> GOOD condition with only minor spot rusting.
> FAIR condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition.
> POOR condition with general breakdown of coating over 20% or more of areas or hard scale at 10% or more of areas under consideration.

[15] Procedural Requirement (PR) 17 is an IACS procedure requiring a report to be completed by a surveyor when deficiencies relating to possible safety management system failures are identified by the surveyor during Class Surveys, Statutory Surveys, additional surveys relevant to Port State Control, Flag State Inspections or any other occasion.

Figure 40: Repair work underway in Liepaja in 2006

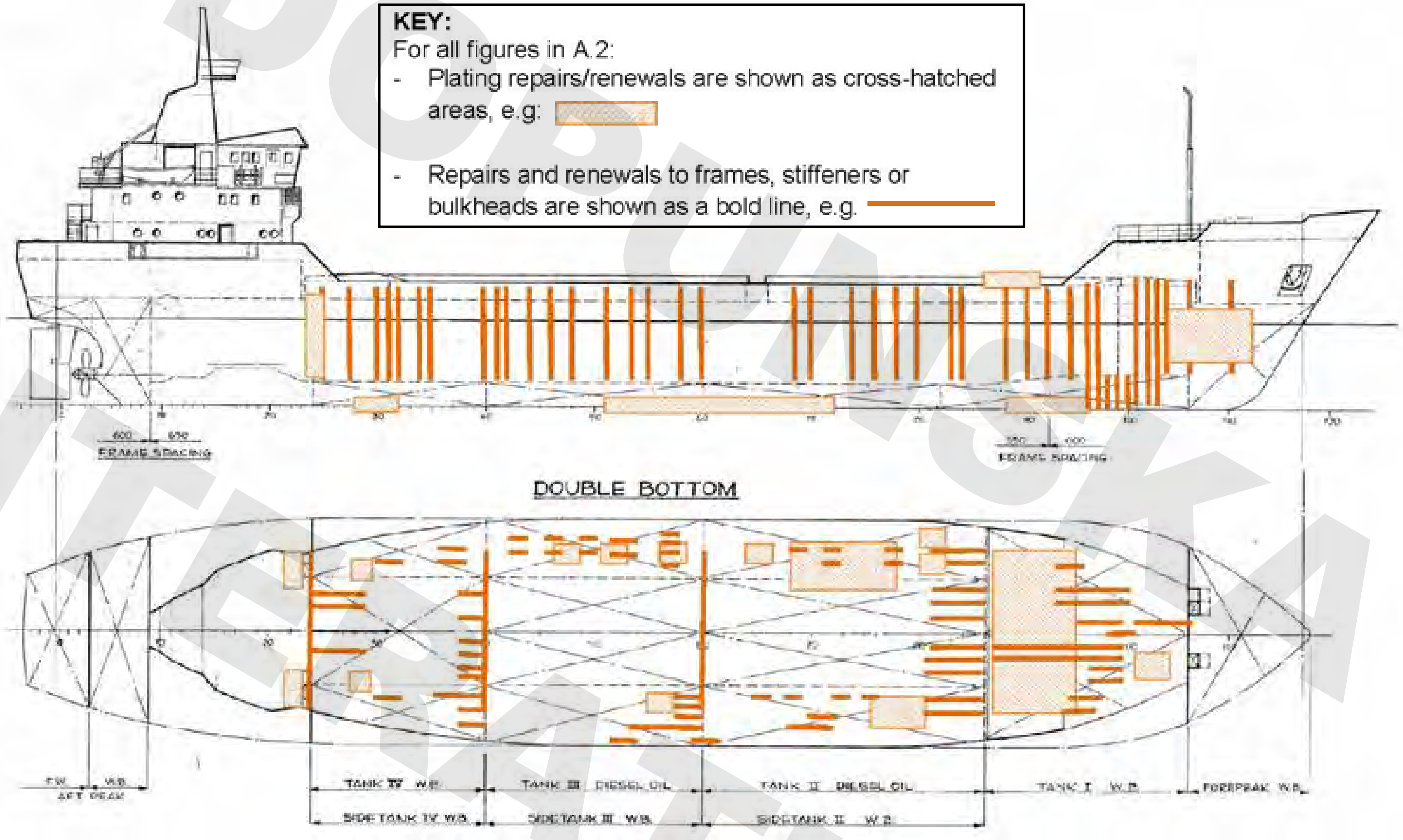

Figure 41: Summary diagram showing extent of repairs in Liepaja in 2006

1.13.5 Post-grounding survey in April 2009

On 8 April 2009, *Swanland* ran aground on a sandbank near Boston, UK. The vessel refloated without assistance 9 hours later; no water ingress was reported. As a result of the grounding, a LR surveyor attended *Swanland* on 14 April 2009 at Warrenpoint, Northern Ireland. During the survey, eight vertical cracks were identified in the bottom shell longitudinals in various DB tanks beneath the cargo hold. The cracks were not considered to have been caused by the grounding and there was no notable diminution in way of the cracks. The LR surveyor raised Conditions of Class (CoC)[13] for the cracked DB longitudinals and Torbulk subsequently brought forward *Swanland*'s next scheduled dry docking in order to undertake the required repairs.

A Port State Control Inspection (PSCI) was also conducted on *Swanland* while at Warrenpoint by the Maritime and Coastguard Agency (MCA). The inspection identified 16 deficiencies, including evidence that the maintenance records were not up-to-date and did not reflect the vessel's condition. All of the deficiencies that had been allocated action code 17 (requiring rectification before departure) were rectified prior to the vessel's departure; other deficiencies were to be verified during the vessel's forthcoming dry docking.

On the basis of the findings of the PSCI, a further PR17 report was submitted by the LR surveyor to LR's head office. As LR had already identified concerns with a number of Torbulk's other vessels, LR met with Torbulk to agree a Quality Improvement Programme (QIP) to address the concerns. The QIP included various measures to improve the safety management of Torbulk's vessels, including: the increased frequency and effectiveness of superintendent ship visits; formal ISM training for superintendents; improvements in the implementation and management of the defect reporting system; and, improved onboard application of the ISM Code.

Following the meeting, LR recommended that *Swanland* be included in its Fleet Quality Management Process (FQMP)[16].

1.13.6 INSB intermediate/entry survey in May 2009

On 16 April 2009, *Swanland* departed Warrenpoint and re-entered service for just over 2 weeks before proceeding to Kaliningrad for repair in dry dock. While the vessel was on passage, Torbulk informed LR that the vessel was transferring class to INSB.

INSB subsequently obtained copies of information pertaining to *Swanland* from Torbulk. The information provided included construction drawings and details of the CoC and the MoC imposed by LR; however, a copy of the LR survey narrative, summarising previous specific repairs required and non-conformities identified by LR, was not provided. INSB did not contact LR to request any information relating to the vessel.

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[16] Fleet Quality Management Process (FQMP) is LR's identification and solution process for vessels with onboard maintenance problems. As part of the process, LR will conduct a survey or audit to identify and verify the root cause of the problems, and LR will then work with the operator to identify, if necessary, a solution.

On 8 May 2009, detailed instructions for the intermediate/entry/dry dock survey were issued from INSB's head office in Greece to the INSB surveyor who was to undertake the survey. These confirmed that the survey activities were to be in accordance with INSB's rules and regulations, as well as specific instructions to internally examine and undertake UTMs of all of the WB tanks. Reference was made to the outstanding CoC imposed by LR regarding the cracked DB longitudinals and to the outstanding MoC, including the requirement for additional inspections and thickness measurements of various transverse frames in the cargo hold.

On 11 May 2009, *Swanland* arrived at Kaliningrad and entered the dry dock. Between 12 and 21 May, UTMs were undertaken by a company that had been approved by LR.

The INSB surveyor attended the vessel from 18 May for 4 to 5 days and then again from 26 or 27 May until 30 May. He therefore did not witness all of the UTMs, including the initial measurements in the DB tanks, the structure of which had already been marked up for repair when he first arrived in Kaliningrad. However, it is reported that the surveyor checked the accuracy of those UTMs he had not monitored using a personal ultrasonic thickness gauge. The gauge had last been calibrated in August 2000. The surveyor also witnessed the start of the renewal of a substantial amount of wasted or thin plating in the DB tanks.

By the time of the INSB surveyor's return to Kaliningrad in late May, the repair work in the DB tanks had been completed and the tanks sealed ready for testing. The surveyor was therefore unable to verify the repairs undertaken inside the tanks. However, the repairs had been witnessed by Torbulk's technical superintendent, who had attended the vessel throughout the dry dock period and he confirmed that the work in the DB tanks had been completed satisfactorily.

Although the INSB surveyor conducted a visual inspection of the cargo hold, he was unable to closely inspect the upper areas of the cargo hold due to a lack of access arrangements.

UTMs were taken of various areas of the hold structure, including the tank top plating. However, an incorrect original plating thickness of 14mm was used as the basis for checking whether the plating's diminution was within the acceptable tolerance stated in INSB's rules. Although 14mm was shown as the tank top plating thickness on the midships section drawings provided to INSB, these drawings were for hull number 352 **(Annex H)**, *Swanland*'s sister vessel, *Carebeka VIII*. Midship section drawings obtained from LR as part of this investigation for hull number 360 (*Swanland*) showed a plating thickness of 17mm[17].

[17] During a special survey in 1997 the plating thickness on the tank top was measured to be 15mm. As this was 1mm thicker than indicated on the drawings held for hull 352, Torbulk contacted Amels Shipyard requesting either a copy of the tank top drawings for hull 360 or details of plate modifications and original thickness measurements. Amels Shipyard reply stated: *about modifying of thickness of plates is not known to us. Please phone if you need the drawings of newb 360*. [Sic]. At the time, Torbulk and the attending surveyor assumed that the plating thickness had been increased during the vessel's repairs in 1992 and the scantling sizes shown on the drawing for hull 352 were assumed to be the same for hull 360. The survey records available indicate that although 15mm was used as the 'original thickness' for the tank top plating during the survey in 1997 (BV), this was reduced to 14mm during subsequent surveys in 2005 (LR), 2006 (LR) and 2009 (INSB).

As part of its analysis, Braemar assessed the implication of the use of the incorrect tank top plating thickness (see section 5.3 of **Annex D**). As shown at **Figure 42** (taken from **Annex D**), Braemar identified that had the correct plating thickness been used, one plate would have had a measured diminution of 33.5%. As this was greater than the 30% diminution allowed by INSB's rules, the plate would have required replacement. Braemar also assessed that virtually all of the plating would have been identified as having a diminution greater than 15%, with 22 plates having diminished by more than 22.5%. Consequently, these plates would have required additional inspection and UTM.

Figure 43 shows the repair work underway, while **Figure 44** (taken from **Annex D**) illustrates the extensive nature of the repairs undertaken, which included bottom plating, main deck plating, double bottom structure and a large number of frames in the hold. **Table 4** confirms that the repairs cost about £149,000.

The INSB survey report for the intermediate survey did not provide details of any of the specific structural repairs that were either required or conducted[18]. The report recorded that all of the structure, including the cargo hold and the WB tanks, was in "good condition" and that all of the ballast tanks were "uncoated".

1.13.7 INSB entry class notation

At the conclusion of the intermediate survey, a CSSCC and Certificate of Class were issued for *Swanland*, and the vessel entered into class with INSB with the notation:

⚓ H/M – 100 – A – E

The ⚓ notation indicated that *Swanland* had been constructed under survey by a recognised classification society. 'H/M – 100' meant that the hull scantlings and machinery fully met the provisions of INSB's rules[19]. The letter 'A' denoted that the vessel was considered in satisfactory condition for her intended service and was to follow the periodic survey schedule in the INSB rules, while E indicated that the anchors and chains complied with the rules.

The INSB rules do not include any specific notations regarding the carriage of heavy or high density cargoes. However, the rules do include service notations for different vessel types. The service notation for ships carrying "***solid cargoes***" includes:

> ***Cargo ship*** *for ships intended to carry general cargo.*

The service notation for ships carrying "***solid cargoes in bulk***" includes:

> ***Bulk carrier*** *for ships constructed generally with single decks, topside tanks and hopper side tanks in cargo spaces, and intended primarily for the carriage of dry cargo in bulk.*

The Certificate of Class issued by INSB categorised *Swanland* as an "Other cargo vessel".

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[18] Details of the work and repairs conducted was included in supporting documentation that was forwarded to INSB's head office in Greece.

[19] INSB Rules and Regulations for the Classification and Construction of Steel Ships, Edition 2008, which were extant at the time of *Swanland*'s entry into INSB class.

1.13.8 Annual survey in 2010

Between 8 and 9 June 2010, an INSB surveyor conducted an annual survey of the vessel. The INSB survey report again noted that the vessel's structure, including the WB tanks, was in "Good condition". The structure of the cargo hold was reported to be in "Fair condition" and the ballast tanks were recorded as having a "Fair coating"[20].

The survey report confirmed that the INSB surveyor had conducted a thorough examination of the cargo hold frames that had been the subject of the LR MoC requiring additional inspections and thickness measurements. These frames were also reported to be in "good condition". There is no record of any structural repairs being required as a consequence of this survey.

1.13.9 Annual survey in 2011

Between 7 and 8 June 2011, *Swanland*'s annual survey was conducted by the same INSB surveyor who had conducted the annual survey in 2010. The 2011 survey report was virtually identical to the 2010 report. It again recorded the structure, including the WB tanks, as being in "Good condition", the cargo hold as being in "Fair condition" and the coatings of the WB tanks as being "Fair".

There was no reference to a detailed examination of the various transverse frames in the cargo hold highlighted in the LR MoC. The surveyor raised a CoC requiring the CO^2 room door to be repaired. However, the survey report did not identify any other structural repairs that needed to be completed.

1.13.10 Braemar's conclusions

Based on its review of *Swanland*'s available structural history, Braemar's report **(Annex D)** reached several conclusions, which are summarised below:

- *Swanland* was subject to extensive and often repeated repairs to key structural members during much of her 34-year service life up until 2009 when the vessel changed classification society and flag administration.
- The various structural repairs carried out were reasonable for the reported defects. However, the repairs appeared to focus solely on the immediate area of damage and were 'piecemeal' and reactive. Hence the overall effect would have been that the original structural strength would possibly never have been regained.
- Following the intermediate survey in 2009, there was an apparent lack of focus by the classification survey and inspection regime on key areas of *Swanland*'s structure, given the lack of any further required repairs.

[20] Part 1, Chapter 3 of the 2008 INSB Rules and Regulations does not include a definition of coating conditions; Part 1, Chapter 5 detailing the requirements for Special Ship Types, including bulk carriers and oil tankers does include coating condition definitions, which align with those listed in IACS UR Z7.1 (as detailed at Footnote 14 of this report).

- The INSB survey reports contain very little specific information on the actual condition of individual structural members or areas of the vessel's structure, and are described as "*cursory in content*".
- The INSB survey reports only provide a simple grading of the structure. For example, in the 2009 report, the condition of the DB tanks is limited to a statement of "*Uncoated all Ballast Tanks. In Good Condition*".
- The INSB survey reports contain contradictions in the simple grading of key structural members of *Swanland*, with descriptions of the condition and coating of the ballast tanks being inconsistent.
- The incorrect diminution calculations used during the 2009 UTMs, meant that parts of the vessel's structure should either have been replaced or subjected to further, detailed inspection and UTM.
- There was an apparent lack of focus on the management and maintenance of *Swanland*'s structural integrity, allowing degradation of the primary structure.

1.14 ASSESSMENT OF STRUCTURAL CONDITION IN NOVEMBER 2011

Braemar also assessed the possible structural condition of *Swanland* at the time of the accident in November 2011, as detailed at sections 5.3 and 7.4 of **Annex D**.

As no UTMs were taken during the annual surveys in 2010 and 2011, Braemar estimated the potential diminution in way of the midships structure, between the date of *Swanland*'s departure from Kaliningrad in May 2009 and the accident. Its estimate was based on applying a standard classification society corrosion rate and a cargo-induced corrosion rate to the thicknesses of the relevant structural elements measured in 2009. The cargo-induced corrosion rate was based on a published corrosion rate for the carriage of salt[21] and was applied proportionately for the 105 days that *Swanland* carried rock salt as a cargo during 2009 and 2011. Although various other potentially corrosive and abrasive cargoes were also carried during this period **(see paragraph 1.18)**, no specific corrosion allowance was assumed for the periods they were carried. In addition, no allowance was made for any possible grooving[22] or pitting corrosion, which could have created localised areas of material loss.

Figure 45 (taken from **Annex D**) shows the percentage diminution values in May 2009 and as estimated in November 2011 for the various structural elements contributing to the longitudinal strength at *Swanland*'s midships section at Frame 58. This confirms that by the time of the accident, the amount of diminution in significant elements of the structure might have been approaching the 30% limit in the INSB rules that should have triggered their renewal.

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[21] Houska C., *De-icing Salt – Recognizing the Corrosion Threat*, International Molybdenum Association, Architecture, Building and Construction series.

[22] Grooving corrosion is often found in or beside welds, especially in the heat affected zone. The corrosion is caused by the galvanic current generated from the difference of the metallographic structure between the heat affected zone and base metal. The grooving corrosion may lead to stress concentrations and further accelerate the corrosion. Grooving may also be exacerbated in areas of structural discontinuity, where water is more likely to gather. An example of grooving is provided in the IACS document *General Cargo Ships Guidelines for Surveys, Assessment and Repair of Hull Structure*, an extract of which is at **Annex I** of this report.

As shown at **Figure 46** (taken from **Annex D**), Braemar used the above diminution rates to calculate the relative midships section modulus[23] values at Frame 58 for the scantlings as follows:

- When the vessel was newly built in 1977 (as these were the original ‘as-built’ scantlings, the calculated section modulus was assumed to be at 100% of its capacity).
- The May 2009 thicknesses (based on the UTM readings in Kaliningrad).
- The November 2011 thicknesses (based on the assumed corrosion rates between May 2009 and November 2011, as discussed above).

Figure 46 shows that even following the repairs conducted as part of the 2009 intermediate survey, the deck section modulus had reduced by approximately 11% from its original ‘as-built’ value. Applying the assumed corrosion rates, Braemar estimated that the section modulus would have been further reduced by about 18% of its original ‘as-built’ value by November 2011.

Braemar concluded that by the time of the accident, significant areas of *Swanland*’s structure contributing to her longitudinal strength would have been significantly weakened due to corrosion and damage. At the time of the accident, the reduction in the thickness of some of these elements would also likely have been close to the INSB diminution limits.

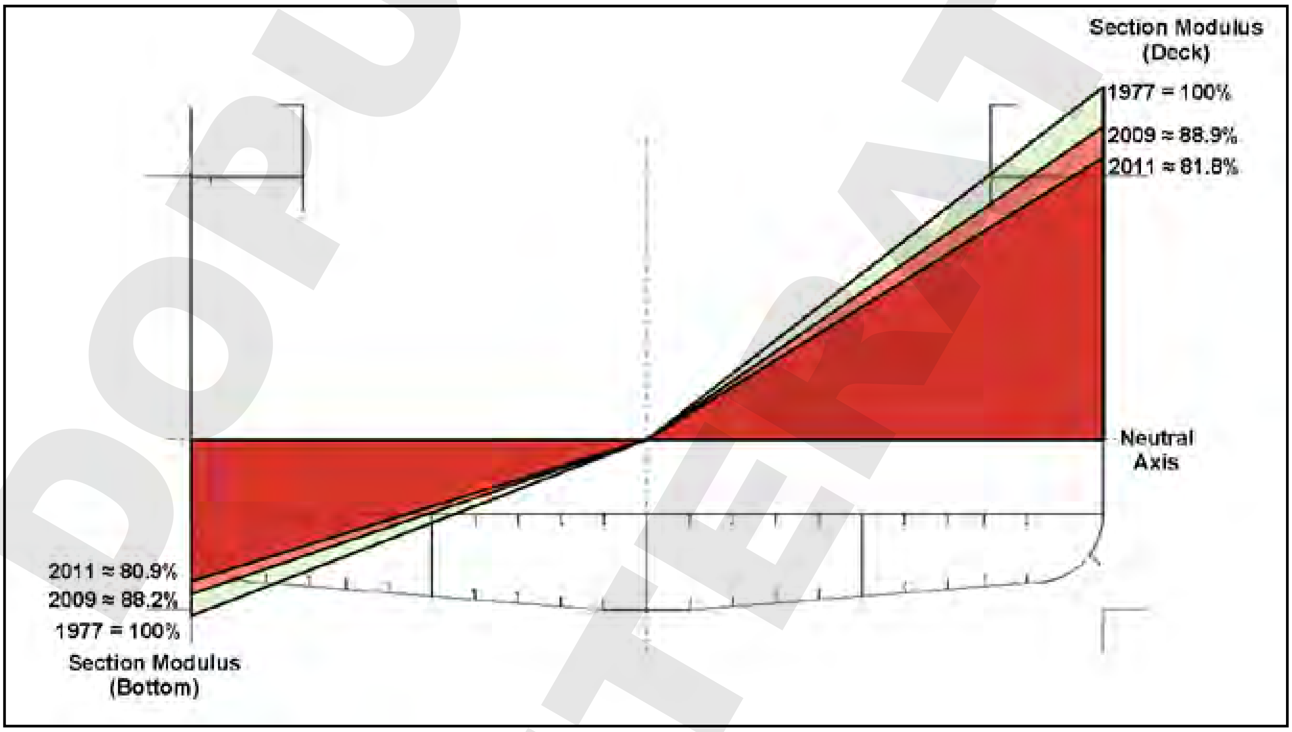

Figure 46: Comparison of calculated *Swanland*’s midships section modulus using scantlings: as-built; in May 2009; and in November 2011 (as estimated by Braemar based on assumed corrosion rates)

[23] Section modulus is a measure of the structural bending strength of a section. It is dependent on the cross-sectional shape, orientation and thickness of the section, and its calculation is based only on structural members that are continuous in the longitudinal direction.

1.15 OTHER CONDITION SURVEYS AND INSPECTIONS

1.15.1 Insurance surveys

In April 2002, an annual condition survey[24] of *Swanland* was carried out in Bari, Italy on behalf of the vessel's owner's Protection & Indemnity (P&I) club, The Shipowners' Mutual Protection and Indemnity Association, more commonly known as The Shipowners' Club. The purpose of the survey was to establish the risk profile of the vessel from an insurance perspective.

Swanland's structural condition at this survey was found to be 'poor'. Substantial diminution was identified by the attending surveyor, who also noted that 'excessive corrosion' existed in the main deck and hold frames. In addition, there was no evidence of a planned maintenance system in operation on board.

Following review of the condition survey report, the P&I Club attached a standard warranty clause to *Swanland*'s policy which meant that, in the event of a claim being made arising wholly or in part from any of the listed defects in the condition survey report, the P&I Club would not pay the claim. In Braemar's view **(Annex D)** this action demonstrated that the P&I Club had significant concerns about the structural condition of the vessel, even though the vessel had undergone a series of repairs during the previous month.

In September 2002, a condition survey of *Swanland* was carried out on behalf of the Hull & Machinery (H&M) insurers. The survey report identified that the condition of the coatings was generally 'poor' (especially in the cargo hold spaces) and that the cargo hold side frames were 'serviceable and repaired regularly'. Slight corrosion was noted on the main deck structure and the tank top plating was reported as set-in between frames. No inspections of the ballast tanks were conducted and no adverse comments were made regarding the vessel's seaworthiness.

In April 2003, an annual condition survey of *Swanland* was conducted on behalf of The Shipowners' Club. The survey was undertaken following the fitting of the self-discharge equipment and repairs in Reimerswaal in March 2003. The attending surveyor noted that the vessel was generally in a satisfactory condition and that the vessel's primary structure was generally free of wastage and corrosion. However, the survey report stated that the hatch comings had:

> *'large areas of rust breaking through, but were free of corrosion'.* [sic]

No inspections were made of the vessel's cargo hold or ballast tanks.

There are no records of any further insurance condition surveys of *Swanland* after 2003.

[24] Condition surveys are commissioned by insurers to determine whether a vessel conforms to acceptable standards. A condition survey is not as detailed or as in-depth as a structural survey.

1.15.2 Maritime Cook Islands (Flag State) initial inspection

On 28 May 2009, an MCI surveyor conducted an initial inspection on board *Swanland* in Kaliningrad to ensure that the vessel met the requirements of the Cook Islands Registration Act 2007. With regard to the general state of the deck and superstructure, the guidance on the inspection checklist stated:

> *If the Inspector's general impressions and his visual observations on board confirm a good standard of maintenance, his/her inspection should be of a general nature. If, however, the Inspector has any reason to consider that the ship or its equipment does not correspond to the requirements of the relevant Conventions, the Inspector should proceed to a more detailed inspection.*

The completed checklist indicated that, as far as was visible, the ship's side shell plates, and the structure of the cargo hold with regard to bulkheads, frames, brackets, tank tops were undamaged and without any excessive wastage. The checklist also indicated that the vessel was maintained to an acceptable standard. No major deficiencies were identified.

1.15.3 Port State Control Inspections

In accordance with the Paris Memorandum of Understanding (Paris MOU) protocol[25], *Swanland* was inspected by port state control officers on 46 occasions between February 1998 and October 2011. During this time, she was detained twice and since 2009, 41 deficiencies were registered.

In addition to the PSCI in Warrenpoint in April 2009, which identified 16 deficiencies, PSCIs in the UK in August 2010 and in May 2011 identified further deficiencies including a damaged gangway, railings, corroded / cracking decks, and failing to follow procedures. It is understood that the deficiency identified in connection with 'corroded / cracking decks' concerned the rails used by the excavator carriage.

1.16 MAINTENANCE ON BOARD *SWANLAND*

1.16.1 Onboard procedures

The Torbulk SMS procedure SMM 01 paragraph 2.2.2 stated that the chief officer was responsible to the master for, inter alia:

- *The maintenance and upkeep of the hull, decks, superstructures, and cargo holds/tanks etc.*

Paragraph 1.1.1 of SMM 05 also stated that the chief officer was responsible for "*the reporting of defects to the Company*." Paragraph 1.1.2 of the same procedure, noted that the chief engineer was responsible for the maintenance of the deck machinery, which included the self-discharging equipment, and the reporting of defects.

[25] The Paris MOU on port state control is an organisation consisting of 27 maritime administrations in Europe and North America. Each year more than 24000 inspections take place on board foreign flagged vessels in the Paris MOU ports to ensure that they meet international safety, security and environmental standards, and that crew members have adequate living and working conditions. http://www.parismou.org/

However, Paragraph 8.1.4 of Section 8 of SMM 01, entitled *Certification & Survey*, also stated that:

> *Each master and chief engineer are jointly responsible for ensuring:*
>
> - *Maintenance that can be carried out onboard, is kept up to date to meet classification society rules. [sic]*

Section 5 of SMM 05 provided further instruction on the vessel's deck maintenance. Paragraph 5.1.2 noted that:

> *The chief officer may seek the help of the chief engineer for items beyond the capabilities of the deck crew.*

Section 5.4 of SMM 05 required the chief officer to maintain a 'Deck Maintenance Work Book' to record details of the maintenance work undertaken. It was not possible to verify the contents of the work book on board *Swanland* but it is reported that maintenance work in the hold was undertaken by her crew, particularly when the vessel was at anchor or waiting for orders. The crew were paid a bonus for each self-discharge to cover the extra work and the sweeping of the hold.

A deck maintenance checklist was also to be submitted to Torbulk's office at the end of every month. The checklist was to include a record of any inspections carried out. All nine of the checklists submitted to Torbulk from January through to September 2011 indicated that the paintwork in the hold was 'satisfactory' and that the hold coamings were in 'good condition'. They also indicated that the hatch and vent covers were watertight and in good condition.

Section 6 of SMM 05 required a defect report to be sent to Torbulk at the end of every month "itemising all defects even if they have already been rectified." If the defect was considered likely to compromise safety, security or pollution prevention, then the defect report was to be raised immediately with Torbulk. In 2011, defect reports were forwarded to Torbulk from *Swanland* on 15 February (no defects), 11 April (pipe leak), 4 May (CO^2 room door) and 11 May (deficiencies from PSCI).

In July 2011 *Swanland*'s cargo hold was cleaned using an industrial ultra high pressure water jet machine. The hold was then painted. The work was undertaken by the crew while alongside in Ipswich, UK. Photographs of the hold taken in September 2011 are shown in **Figures 47a, b, c, d, e and f**.

1.16.2 Hull maintenance expenditure and budgets

The monthly financial accounts for *Swanland* included entries for the actual and budgeted expenditure on "hull maintenance", although the actual expenditure might have included some items not directly related to the maintenance of the "hull". **Figure 48** shows that both the actual and budgeted annual expenditure on "hull maintenance" reduced after 2008.

Figure 47: Photographs of *Swanland*'s hold in September 2011

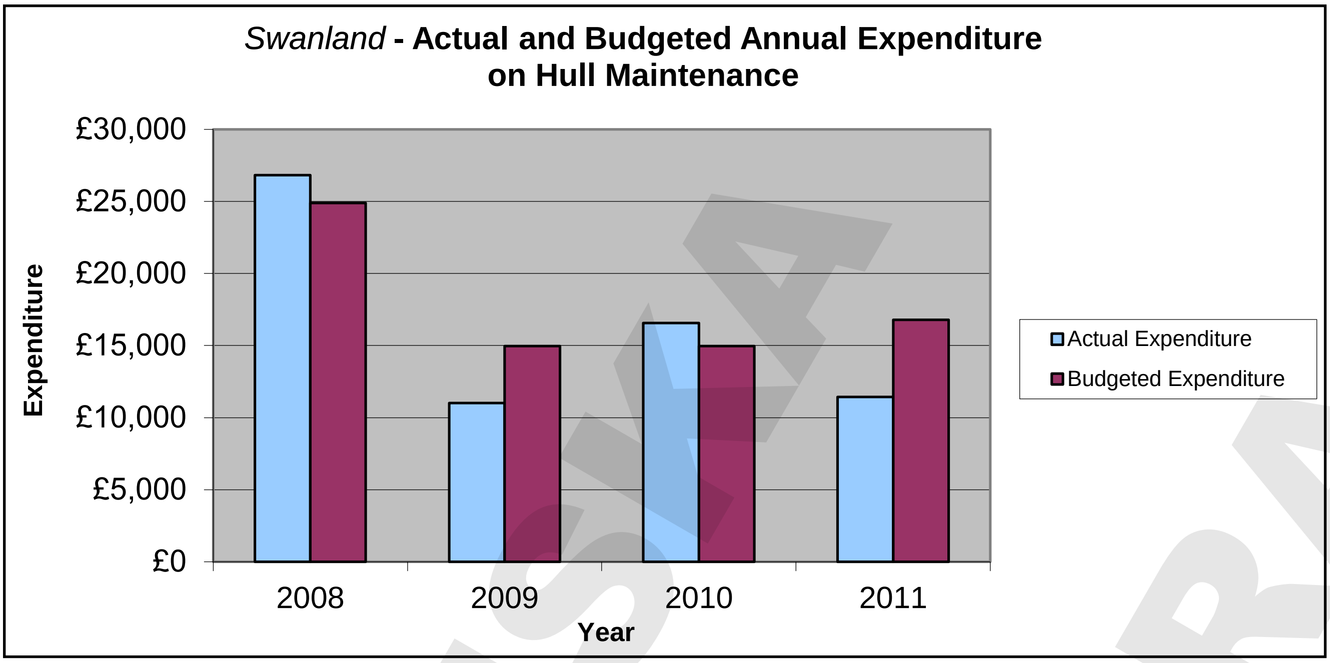

Figure 48: Actual and budgeted Annual Expenditure on *Swanland*'s Hull maintenance, 2008 - 2011

1.17 COMPARISION OF SURVEY REGIMES FOR GENERAL CARGO SHIPS AND BULK CARRIERS

1.17.1 IACS survey requirements for general dry cargo ships

International Association of Classification Societies (IACS) Unified Requirement[26] (UR) Z7.1[27] stipulates the detailed requirements for the hull survey regime for general dry cargo ships entered into class with IACS member societies, including LR. The requirements were first introduced in 2000 and have been revised on a number of occasions. UR Z7.1 does not include a definition for a "general dry cargo ship" or for a "general dry cargo". However, it does include a list of different cargo vessel types for which its requirements do not apply; *Swanland*, being a single-skin[28] vessel carrying cargo in her hold, did not fall into any of these listed vessel types.

As described at **paragraph 1.13.1**, the survey regime stipulated by UR Z7.1 is based on a cycle of 5-yearly special surveys, with annual surveys and an intermediate survey conducted in the intervening period. The principal survey requirements in UR Z7.1 for a general cargo vessel of the same age as *Swanland* at the time of the accident are summarised at **Annex J**.

[26] IACS develops, reviews and promotes minimum technical requirements in relation to the design, construction, maintenance and survey of ships. A Unified Requirement (UR) is an 'umbrella' requirement to which individual classification society's rules adhere to and which is intended to provide consistency across all IACS members. The association comprises the 13 leading classification societies for shipping, including LR and BV, who were both founder members. Further details about IACS can be found at: http://www.iacs.org.uk/explained/default.aspx

[27] IACS UR Z7.1 is available on the IACS website at: http://www.iacs.org.uk/publications/publications.aspx?pageid=4&sectionid=3

[28] Skin in this context refers to the layers of hull plating that a vessel has; single-skin therefore refers to a single layer of hull plating, while a double-skin vessel has an outer and inner layer of hull plating.

1.17.2 INSB survey requirements for general cargo ships

The detailed survey requirements for a vessel entered into class with INSB are defined in its rules and regulations. During the period that *Swanland* was entered into class with INSB, the 2008 edition of the INSB rules was extant and its requirements were therefore applicable. As for IACS societies, this regime was based on the standard 5-year cycle of surveys. The principal survey requirements in the 2008 INSB rules for a general cargo vessel of the age of *Swanland* are also summarised at **Annex J**.

1.17.3 Enhanced Survey Programme for bulk carriers

During the early 1990s, concern at the continuing loss due to structural failure of vessels carrying solid bulk cargoes[29] prompted the development of guidelines for an enhanced programme of surveys and inspections of bulk carriers[30]. In November 1993, IMO Resolution A.744(18) was adopted, which introduced these guidelines for both bulk carriers and oil tankers; the resolution was subsequently made mandatory at the 1994 SOLAS Conference.

Resolution A.744(18) has since been amended on a number of occasions and details the requirements for enhanced surveys of bulk carriers and oil tankers from the first special survey onwards. The definition of a bulk carrier detailed in the Resolution is the same as listed in Chapter XII of SOLAS.

On 30 November 2011, IMO Resolution A.1049(27) was adopted, setting out the International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, 2011. Referred to as the 2011 ESP Code, this supersedes the guidelines at Resolution A.744(18), and will enter into force on 1 January 2014, when Chapter XI of the 1974 SOLAS Convention is revised.

The 2011 ESP Code is divided into four parts, listing survey requirements for both single-skin and double-skin construction bulk carriers, and double-hull and non-double-hull oil tankers. A summary of the survey requirements in the 2011 ESP Code for a single-skin bulk carrier is included at **Annex J**, as a comparison with the equivalent requirements stipulated in IACS UR Z7.1 and the 2008 INSB rules.

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[29] Chapter VI of the 1974 SOLAS Convention, as amende d, defines a solid bulk cargo as:

> *any material, other than liquid or gas, consisting of a combination of particles, granules or any larger pieces of material, generally uniform in composition, which is loaded directly into the cargo spaces of a ship without any intermediate form of containment.*

[30] Chapter XII of the 1974 SOLAS Convention, as amended, stipulates various additional safety measures for bulk carriers, including damage stability and structural strength requirements. For the purposes of Chapter XII, a bulk carrier is defined as:

> *a ship which is intended primarily to carry dry cargo in bulk, including such types as ore carriers and combination carriers.*

However, a footnote to this definition states that for vessels constructed before 1 July 2006, the definition of a bulk carrier should be as given in Chapter IX of the 1974 SOLAS Convention, as amended. Chapter IX stipulates requirements for the safety management of vessels and, for the purposes of the chapter, defines a bulk carrier as:

> *a ship which is constructed generally with single deck, top-side tanks and hopper side tanks in cargo spaces, and is intended primarily to carry dry cargo in bulk, and includes such ship types as ore carriers and combination carriers.*

Top-side tanks and hopper tanks are wing tanks integrated into the upper and lower structure of a vessel's cargo hold. **Annex K** shows a typical arrangement of a top-side and hopper tank in way of the hold of a bulk carrier.

1.18 CARGOES CARRIED BY *SWANLAND*

Section 4.5 of **Annex D** provides a detailed analysis of the cargoes carried by *Swanland* from 2009 until the time of the accident. **Figure 49** (taken from **Annex D**), shows the number of days that the various cargo types were carried during this period.

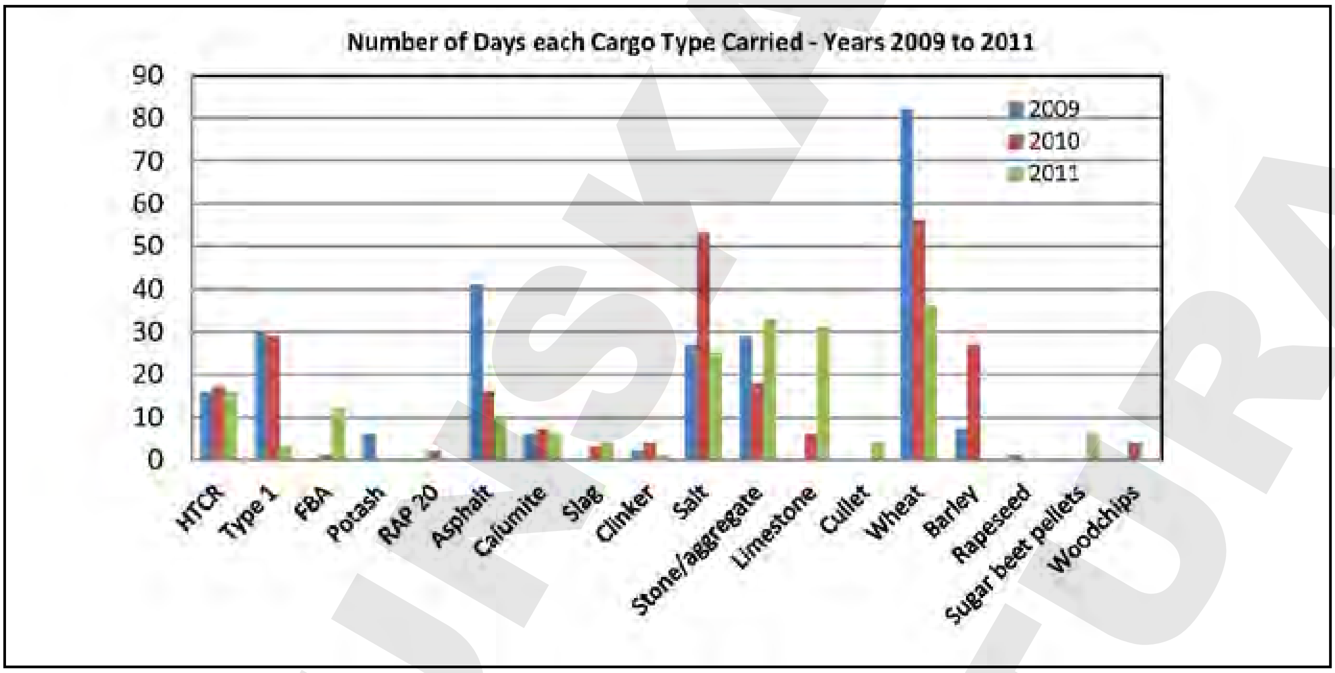


Figure 49: Summary of cargoes carried by *Swanland* between 2009 and 2011 and the duration of carriage for each cargo

Swanland carried a variety of bulk cargoes, ranging from agricultural products, including wheat and barley, to aggregates such as limestone, sand or gravel and by-products from industrial processes. A number of these cargoes, such as furnace bottom ash (FBA), potash, clinker and salt were potentially corrosive, while others, including limestone and asphalt, were abrasive. It is of note that in 2010, the number of days (52) *Swanland* carried salt was almost double that of the previous and subsequent year. This reflected the bad winter experienced in 2010 in the UK and the resulting increased demand for road gritting salt by local councils.

In its report **(Annex D)**, Braemar stated:

> *Examining the nature of the voyages that MV SWANLAND was engaged in, it is our opinion that full and proper hold cleaning, coating and maintenance would have been difficult to have been carried out due to time constraints. Based on the record of cargoes carried, she rarely operated on ballast voyages and carried varying cargoes between ports often within 1 day of discharge of the previous cargo. Combined with mechanical damage due to the discharge method (grabs and excavators), there would potentially have been regular and significant damage and / or corrosion to the vessel's cargo hold structure.*

1.19 LIMESTONE CARGO

MOT Type 1 GSB Limestone is a crushed aggregate material, providing particulate sizes ranging from 40mm down to dust. Widely used in the construction industry, it is also known as "DOT Type 1" which refers to the former UK government's Department of Transport's specification for materials used on highways.

At the time of the accident, *Swanland* was loaded with MOT Type 1 GSB Limestone of particulate size 28mm down to dust. As detailed at **Annex L**, the MOT Type 1 GSB Limestone loaded at Raynes Jetty had a calculated angle of repose[31] of 50° and a density of 1.85 tonnes/m^3. This information had not been provided to the crew, owner or managers of *Swanland* by CEMEX UK Materials Limited (CEMEX), the operator of Raynes Jetty.

The International Maritime Solid Bulk Cargoes (IMSBC) Code includes a standardised data sheet for limestone cargoes **(Annex M)**. This indicates that the material has a density range of 1.190 to 1.493 tonnes/m^3. A report prepared by Tarmac Ltd and Partners[32] states that Type 1 limestone can have densities in excess of 2.0 tonnes/m^3.

1.20 HIGH DENSITY CARGOES

The IMSBC Code defines a high density solid bulk cargo as a cargo having a stowage factor of 0.56 m^3/tonnes or less. This corresponds to a density of 1.786 tonnes/m^3 or greater.

1.21 RAYNES JETTY

1.21.1 Description

Raynes Quarry and Raynes Jetty at Llanddulas **(Figure 50)** are owned and operated by CEMEX. The jetty is used to distribute limestone aggregates directly from Raynes Quarry to various locations in the UK and the near continent for use in the construction and chemical industries. The jetty can accommodate vessels up to 5000 deadweight but is tidally constrained and almost dries at low water. Approximately 150 vessels, and a total of nearly 400,000 tonnes of cargo, were loaded at Raynes Jetty during 2011.

The jetty is equipped with a conveyor belt which is capable of moving fore and aft and athwartships in relation to vessels moored alongside in order to distribute the cargo. A loading arm loads the limestone onto the vessels at a rate of approximately 1000 tonnes per hour. The cargo is weighed as it passes down the conveyor belt, with the weight displayed on a digital readout in the control cabin on the jetty. The conveyor was calibrated on 17 October 2011 and on 23 March 2012. On both occasions the machine had an error of less than +/ – 1% of the load value.

The quarry manager had overall responsibility for all the operations of the quarry, including the loading of vessels at Raynes Jetty. The manager's experience of port operations was limited to that gained during his tenure at Raynes Jetty.

[31] Angle of repose, as defined in the IMSBC Code 2012, is the maximum slope angle of non-cohesive (i.e. free-flowing) granular material. It is measured as the angle between a horizontal plane and the cone slope of such material.

[32] *The Use of Quarry Dust in Road Foundation Materials Performance of High Dust Unbound Sub-Base*, Report No. MA/7/G/6/003, Final Project Report by Tarmac Ltd and Partners, March 2011, available at: http://www.sustainableaggregates.com/library/docs/mist/l0055_ma_7_g_6_003.pdf

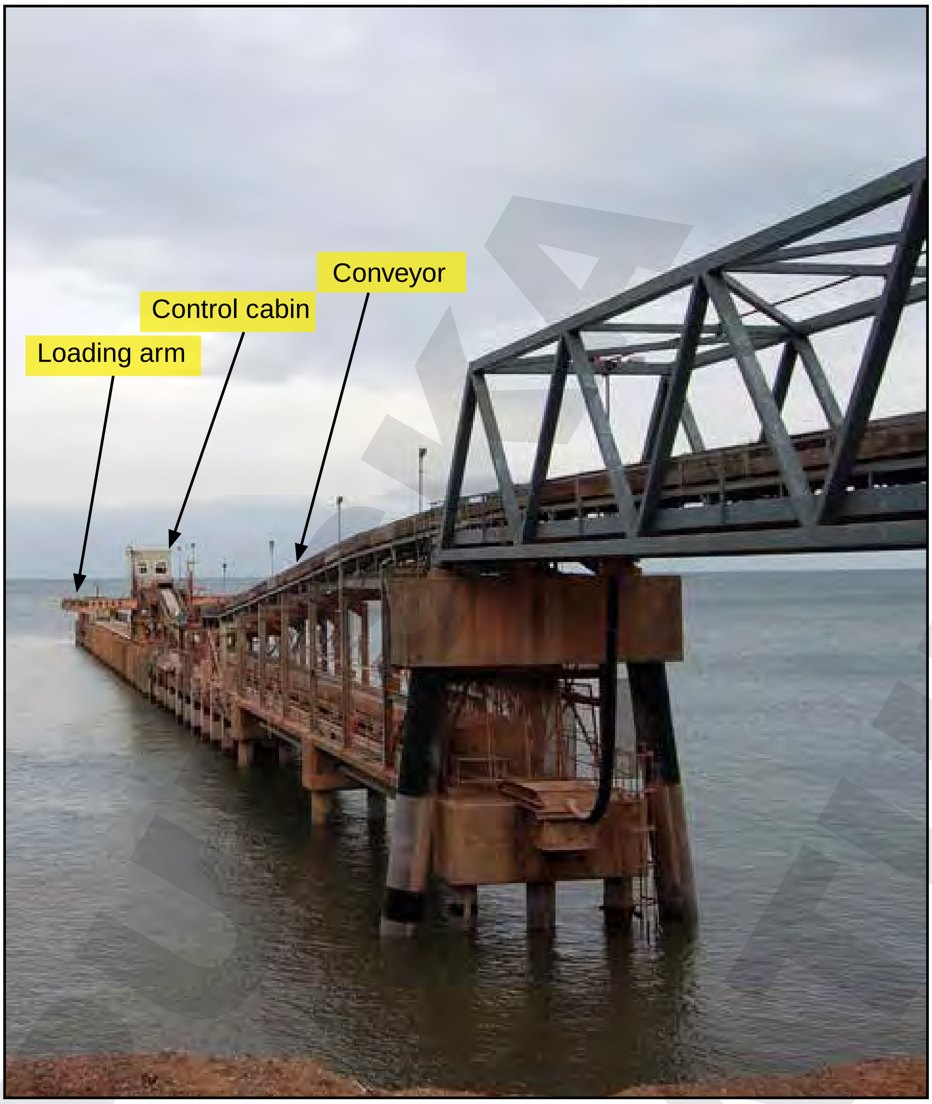


Figure 50: Raynes Jetty, Llanddulas

1.21.2 Visits by *Swanland*

Swanland was a regular visitor to Raynes Jetty, having loaded limestone cargoes on over 20 occasions since February 2010 **(Figure 51a** and **b)**. The weight of the cargo loaded during these visits ranged between 2530 and 2835 tonnes, and the loading time varied between 2.5 hours and 3.5 hours. The distribution of limestone within the hold at the time of the accident was reported to be similar to the previous occasions when *Swanland* had loaded limestone at Raynes Jetty. If required, *Swanland*'s excavator could be positioned to allow the shore conveyor to discharge into the forward part of the vessel's cargo hold.

Swanland usually arrived at Raynes Jetty about 3 hours before the predicted time of high water and was usually in full ballast in order to maintain manoeuvrability. Once *Swanland* was alongside, the duty engineer started to pump out the WB, which usually took approximately 4 hours. As the vessel only stayed alongside the jetty for about 3 hours due to the rapid fall of the tide after high water, a peak tank was sometimes not completely emptied and the hold hatch covers were not fully secured until after the vessel had sailed. It was reported that the WB tanks were usually dipped after sailing, although this was deferred if the vessel left the jetty at night or if the weather conditions were poor.

Image courtesy of Jennifer

Figure 51a: *Swanland* alongside Raynes Jetty, June 2010

Image courtesy of Jennifer

Figure 51b: *Swanland* alongside Raynes Jetty, June 2010

1.22 LOADING AND DISCHARGE

1.22.1 Onboard procedures

The Torbulk SMS procedure SMM 06 paragraph 1.2 and 1.2.1 instructed that:

> *<u>Prior to Cargo Operations</u>*
>
> *The chief officer is responsible for all cargo operations and shall ensure that the following checks are made prior to commencement:*
>
> - *Strength and stability checks made*

In addition, procedure SMM 06 paragraph 1.2.9 stated:

> *The vessel should never be in an 'overloaded' condition. It is the master's responsibility to ensure that the chief officer is aware of the maximum draft for the 'zone' the vessel is in, and that this draft is never exceeded taking into account the density of the water.* [sic]

During a 'Safety and Security Review' meeting held on board *Swanland* on 1 September 2011, 'SMM 06 Cargoes' was included on the agenda. However, no comments against this item were recorded in the minutes of the meeting.

1.22.2 Load Line

Swanland's Load Line certificate **(Annex N)** was used to confirm that the vessel's mean summer draught was 5.364m and the winter load line was 110mm below the summer mark. Her allocated mean winter draught was therefore 5.254m.

1.22.3 Onboard practice

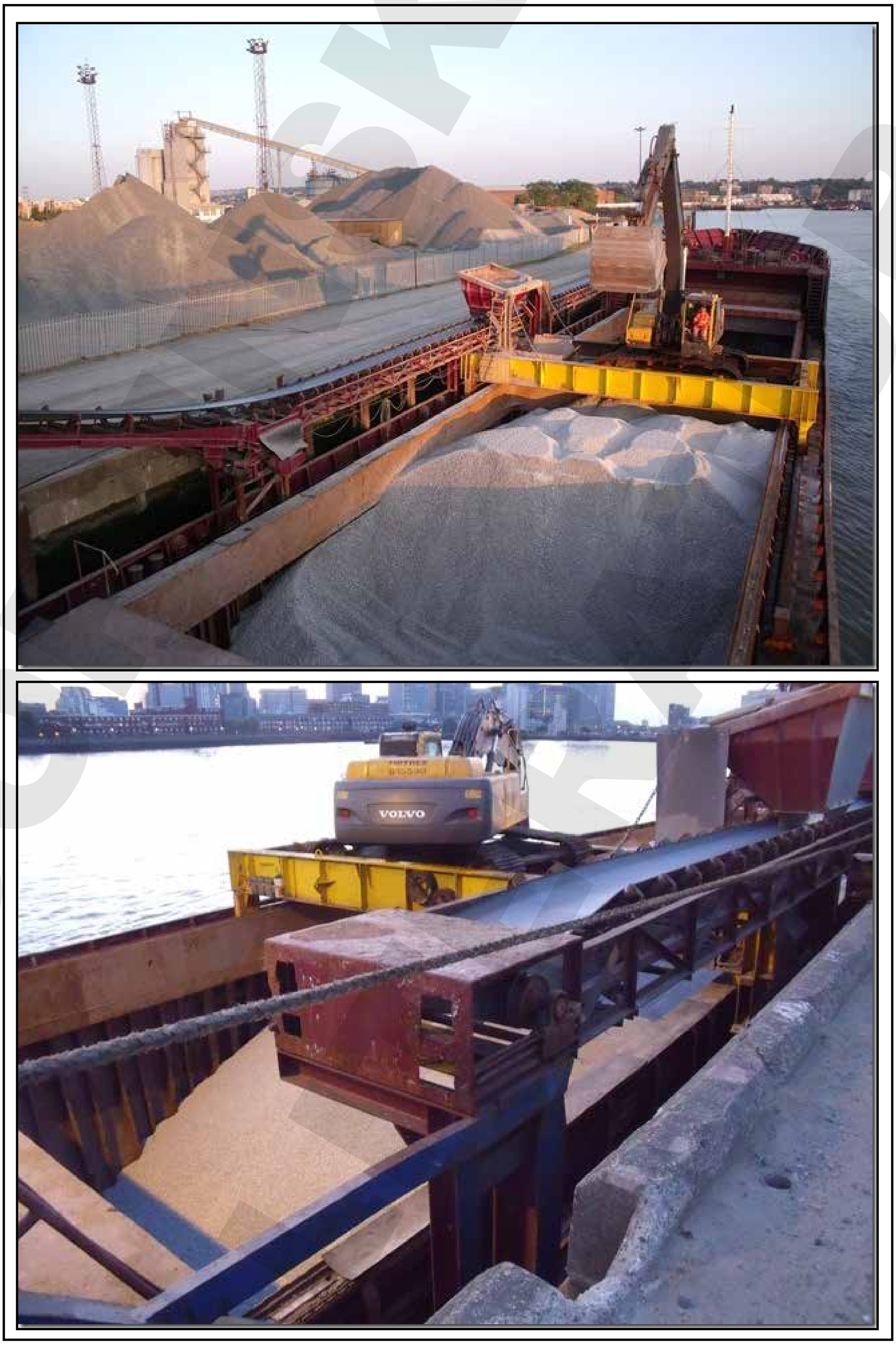
Carriage of stone cargoes had formed part of *Swanland*'s trade since the vessel was purchased by Swanland Shipping Ltd in 1996. The stone cargoes were never usually placed in the decked over parts of the cargo hold at the fore and after ends because shore grabs could not easily reach into these areas.

The self-discharge system was designed to cope with bulk cargoes as loaded in vessels of *Swanland*'s size and type. A change in the way of loading to suit self-discharging was not contemplated. The vessel was converted to self-discharge to take up an opportunity to transport HTCR from Flushing, Belgium to Gravesend, UK.

The discharge excavator was able to reach all parts of the hold except for an area 3m forward of the aft hatch coaming (frame 35) due to the position of the side conveyor luffing mechanism. Cargo stowed in this area had to be moved forward by the vessel's "bobcat". A small time advantage could be gained during discharge by not loading cargo in this area, but this was generally impractical and the "bobcat" could access the cargo once about two thirds of the cargo had been discharged and the excavator was working at the hold's forward end.

It is reported that it was quicker and more efficient to discharge cargoes in layers along the length of the hold rather than digging down into a concentrated area. However, it is also reported that in recent years stone cargoes were usually loaded in piles biased towards the aft of the centre part of the hold to aid discharge and to keep the vessel on an even trim.

Figures 52a and **52b** show *Swanland* discharging 4mm-20mm aggregate at Victoria Deep, Greenwich on 22 October 2011. The vessel had arrived loaded with 2796 tonnes of aggregate. When the photographs were taken approximately 200 tonnes of cargo had been discharged.



Figures 52a and **52b:** *Swanland* discharging aggregate in October 2011

1.23 LONGITUDINAL STRENGTH ASSESSMENT

1.23.1 Background

The standard method of assessing the overall strength of a ship is to assume that the longitudinal elements forming the midships section structure (as denoted by the section modulus[23]) act together as a single beam. Commonly referred to as “beam theory”, the bending behaviour of the beam is analysed by applying various loads to calculate the resultant shear forces[33], bending moments[34] and bending stresses[35] in the beam. The values of shear force and bending moment are then compared against permissible limits stipulated in the classification society’s construction rules. The analysis will often identify that the hull (or beam) is experiencing either a hogging[36] or sagging[37] bending stress. Draft surveys undertaken in August, September and October 2011 indicate that *Swanland* was hogged by a few centimetres in the ballast condition and remained hogged by about 3cm when fully loaded.

1.23.2 TMC’s longitudinal strength analysis methodology

As part of its investigation into the loss of *Swanland*, the vessel’s P&I insurers, The Shipowners’ Club, contracted TMC (Marine Consultants) Limited (TMC) to calculate the vessel’s longitudinal strength. TMC used its in-house software program, SEAMASTER[38], to undertake a detailed analysis of *Swanland*’s longitudinal strength for various possible loading conditions, based on an input 3D model of *Swanland*’s hull form.

No details of *Swanland*’s longitudinal weight distribution[39] could be obtained from the available documentation. TMC therefore estimated the distribution using an established in-house algorithm; the weight of the self-discharging equipment was included as a separate item in the distribution. The estimated distribution was then input into SEAMASTER, along with the components of the various loading conditions, as described below at **paragraph 1.23.4**.

For each of the loading conditions, TMC used the SEADAM[40] module of SEAMASTER to calculate the loading induced on various longitudinal sections of the hull structure, both in still water conditions and the sea conditions at the time of

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[33] A shear force is a force in a beam acting perpendicular to the beam’s longitudinal axis.

[34] A bending moment in simple terms is a measure of the amount of bending caused to a ship’s hull by a rotational force acting on the structure. The loads acting on a ship to induce a bending moment include the: weight of the ship’s structure and equipment; weight of the cargo and onboard fluids; the vessel’s buoyancy; and, the external forces imposed by the sea.

[35] A bending stress is the average force per unit area induced at a point in a body causing it to bend. The expression for stress is Load / Area, the units being N/m^2, where N is the symbol for Newtons, the unit of force.

[36] Hogging is the stress experienced when the midships area of the hull bends upwards in the longitudinal axis. The upper elements of the hull will experience tensile forces (pulling), while the lower element will be in compression (pushing).

[37] Sagging is the stress when the hull bends downwards. The upper elements of the hull will experience compressive forces, while the lower element will be in tension.

[38] SEAMASTER is a classification society-approved program used to calculate the stability and longitudinal strength of a vessel, based on a 3D computer model of the hull form. The program includes various modules to undertake specialist analysis of a vessel’s condition.

[39] The longitudinal weight distribution calculates the physical weight of the vessel, broken down into longitudinal sections, and includes the structure and equipment, but excludes consumable or variable items, such as cargo and onboard liquids.

[40] The SEADAM module of SEAMASTER enables the calculation of wave-induced loadings, based on the input wave parameters. The algorithms applied are limited to linear motion theory concerning very high waves and the varying shape and size of the hull.

the accident, based on Met Office calculations, (see **paragraph 1.4** and **Annex B**). As part of its analysis, TMC compared the calculated bending moments and shear forces with the respective permissible limits detailed in the “full” 1975 LR Rules (the rules that were available to TMC) extrapolated down to *Swanland*’s length of 81m.

TMC also used SEADAM to calculate the section modulus for the vessel at Frame 65, which TMC assumed to be representative of the midships section[41], for both the vessel’s original as-built scantlings and the scantling thicknesses based on the UTMs during the intermediate survey in 2009 at Kaliningrad. For both of these structural conditions and the various loading conditions in still water and waves, SEADAM was then used to calculate the induced bending stresses within each of the defined longitudinal structural members.

TMC also calculated the stress that would be required to cause buckling[42] in three of the main upper elements of longitudinal structure where the stresses were found to be largest: the hatch coaming; the deck plating; and the sheer strake[43]. The calculations were performed using the Panel Ultimate Limit State (PULS) software, developed by Det Norske Veritas (DNV). For the analysis, each panel was considered to be an integrated panel, and the rotational support of the panels was assumed to be simply supported, i.e. the panels were considered to be able to freely rotate.

As for the section modulus calculations, TMC calculated the stresses using both the original as-built scantlings and the reduced 2009 thicknesses, as shown at **Table 5**. The stress to cause buckling was also calculated for an additional scenario: the hypothetical detachment or loss of an intermediate deck frame underneath the deck plating. This doubled the effective span of deck plating liable to buckle, and therefore would have required a smaller stress to induce buckling.

Structural item	As-built Scantlings (N/mm^2)	2009 UTM Scantlings (N/mm^2)
Hatch coaming (1300mm span - normal structure)	159	140
Deck plating (650mm span - normal deck structure)	115	85
Deck plating (1300mm span - double span; assumed intermediate stiffener detached/lost	55	40
Sheer strake (650mm span - normal structure)	159	157

Table 5: Calculated stresses to cause buckling

[41] *Swanland*’s actual midships section was at Frame 58, as confirmed by Braemar **(Annex D)**.

[42] Buckling is a sudden, uncontrolled deformation of a structural element resulting from structural instability due to compressive action on the element.

[43] The sheer strake is the uppermost line of side plating.

1.23.3 Loading conditions

In order to try to accurately recreate the loading of the vessel at the time of the accident, TMC analysed a number of loading conditions in SEAMASTER.

The derivation of the loading condition was driven both by a number of known factors regarding the vessel's loading, as well as various unknown and variable aspects.

Factors used to evaluate the loading conditions included the reported draughts of 5.3m forward and 5.4m, and the amounts of fuel and fresh water on departure from Raynes Jetty. It was assumed that the vessel's WB tanks were all empty by the time of the accident. However, TMC had to add 45 tonnes of ballast to the loading conditions, which was distributed between the AP, FP and No.1 WB DB tanks, in order to try to replicate the reported draught readings.

The weights of the forward and aft piles of the cargo, and their approximate positions were derived from the loading plan **(Figure 3)**. However, the exact position of the cargo was unknown, despite some witness estimates of possible longitudinal extents of the cargo. Likewise, although the density of the limestone was reported to be 1.85 tonnes/m^3 and the certified angle of repose was 50° **(Annex L)**, it was noted from stockpiles of the cargo at Raynes Quarry **(Figure 53)** that the actual angle of repose appeared to be closer to 35°. TMC therefore analysed a number of scenarios with various angles of repose between 35° and 50°, using the 3D Computer Aided Design (CAD) package RHINOCEROUS 3D to calculate estimates of the cargo distributions and centres of gravity.

Figure 53: Type 1 limestone stockpile at Raynes Quarry

Annex O shows the derivation of the various cargo distributions assessed by TMC and the resulting conditions are summarised at **Table 6**. Conditions 1 to 4 were derived by TMC, while condition 5b was proposed by the MAIB; all in an attempt to recreate the cargo distribution at the time of the accident. Condition 7 represented a hypothetical homogenous[44] distribution of the limestone cargo, as calculated by TMC.

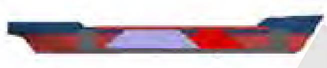
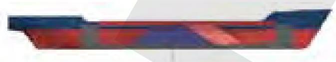
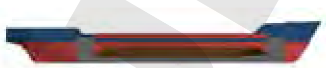
Condition No.	Loading Distribution	Mean Draught (m)	Trim (+ve by stern) (m)	Aft Cargo pile LCG (m fwd of Aft Perpendicular)	Fwd Cargo pile LCG (m fwd of Aft Perpendicular)	Overall Cargo LCG (m fwd of Aft Perpendicular)
1		5.33	1.13	33.88	49.97	39.35
2		5.34	0.91	35.15	48.63	39.74
3		5.34	0.75	35.69	48.36	40.02
4		5.36	0.09	35.69	51.63	41.13
5b		5.35	0.08	37.57	48.08	41.15
7		5.36	0.01	-	-	41.27

Table 6: Summary of loading conditions analysed

1.23.4 Analysis results

For each of the loading conditions analysed, TMC confirmed that the required stability criteria were met with good margins. **Table 7** overleaf compares the calculated maximum bending moments and shear forces for each loading condition in still water and waves against the permissible limits prescribed in the "full" 1975 LR Rules.

Tables 8 and **9** (overleaf) show the calculated average bending stresses in still water and the wave conditions for the three structural elements, in both their as-built and 2009 conditions. The results of a comparison of the stresses required to cause buckling were shown by colour coding the resulting values. The values in **red** indicate where the calculated bending stress exceeds the stress to cause buckling in the corresponding scantling. The values in **Blue** also show where the calculated bending stress exceeds the buckling stress, but only when the effective span is doubled due to the hypothetical detachment or loss of an intermediate frame. Tensile stresses are shown as positive values, while compressive stresses are negative.

TMC noted that the results in **Table 8** appeared to show that the bending stresses in conditions 2, 3 and 5b exceeded the stress to cause buckling even in the still water condition. However, it recognised that this outcome was unlikely and was probably indicative of some of the assumptions used and the limitations in its analysis. For example, the calculation method assessed each plate individually, whereas in reality

[44] Homogenous in this context refers to the cargo being evenly distributed.

the stress would be distributed from the loaded plate to adjacent plates, therefore reducing the actual stress in the individual plate. Also, although TMC assumed the classification society minimum yield strength[45] for a plate of 235 N/mm^2, the plate strength might have been greater.

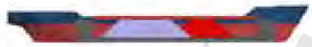
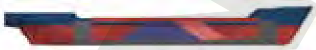
Condition No.	Loading Distribution	Still Water: Max Bending Moment (% of 1975 "full" LR Rule limit)	Still Water: Max Shear Force (% of 1975 "full" LR Rule limit)	Waves (4.0m wave height, 8.2s period): Max Bending Moment (% of 1975 "full" LR Rule limit)	Waves (4.0m wave height, 8.2s period): Max Shear Force (% of 1975 "full" LR Rule limit)
1		-120%	-38%	-172%	-48%
2		-142%	-37%	-195%	48%
3		-149%	-38%	-201%	51%
4		-119%	-32%	-169%	-42%
5b		-165%	-52%	-216%	58%
7		-53%	-18%	-104%	-29%

Table 7: Comparison of calculated maximum bending moments and shear forces against the nominal "full" 1975 LR Rules permissible limits

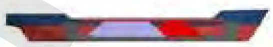
		Still water					
		As-built Scantlings			2009 UTM Scantlings		
Condition No.	Loading Distribution	Hatch Coaming	Deck Plating	Shear Strake	Hatch Coaming	Deck Plating	Shear Strake
1		-95	-76	-76	-104	-84	-84
2		-114	-91	-91	-125	-100	-100
3		-118	-95	-95	-130	-104	-104
4		-93	-75	-75	-102	-82	-82
5b		-131	-105	-105	-143	-115	-115
7		-42	-33	-33	-46	-37	-37
Key							
Calculated stresses to cause buckling (taken from Table 5)		-159	-115/-55	-159	-140	-85/-40	-157
NB. For the deck plating, the first calculated stress value to cause buckling assumes the normal 650mm span between stiffeners; the second value assumes a double span (1300mm) due to the hypothetical detachment/loss of an intermediate stiffener.							
-##	calculated bending stress exceeds the stress to cause buckling in the corresponding scantling with the intended span between stiffeners.						
-##	calculated bending stress exceeds the buckling stress when the effective span of the deck plating is doubled due to an assumed detached/lost intermediate frame.						

Table 8: Calculated average bending stresses in still water

[45] The yield strength or yield point of a material is defined as the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible.

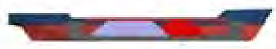
		Waves (4.0m wave height, 8.2s period)					
		As-built Scantlings			2009 UTM Scantlings		
Condition No.	Loading Distribution	Hatch Coaming	Deck Plating	Shear Strake	Hatch Coaming	Deck Plating	Shear Strake
1		-138	-110	-110	-151	-122	-122
2		-156	-125	-125	-171	-137	-137
3		-161	-129	-129	-176	-142	-142
4		-135	-108	-108	-148	-119	-119
5b		-172	-138	-138	-189	-152	-152
7		-83	-67	-67	-91	-73	-73
Key							
Calculated stresses to cause buckling (taken from Table 5)		-159	-115/-55	-159	-140	-85/-40	-157
NB. For the deck plating, the first calculated stress value to cause buckling assumes the normal 650mm span between stiffeners; the second value assumes a double span (1300mm) due to the hypothetical detachment/loss of an intermediate stiffener.							
-##	calculated bending stress exceeds the stress to cause buckling in the corresponding scantling with the intended span between stiffeners.						
-##	calculated bending stress exceeds the buckling stress when the effective span of the deck plating is doubled due to an assumed detached/lost intermediate frame.						

Table 9: Calculated average bending stresses based on the Met Office wave calculations (4m wave height and 8.35s wave period)

1.24 ONBOARD STABILITY INFORMATION

1.24.1 Stability books

An approved trim and stability manual (stability book) for *Carebeka IX* was issued by LR in November 1977 **(Annex P)**. A revised stability book was issued on 15 December 1988, when the vessel was named *Artemis* and class had been transferred to BV. This stability book was approved by BV in March 1989, and subsequently by LR in March 1999 following the vessel's transfer of class back to LR from BV. The vessel's lightship[46] used in the 1988 stability book was based on the inclining experiment conducted in February 1977 when the vessel was new. It included four loading conditions for the vessel, two of which were ballast conditions; the others being "homogenously loaded" conditions. **Figure 54** shows the "Homogenously loaded Commence Voyage" condition which illustrates a hold apparently fully loaded with 2857 tonnes of cargo, with a stowage factor of "49.6 CU.FT / TON"[47]. This stowage factor[48] equates[49] to 1.383m^3/tonnes, which is equivalent to a density of 0.723 tonnes/m^3.

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[46] Lightship is the actual weight of a vessel which is complete and ready for service, excluding any variable loads or consumables. A vessel's lightship weight and corresponding centres of gravity are calculated during an inclining experiment and are used as the basis for calculating the vessel's stability characteristics.

[47] Given the use of cubic feet, a "ton" in this context is considered to refer to an imperial ton which is equal to 2240 pounds (lbs), where 1lb equals 0.454kg. Therefore 1 ton equals 1.016 tonnes.

[48] The stowage factor for a cargo is measured in m^3/tonnes and is therefore the reciprocal of its density, which is measured in kg/m^3 or tonnes/m^3.

[49] 1 cubic foot is equal to 0.3048m x 0.3048m x 0.3048m = 0.0283m^3. Therefore 49.6 cubic feet/ton = 1.405m^3/1.016 tonnes = 1.383m^3/tonnes, which is equivalent to a density of 0.723 tonnes/m^3.

The 1988 stability book only contained stability calculations for the loading conditions. There was no reference to any longitudinal strength calculations or structural considerations for the vessel's operation.

In January 2003, a revised stability book was issued following the addition of the self-discharge equipment. This was based on a new lightship for the vessel derived from an inclining experiment in January 2003. The book was approved by LR in March 2003, and again contained stability calculations for two ballast conditions and two "homogenously loaded" conditions. An extract from the stability book showing the heavier "homogenously loaded" condition is at **Figure 55**. This confirms that there was no indication of the longitudinal extent of the cargo, other than the values for its vertical and longitudinal centres of gravity (VCG and LCG respectively) and that it was "homogenous". The 2003 stability book did not include any reference to the cargo's stowage factor or density or to any longitudinal strength calculations or structural considerations. The marine consultancy which produced the stability book in 2003 was not requested to provide a loading manual.

1.24.2 Onboard stability calculations

It was reported that *Swanland*'s chief officers did not routinely calculate the vessel's stability prior to departure. The nature of the vessel's operation meant that she usually operated in a ballast condition or with a full load of cargo.

In July 2005, an ISM audit conducted by LR identified that *Swanland*'s crew had been using a non-approved loading programme to calculate the vessel's stability. A non-conformance was raised and the loading programme was removed.

1.25 ONBOARD LOADING INFORMATION

1.25.1 General

During the investigation, a number of *Swanland*'s former crew were consulted regarding the availability of any onboard loading guidance relating to longitudinal strength. None of the crew members were able to definitively confirm that a dedicated loading manual was available on board the vessel.

Only one reference to the approval of loading guidance was identified in LR's records for *Swanland.* This was a request made by LR's head office during the vessel's construction for a copy of the loading manual to be forwarded by the local surveyors in the Netherlands **(Annex P)**. Although a trim and stability manual was issued, it is not clear whether the stability book also contained loading information. No records are available that confirm whether the requested loading manual was provided separately. No information was available on any construction drawings or other documentation stating a maximum permissible tank top loading for *Swanland*.

Both Swanland Shipping Ltd and Torbulk were also unable to confirm whether there had been any longitudinal strength loading guidance or loading manual on board *Swanland*[50]; Torbulk was of the opinion that a manual was not carried. However, it confirmed that the vessel did not have a loading instrument.

[50] Regulation 3-7 of Part A-1 of SOLAS requires that a set of as-built construction drawings and plans showing structural alterations be kept both on the vessel and ashore by the vessel's operator. However, this only applies to vessels constructed on or after 1 January 2007. The IMO circular, MSC/Circ.1135, stipulated the list of drawings to be maintained, which included the loading manual, where required, and plans of the midship section.

At the time of the accident, two other vessels managed by Torbulk carried loading manuals, *Sea Hunter* and *Swan Diana.* However, the ship manager was unaware that *Swan Diana* had a loading manual on board. An extract from *Swan Diana*'s loading manual is at **Annex Q**.

1.25.2 Survey records

In June 2008, during the annual survey conducted by LR, the attending surveyor annotated the 'survey checklist' to confirm that a loading booklet for the carriage of cargoes in bulk was on board, as was the approved stability/loading information.

Between 2009 and 2011 a 'Report of Cargo Ship Safety Construction Survey' and a 'Report of Load Line Survey' were completed by the attending surveyor during each INSB structural survey. Both of these forms included an entry to record the presence of a loading manual on board the vessel. The results of these entries are summarised at **Table 10**.

		Report of Cargo Ship Safety Construction Survey form		Report of Load Line Survey
INSB survey	**Date of Survey**	**Loading Manual recorded as on board**	**"Loading and unloading manual and stowage of solid bulk cargoes manual" recorded as on board**	**Approved Loading Manual or approved Loading Instrument**
Intermediate Survey	2 June 2009	No	No	No
Annual Survey	9 June 2010	No	Yes	Yes
Annual Survey	8 June 2011	No	Yes	Yes

Table 10: Summary of INSB survey records of onboard loading manuals

1.26 LOADING GUIDANCE REQUIREMENTS

1.26.1 International Convention on Load Lines, 1966

Regulation 10 of The International Convention on Load Lines, 1966 states that:

> *The master of every new ship shall be supplied with sufficient information, in an approved form, to enable him to arrange for the loading and ballasting of his ship in such a way as to avoid the creation of any unacceptable stresses in the ship's structure, provided that this requirement need not apply to any particular length, design or class of ship, where the Administration consider it to be unnecessary.* [sic]

1.26.2 SOLAS

Although Chapter VI of SOLAS covers the carriage of solid bulk cargoes, the requirements provided originally only applied to the carriage of grain. However, in 1994, the chapter was amended to also introduce mandatory provisions for the carriage of other solid bulk cargoes.

Relevant extracts from Parts A and B of Chapter VI are included at **Annex R**. Regulation 2 of Chapter VI notes that the shipper of the cargo shall provide the master or his representative with appropriate information on the cargo, including its stowage factor, to enable precautions to be taken for its safe carriage. Regulation 7 also requires vessels to be provided with a booklet to enable the master to prevent excessive stresses in the vessel's structure. The regulation requires the booklet to provide, inter alia, details of the:

- Maximum allowable load per unit surface area of the tank top plating.
- General loading and unloading instructions with regard to the strength of the ship's structure including any limitations on the most adverse operating conditions during loading, unloading, ballasting operations and the voyage.

1.26.3 IMO Resolution MSC.277(85)

On 28 November 2008, the IMO Resolution MSC.277(85) was adopted that provided guidance for ships which were not determined to be bulk carriers but occasionally carried dry cargoes in bulk. The guidance was to be applied for vessels that had their keel laid on or after 1 July 2010, and included certain provisions to allow the occasional carriage of dry bulk cargoes. A vessel of single-side skin construction of less than 100m in length was required to:

- Have an assigned freeboard of "Type B[51] without reduced freeboard" (as was the case for *Swanland*).
- Comply with certain SOLAS regulations applicable to bulk carriers, including, inter alia:
    - Regulation XII/11 of the 1974 SOLAS Convention, as amended, for loading instruments. For a bulk carrier of under 150m in length, the loading instrument was to be capable of providing intact stability information.

1.27 APPLICATION OF LOADING GUIDANCE REQUIREMENTS BY CLASSIFICATION SOCIETIES

1.27.1 International Association of Classification Societies

IACS UR S1 stipulates requirements for loading manuals and loading instruments on vessels entered into class with an IACS member classification society. The latest revision of UR S1, introduced in 2010, states that its requirements apply to vessels of over 65m in length which were contracted for construction from 1 July 1998 onwards. However, for vessels contracted for construction before this date, the relevant prior revisions of the UR apply.

Although the exact date of *Swanland*'s construction being contracted is unknown, the original version of UR S1 was introduced in 1971 and was first revised in 1981. The original version of UR S1 stated:

> *All ships, regardless of length, for approved uneven cargo or ballast distributions, or intended to carry cargo of high density are to be supplied with information to facilitate rapid assessment of stresses in the hull.*

[51] The 1966 International Convention on Load Lines defines a Type A vessel as one that is designed to only carry liquid cargoes in bulk; all other vessels are Type B. Type B vessels may be assigned a "Reduced" freeboard if the vessel complies with certain requirements.

The original version and 1st revision of UR S1 provided no information on the format or content of the loading manual. However, the 2nd revision, in 1981, provided definitions for a loading manual and loading instrument as follows, and which remain valid in the latest version of UR S1:

> *A loading manual is a document which describes:*
>
> *– the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moment and shear force*
>
> *– the results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional and lateral loads*
>
> *– the allowable local loading for the structure (hatch covers, decks, double bottom, etc.)*
>
> *A loading instrument is an instrument, which is either analogue or digital, by means of which it can be easily and quickly ascertained that, at specified read-out points, the still water bending moments, shear forces, and the still water torsional moments and lateral loads, where applicable, in any load or ballast condition will not exceed the specified permissible values.*

The 2nd revision of UR S1 in 1981 also introduced specific requirements for different categories of vessel requiring a loading instrument. However, *Swanland* did not fall into any of the categories requiring a loading instrument.

1.27.2 Lloyd's Register

<u>Longitudinal strength and loading manual</u>

As detailed at **paragraph 1.12.5**, LR was unable to confirm to which version of its 1976 rules *Swanland* had been constructed. However, both the 1976 "full" LR Rules **(Annex F)** and the 1976 LR Small Ship Rules **(Annex G)** required that longitudinal strength calculations and a loading manual should have been submitted to LR for approval.

Regulation 301 of the 1976 LR Small Ship Rules required that still water bending moments be calculated for all vessels greater than 65m in length with "100A1" in their class notation. The regulation also noted that:

> *Special consideration will be given to ships designed for the carriage of dry cargoes, such that the loading (in at least one hold or compartment) is denser than that corresponding to a stowage rate of 1m³/tonne.*

The 1976 LR Small Ship Rules provided no further details on the content or format of the required loading manual, other than details of information to be included for the specific scenario of "short voyage stresses".[52]

As noted by Braemar in Section 4.3 of its report **(Annex D)**, the 1976 LR Small Ship Rules did not have an explicit requirement for the calculation of wave bending moments. However, the "full" 1976 LR Rules for vessels over 90m in length did include wave bending moment limits, as well as guidance on the content of the

[52] A "short voyage" was defined as one not exceeding 24 hours duration.

required loading manual. The loading manual was to contain details of the "*proposed load, ballast and part-loaded conditions, subdivided into departure and arrival conditions*". The "full" 1976 LR Rules also stated that:

> *Where non-homogeneous loading conditions are proposed, or where it is likely that service conditions significantly different from those for which the scantlings were approved may arise, it is recommended that an approved means of determining the suitability of loading be placed on board.*

<u>Tank top loading</u>

Regulation 2505 of both the "full" 1976 LR Rules and the 1976 LR Small Ship Rules stated that:

> *For ships having the class 100A1, the loading on the tank top may be that equivalent to a head of 1,4d with a stowage rate of 1,39m^3/tonne. d is the load draught, in metres.*[53]
>
> *For ships having a heavy cargo notation, the inner bottom may be suitable for increased load, see SD 606(b).*

where regulation 606(b) of both sets of rules includes an additional requirement for the inner bottom longitudinals scantlings in way of the cargo hold on vessels with a notation to carry heavy cargoes.

1.27.3 International Naval Surveys Bureau

Part I of the 2008 INSB Rules, dealing with classification and survey requirements, states that for a vessel being transferred into class with INSB, various items of information are to be submitted for approval. The required information includes, inter alia:

> *(j) Loading conditions, calculations of still water bending moments and relevant documents; particulars of loading calculations and Instruction Booklets, as applicable.* [sic]

Part I of the 2008 INSB Rules also included a further list of documentation that was "*considered necessary*" and was to be submitted as part of the transfer of class. This list included, inter alia:

> *(b) Loading Manual, if applicable.*

Part I of the 2008 INSB Rules does not specify when a loading manual is applicable. However, Part I of the previous INSB Rules, issued in 2001, only required a loading manual to be provided during transfer of class for general dry cargo vessels of length 120m and over constructed before 1 July 1998.

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[53] Although the vessel's general arrangement drawing at **Figure 1** shows a load draught of 5.37m, the as-built capacity plan **(Annex E)** stated the draught was 5.364m, which aligns with the Load Line certificate at Annex N.

Part II of the 2008 INSB Rules stipulated hull construction requirements, including the provision of longitudinal strength and loading information for vessels built to its rules. Although these would therefore have not applied to *Swanland*, an extract from Part II of the 2008 INSB Rules is at **Annex S** for comparison. This confirms that had *Swanland* been built to these Rules, a loading manual but not a loading instrument would have been required.

1.28 INTERNATIONAL MARITIME SOLID BULK CARGOES CODE

1.28.1 Origins

The problems associated with the carriage of bulk cargoes were formally recognised during the 1960 International SOLAS Conference, which recommended that an internationally acceptable code of safe practice for the shipment of bulk cargoes be developed.

The first Code of Safe Practice for Solid Bulk Cargoes (hereafter referred to as the BC Code) was subsequently published in 1965, with the last edition being issued in 2005.

The BC Code provided guidance to Flag State administrations, ship owners, shippers and masters on the standards to be applied in the safe stowage and shipment of solid bulk cargoes excluding grain, which are dealt with under separate rules. The BC Code included practical guidance on the procedures to be followed and appropriate precautions to be taken in the loading, trimming, carriage and discharge of bulk cargoes. It also included:

> *It is therefore recommended that the master be provided with sufficiently comprehensive loading information to enable him to arrange the loading aboard his ship so as not to overstress the structure. In general, masters should be guided by the loading information provided in the ship's stability information booklet and by the results obtained by the use of loading calculators, if available.*

1.28.2 Application

On 4 December 2008, the IMSBC Code was adopted by IMO resolution Maritime Safety Committee (MSC).268(85). The IMSBC Code superseded the BC Code and entered into force on 1 January 2011, although owners had been able to apply the Code on a voluntary basis since 1 January 2009. From 1 January 2011, the Code became mandatory under the provisions of the amended SOLAS Convention. All ships carrying solid bulk cargoes are now required to comply with the IMSBC Code, irrespective of their keel-laying date or gross tonnage.

1.28.3 Scope

The primary aim of the IMSBC Code is to facilitate the safe loading/unloading, stowage and shipment of solid bulk cargoes by providing information on the dangers associated with carrying solid bulk cargoes and procedures to be adopted when the shipment of solid bulk cargoes is contemplated. As indicated at **paragraph 1.19** above and as shown at **Annex M** for Limestone, Appendix 1 of the IMBSC Code also provides individual schedules for specific solid bulk cargoes, together with advice on their properties and methods of handling. The properties include details of a cargo's bulk density and angle of repose; however, these properties are provided for guidance only.

1.28.4 Loading requirements

Section 2 of the IMSBC Code **(Annex R)** includes provisions on the general loading and carriage of solid bulk cargoes. Paragraph 2.1.1 notes that various accidents have been caused due to the improper loading of cargoes, and that:

> *…solid bulk cargoes have to be properly distributed throughout the ship to provide adequate stability and to ensure that the ship's structure is never overstressed.*

Paragraph 2.1.1 also requires that:

> *the shipper shall provide the master with adequate information about the cargo, as specified in section 4, to ensure that the ship is properly loaded.**

where * refers to the Code of Practice for the Safe Loading and Unloading of Bulk Carriers, adopted by the IMO by Resolution A.862(20), as amended. An extract from Section 4 of the IMBSC Code is included at **Annex R**, which confirms that the information to be provided by the shipper should include the cargo stowage factor and the need for cargo trimming.

Paragraph 2.1.2 of the IMSBC Code **(Annex R)** provides further requirements to ensure the structure of a vessel is not overstressed. This includes, inter alia:

> *When loading a high-density solid bulk cargo, particular attention shall be paid to the distribution of weights to avoid excessive stresses…*

Section 5 of the IMSBC Code **(Annex R)** also includes provisions on the trimming of cargoes, and states:

> *Due consideration shall be given to the amount of a solid bulk cargo in each cargo space, taking into account the possibility of shifting and longitudinal moments and forces of the ship. Cargo shall be spread as widely as practicable to the boundary of the cargo space.*

1.28.5 Cargo requirements

Paragraph 1.2.2 **(Annex R)** requires that any solid bulk cargoes specifically listed in Appendix 1 of the IMSBC Code shall be transported in accordance with the provisions of the Code. If a solid cargo is not listed in Appendix 1 and is to be carried in bulk, the competent authority of the port of loading shall provide the vessel's master with a certificate stating the cargo's characteristics and the required conditions for its carriage. The competent authority shall also submit an application to the IMO within 1 year from the issue of the certificate to incorporate the cargo into Appendix 1 of the IMSBC Code.

1.29 AUTHORISATION TO CARRY CARGOES

Although not a mandatory requirement, certain port and PSCI authorities from various Flag States require proof of compliance with the IMSBC Code. This is typically demonstrated by a “Certificate of Compliance” or “Document of Compliance” for the Carriage of Solid Bulk Cargoes, which is usually issued by ROs on behalf of the Flag State administrations.

There are no records of a “Certificate of Compliance” or “Document of Compliance” for the Carriage of Solid Bulk Cargoes having been issued to *Swanland* by either LR or INSB.

In 1992, when the BC Code was still extant, an attestation **(Annex T)** was issued by BV confirming that *Artemis* (as *Swanland* was then called) was found to be suitable to carry various bulk cargoes, including limestone, subject to the vessel being:

> *“…loaded according to the said regulations and to the loading manual on board to the satisfaction of the master.”* [sic]

1.30 CLASSIFICATION SOCIETY REQUIREMENTS FOR THE CARRIAGE OF CARGOES

1.30.1 Lloyd’s Register requirements

The 2008 LR Rules and Regulations Part 1, Chapter 1, Section 1.1.6 states that:

> *The Rules are framed on the understanding that ships will be properly loaded and handled. They do not, unless stated or implied in the class notation, provide for special distributions or concentrations of loading. The Committee may require additional strengthening to be fitted in any ship which, in their opinion, would otherwise be subjected to severe stresses due to particular features in the design, or where it is desired to make provision for exceptional loaded or ballast conditions. In such cases, particulars are to be submitted for consideration.*

Section 1.1.7 also stipulates that:

> *When longitudinal strength calculations have been required, loading guidance information is supplied to the Master by means of a Loading Manual and in addition, when required, by means of a loading instrument.*

1.30.2 INSB requirements

The 2008 INSB Rules and Regulations do not provide any specific conditions regarding the loading or carriage of cargoes. However, Part 1, Chapter 2, Section 4.1.1 (d) states that:

> *The class of a ship will be automatically suspended in the following cases (inter alia):*
>
> *(d) When the ship proceeds to sea with less freeboard than that assigned, or when the freeboard marks on the ship sides are placed higher than the assigned position.*

1.31 MARITIME COOK ISLANDS

1.31.1 Overview

The Cook Islands consist of 15 small islands scattered over some 2 million square kilometres of the Pacific Ocean. The country is a State in free association with New Zealand and has a population of approximately 18000.

MCI is a commercial organisation that operates an open register for ships and yachts on behalf of the Cook Islands Ministry of Transport, using internet-based technology to facilitate the issue of certificates. MCI operates a worldwide network of deputy registrars and surveyors.

Cook Islands maintain an ambassador and permanent representative to the IMO. It does not impose additional requirements on ship owners beyond the requirements of IMO Conventions read in conjunction with the IACS Unified Interpretations.

1.31.2 Register

As of 18 July 2012, MCI had 56 SOLAS vessels registered, most of which were general cargo vessels. The total gross tonnage of the SOLAS vessels was 595,138 and their average age was close to 30 years. In addition to *Swanland*, the other Cook Islands registered ships managed by Torbulk at the time of *Swanland*'s loss *were Swan Diana*, *Shoreham* and *Thames*.

1.31.3 Vetting procedures

With regard to vetting procedures, MCI's Quality Manual dated April 2009 included:

Cook Islands Ship Registry seeks Vessels meeting the following criteria:

– $\underline{\geq}$ GT (SOLAS)

– < 25 years;

– Classed with a ***<u>Recognised Class Society</u>***

– Good port state record

> *N.B. If the vessel doesn't meet all of the above criteria, then before the vessel will be accepted for registration an investigation into the circumstances of the Vessel must be carried out to determine that the Vessel will be able to comply with all of the requirements of registration and is likely to be maintained in compliance. [sic]*

The Quality Manual also states:

> *INSB classed vessels under the age of 15 years will be accepted. Vessels over 15 years old must be subject to IACS Enhanced Survey Programme or equivalent to ensure that they get extra attention on structural metal fatigue and general wear and tear.* [sic]

The vetting procedure stipulated that if a classification society was not recognised, or a vessel was entered in class with INSB and more than 15 years old, acceptance of the vessel onto the register required justification.

1.31.4 Relationships with classification societies

MCI had formal agreements with nearly all of the IACS member classification societies and INSB to act as ROs on its behalf. MCI had not conducted any audits of these societies and had based its approval of INSB as an RO on an audit of INSB conducted by the Panama Maritime Authority (PMA) on 6 March 2008. Although this audit had recommended the continued recognition of INSB as an RO for PMA, it raised four major and four minor non-conformities. At the time of the accident, MCI was unable to provide any record of these non-conformities having been closed out. MCI was not aware of any other Flag State audits of INSB conducted between 2008 and 2011.

1.31.5 Performance

Between 2009 and 2011, Cook Islands' registered vessels were inspected on 160 occasions under the Paris MOU on port state control. During these inspections 14 vessels were detained, resulting in the Cook Islands being placed towards the bottom of the Grey List[54] **(Annex U)**. A further 30 inspections of Cook Islands' registered vessels were conducted under the Tokyo MOU[55] on port state control, none of which had resulted in detentions and placing Cook Islands on its white list **(Annex V)**. During this period, MCI deleted five SOLAS vessels from its register due to repeated detentions under the Paris MOU.

1.32 INTERNATIONAL NAVAL SURVEYS BUREAU

1.32.1 Overview

INSB was established in 1977 to undertake a range of business activities including classification and technical assessment, statutory surveys and verification services. Although based in Greece, INSB's global network extended to more than 50 countries, incorporating five regional offices and 60 outstations. INSB employed over 200 ship surveyors and auditors, supported by subject-matter experts and administrative staff. INSB is not a member of IACS.

1.32.2 North West Europe Regional Office

Prior to July 2010, INSB survey activities in north west Europe were conducted by Marine Technical Services (MTS), a marine consultancy based in Antwerp. MTS also undertook survey work on behalf of other classification societies and various Flag States.

On 18 May 2006, IMO Resolution MSC.208(81) was adopted, requiring that from 1 July 2010 onwards, ROs only use exclusive surveyors and auditors to perform statutory survey and certification functions. As a result, on 1 July 2010 INSB opened

[54] The Paris MOU categorises the performance of both maritime administrations and recognised organisations into White, Grey and Black lists based upon vessel detention rates. The better performing maritime administrations and recognised organisations are placed on the white list.

[55] An organisation similar to the Paris MOU comprising 18 member maritime administrations covering the Asia-Pacific region.

its North West (NW) Europe office in Antwerp. The new office was managed by a nautical surveyor (managing director), supported by one other surveyor, who had joined MTS in early 2009. The owner of MTS, who had conducted the 2009 intermediate survey on *Swanland*, was not employed in INSB's Antwerp office.

1.32.3 Qualifications, training and experience of surveyors

<u>Intermediate survey, Kaliningrad, 2009</u>

The owner of MTS was an ex-ships' master, with around 20 years' experience of undertaking classification surveys, 16 years of which were on behalf of INSB. He had also acted as a surveyor on behalf of the Liberia, Marshall Islands, Malta, Bahamas and Barbados flag administrations, as well as P&I clubs and other insurers. The owner had had no formal training in hull surveying, but had attended two seminars in 2005 and 2009 at INSB's head office that were relevant to classification surveys, including hull surveys. He had also attended an ISM Code seminar in 2002 and an International Ship and Port Facility Security Code (ISPS) seminar in 2004.

<u>Other surveys of *Swanland* and audits of Torbulk</u>

The following surveys of *Swanland* and audits of Torbulk were conducted by the INSB NW Europe surveyor who had joined MTS in 2009:

23 July 2009 – DOC office verification audit of Torbulk;

23 September 2009 – Initial SMC verification audit for *Swanland;*

8-9 June 2010 – Annual survey of *Swanland*;

23 July 2010 – Annual DOC audit of Torbulk;

7-8 June 2011 – Annual survey of *Swanland*;

19 July 2011 – Annual DOC audit of Torbulk;

Before joining INSB, the surveyor had served in the UK's Royal Navy (RN) for 22 years, leaving as a Chief Petty Officer Marine Engineer Mechanic (Electrical) (CPOMEM(L)). He had then worked in a plastic factory in Belgium for 5 years, before taking up a role at the British Embassy in Belgium for 8 years. Between 2005 and 2007, the surveyor renovated a house, and in 2008 he managed a reprographic centre in Antwerp. After the surveyor joined MTS in February 2009, he was given 'on the job' training but did not receive any formal or external training in ship survey. The surveyor had attended in-house training in ISM at the INSB head office and hoped to attend an external ISM course to build more confidence in the subject.

INSB's training records indicate that the surveyor attended a training course between 9 and 13 February 2009 covering the certification and survey requirements for: ISM and ISPS certification schemes, machinery systems, load line, structural fire protection, safety equipment, oil pollution prevention, safety radio, MARPOL, antifouling systems, solid bulk cargoes, carriage of dangerous cargoes in bulk, fishing vessels, crew accommodation and hull structure. The course also provided an overview of the port state control regime.

From 6 February 2009 until 12 December 2009, the surveyor accompanied a more experienced surveyor during five ship surveys (two annual, two special and one occasional), three ship SMC audits (one initial, one interim and one renewal) and one company DOC audit as a trainee. INSB records indicate that the surveyor's performance had been monitored on two occasions; in September 2009 during an initial SMC audit and in March 2010 during an annual class and statutory survey.

During ISM audits, the surveyor did not like to issue non-conformities, which he felt penalised the crew; he instead preferred to discuss the issues he had identified with them.

On 3 October 2011, the managing director of INSB NW Europe attended *Swanland* to undertake a tail shaft inspection at Flushing. He was an ex-ships' master who left the sea in 1987. He then worked as a surveyor in marine insurance, hull P&I, cargo surveys, audits and assessments. The managing director joined INSB NW Europe in June 2010. He also did not like to issue non-conformities in writing and preferred to discuss any concerns, in order to minimise the administrative workload of ISM.

1.32.4 Quality system and internal audits

At the time of the accident, INSB's Quality Management System (QMS) was certified to the ISO standard: ISO 9001:2008. Verification of this standard was undertaken during annual audits of INSB by the Greek independent third party inspection and certification body, the European Inspection and Certification Company S.A. Prior to the accident, the inspection and certification body last audited INSB, Piraeus in February 2011; no non-conformities were identified. INSB's Antwerp office shared the same QMS as the INSB head office, but no audits of its technical functions had taken place.

1.32.5 Performance

Between 2009 and 2011, 915 port state control inspections were conducted on vessels entered into class with INSB under the Paris MOU. These resulted in 13 detentions which led to INSB being categorised a 'medium' performer (similar to the 'Grey List') **(Annex U)**. A further 174 inspections were conducted under the Tokyo MOU, resulting in only one detention, with INSB again being categorised as a 'medium' performer **(Annex V)**.

1.32.6 Flag State audits

As noted at **paragraph 1.31.4** above, the PMA audit of INSB in 2008 had indentified four major and four minor non-conformities. Two of the major non-conformities related to the training of surveyors, including, inter alia:

- *there are no documented criteria to establish, designate and train surveyors at different levels pertaining to the various certificates and type of vessels, as per IMO Resolution A. 789(19);*[56]
- *Degree of authorization as ISM and ISPS Auditor issued to [a named surveyor] was done without complying with the practical training (10 supervised SMC audits) required by the evaluator…*

Both non-conformities were subsequently confirmed as closed.

[56] IMO Resolution A. 789(19) Specifications on the Survey and Certification Functions of Recognized Organizations acting on behalf of the Administration.

In 2009 and 2010, the only Flag State audits conducted on INSB were by the International Merchant Marine Registry of Belize (IMMARBE), while in 2011, the only audit was a surveillance assessment conducted by the Togolese Ship Register.

1.33 RECOGNISED ORGANIZATION CODE

1.33.1 Overview

In December 2013, it is anticipated that the IMO Assembly will formally adopt the Code for Recognised Organizations (RO Code). In its preamble, the draft RO Code states that it:

.1 *provides flag States with a standard that will assist in achieving harmonized and consistent global implementation of requirements established by the International Maritime Organization's (IMO) instruments for the assessment, and authorization of recognized organizations (ROs);*

.2 *provides flag States with harmonized, transparent, and independent mechanisms, which can assist in the consistent oversight of ROs in an efficient and effective manner; and*

.3 *clarifies the responsibilities of organizations authorized as ROs for a flag State and overall scope of authorization.*

The draft RO Code includes detailed requirements and guidance regarding management and organisation, resources, statutory certification, performance measurement, analysis and improvement, quality management system certification, authorization and oversight. All of the Code's requirements are generic and apply to all ROs, regardless of type, size and the statutory certification and services provided.

1.33.2 Training and qualifications of surveyors

Section 2.6.1 of the draft RO Code states:

The RO shall perform statutory certification and services by the use of competent surveyors and auditors that are duly qualified, trained and authorized to execute all duties and activities incumbent upon their employer, within their level of work responsibility.

The draft Code also requires ROs to document the qualifications of personnel, including any continuation training and training appropriate to the tasks they are authorised to undertake, and to provide evidence of the satisfactory completion of training.

Detailed requirements for the entry, theoretical and practical training, examination and testing, qualification, monitoring, reporting and evaluation of ROs technical staff are detailed in Appendix 1 of the draft RO Code.

1.33.3 Flag State oversight

Part III of the draft RO Code deals specifically with the oversight of ROs and details mandatory requirements. It also provides guidance to assist Flag States in the development and implementation of an effective oversight programme of ROs.

The draft RO Code requires Flag States to verify that ROs that are authorized to perform statutory certification and services on their behalf meet the requirements of the Code. To this end, Flag States should implement an effective oversight programme of the ROs that act on their behalf. The oversight programme could include monitoring activities such as audits and inspections. A Flag State may enter into written agreements to participate in a combined oversight programme with other Flag States that have authorisations with the same RO.

1.34 PORT STATE CONTROL INSPECTION REGIME

1.34.1 Application

On 1 January 2011, a new inspection regime was introduced in the Paris MOU port state control region. The new inspection regime was published in Directive 2009/16/EC on 23 April 2009 and was implemented into UK law by *The Merchant Shipping (Port State Control) Regulations 2011*. A similar regime is to be implemented by the Tokyo MOU on 1 January 2014.

1.34.2 Ships' risk profile

The new inspection regime was developed by the Paris MOU to provide, inter alia, a more risk-based system of targeting ships instead of a quota based system, and to eliminate substandard shipping by increasing the frequency of inspection of 'high-risk' ships. Each ship in the Paris MOU database is allocated a risk profile based on its type, age, flag, RO, company performance, number of deficiencies and number of detentions. Ships are designated 'high risk', 'standard risk' or 'low risk' using a calculator which is available on the Paris MOU website[57] **(Annex W)**.

1.34.3 Frequency of inspection

Frequency of inspection depends on a ship's risk profile. Ships with a 'high risk' profile are inspected between every 5 and 6 months, ships with a 'standard risk' profile between every 10 and 12 months, and ships with a 'low risk' profile between every 24 and 36 months. Additional inspections may be carried out between periodic inspections due to 'overriding' or 'unexpected' factors such as a report from a pilot and ship-related accidents.

1.34.4 Scope of inspections

Three types of Port State Control inspection may be conducted: 'Low' risk and 'standard' risk ships undergo 'initial inspections' or 'more detailed inspections'[58]; 'High risk' ships undergo as a minimum an 'expanded inspection', which is a

[57] www.parismou.org/.../ship_risk_profile/ship_risk_profile_calculator/

[58] An 'initial inspection' is an inspection aimed at checking compliance with the conventions and comprises a check of certification and a walk around the ship. A 'more detailed inspection' is conducted where the 'initial inspection' has revealed 'clear grounds' that the ship does not substantially meet the requirements of the conventions.

prescriptive inspection that covers specific items on different ship types. Other ships requiring 'expanded inspections' also include gas, oil or chemical tankers, bulk carriers or passenger ships, over 12 years of age. Ships requiring an 'expanded inspection' are required to give UK port authorities at least 72 hours' notice of arrival. In turn, the port authority must notify the MCA of the vessel's impending arrival via its Consolidated European Reporting System (CERS).

1.35 IMMERSION SUITS AND LIFEJACKETS

1.35.1 Vessel holdings

Torbulk's records and the record of equipment attached to *Swanland*'s Cargo Ship Safety Equipment Certificate, issued by INSB on 5 October 2010 and verified on 8 June 2011, indicate that 14 immersion suits and 15 lifejackets were carried on board. The immersion suits were of different types with nine of the suits having sufficient buoyancy to comply with the requirements for lifejackets. The other five suits needed to be worn in conjunction with a lifejacket. In 2008, the vessel had carried 10 immersion suits of which one suit needed to be worn in conjunction with a lifejacket.

The immersion suits worn by the second officer and the AB were Parkway Imperial MQ254 **(Figure 56)** (serial numbers 118716 and 118781 with a manufactured date of 27.6.91). Details embossed on the fabric indicate that the suit was approved by the United States Coastguard (USCG) and met the requirements of SOLAS 74/83. The immersion suits were fitted with rings that were inflated by the wearer in order to provide sufficient buoyancy to keep the wearer afloat without the assistance of a lifejacket. The glove design fitted to the Parkway Imperial MQ254 is shown at **Figure 56**.

The immersion suit worn by the chief officer was an Autoflug KS1 **(Figure 57)**, which was originally manufactured for use within the aviation industry. The label inside the suit indicated that the suit was approved in 1988. The suit was not designed to provide sufficient buoyancy to keep the wearer afloat and therefore needed to be used with a lifejacket. The glove design fitted to the Autoflug KS1 is shown at **Figure 57**.

During the search for *Swanland's* missing crewmen between 27 and 28 November 2011, one of the vessel's lifejackets was washed up onto a beach in Hell's Mouth **(**Item 13 on **Figure 10)** and was recovered. Two other lifejackets were also sighted at sea, but these were some distance from other flotsam and were not confirmed to be from *Swanland*. The recovered lifejacket **(Figure 58)** was an Aquavel Mk2/UK which was stamped to indicate that it was approved by the Department of Transport and was manufactured in 1996. The lifejacket was intended to be secured onto a person with a webbing belt fitted with a male/female buckle arrangement. The male bayonet attachment was missing from the webbing belt and there was no evidence that the end of the webbing belt had been stitched to prevent the male bayonet from detaching **(Figure 58)**.

1.35.2 Inspection and servicing

Torbulk held service certificates for the immersion suits on board 11 of its managed vessels, but not for *Swanland*. Torbulk's records indicate that the suits carried on board *Swanland* were last serviced in May 2009 when the vessel was in dry dock in Kaliningrad. Service records for the immersion suits on board Torbulk's other vessels, which were serviced by Survitec Group Limited, show that each ship carried up to five different types of immersion suit **(Annex X)**.

In October 2010, *Swanland*'s master forwarded to Torbulk a *Certificates and Maintenance Checklist* indicating that the immersion suits on board had been inspected, tested, and were ready for immediate use. On 31 July 2011, the chief officer signed a safety equipment planned maintenance report, also forwarded to Torbulk, to indicate that a scheduled 3-monthly planned maintenance inspection of the immersion suits had been completed. The 3-monthly check required that the number of immersion suits carried was in accordance with the safety equipment certificate and that the service records of the suits had been checked to ensure that they were in date for annual inspection and a '*3-yearly pressure test'*. No defects were noted on the planned maintenance report, which was also signed by the master and the chief engineer.

1.36 LIFE-SAVING APPLIANCES AND ARRANGEMENTS

1.36.1 The carriage of immersion suits

The international requirements for the carriage of life-saving appliances are detailed in Chapter III of the 1974 SOLAS Convention, as amended. Regulation 32.3 stipulates requirements for Immersion suits, which include:

> *3.1 This paragraph applies to all cargo ships. However, with respect to cargo ships constructed before 1 July 2006, paragraphs 3.2 to 3.5 shall be complied with not later than the first safety equipment survey on or after July 2006.*
>
> *3.2 An immersion suit of an appropriate size, complying with the requirements of section 2.3 of the Code shall be provided for every person on board the ship. However, for ships other than bulk carriers, as defined in regulation IX/1, these immersion suits need not be required if the ship is constantly engaged on voyages in warm climates where, in the opinion of the Administration, immersion suits are unnecessary.*
>
> *3.3 If a ship has watch or work stations which are located remotely from the place or places where immersion suits are normally stowed, including remotely located survival craft carried in accordance with regulation 31.1.4, additional immersion suits of an appropriate size shall be provided at these locations for the number of persons normally on watch or working at those locations at any time.*
>
> *3.4 Immersion suits shall be so placed as to be readily accessible and their position shall be plainly indicated.*

1.36.2 Life-Saving Appliance Code requirements for immersion suits

Section 2.3 of the Life-Saving Appliance Code **(**LSA Code) **(Annex Y)** (referred to in the SOLAS reference above) details the general requirements for immersion suits. Section 2.3.11 includes:

> *The immersion suit shall be constructed with waterproof materials such that it will cover the whole body with the exception of the face. Hands shall also be covered unless permanently attached gloves are provided*

With regard to buoyancy, Section 2.3.1.2 states:

> *An immersion suit on its own, or worn in conjunction with a lifejacket if necessary, shall have sufficient buoyancy to:*
>
> *.1 lift the mouth of an exhausted or unconscious person clear of the water by not less than 120mm; and*
>
> *.2 allow the wearer to turn from a face-down to a face-up position in not more than 5 s.*

Section 2.3.1.7 of the LSA Code, states:

> *If an immersion suit is to be worn in conjunction with a lifejacket, the lifejacket shall be worn over the immersion suit. Persons wearing such an immersion suit shall be able to don a lifejacket without assistance. The immersion suit shall be marked to indicate that it must be worn with a compatible lifejacket.*

1.36.3 The standards and tests for immersion suits

The test requirements for immersion suits are included in the IMO Resolution MSC.81(70) *Revised recommendation on testing of life-saving appliances*, which is supported by MSC/Circ.980 *Standardized life-saving appliance evaluation and test report forms*. Section 3.1.5 of MSC.81 (70) *Ergonomic tests* states:

> *When wearing the immersion suit or anti-exposure suit, the test subjects should be able to climb up and down a vertical ladder of at least 5m in length and demonstrate no restriction in walking, bending or arm movement. The test subjects should be able to pick up a pencil and write. The diameter of the pencil shall be 8 to 10mm.*

Performance and test requirements for immersion suits are also detailed in International Standards Organisation (ISO) 15027-2; 2012, Parts 2 and 3. Section 4.11.4 of Part 2 *Dexterity and mobility* states:

> *The suit system, when correctly donned and adjusted, shall not prevent the user from bending over (without squatting), picking up a rope, passing it around the waist and tying a double overhand knot in front of the body, picking up a pencil and writing something, when tested in accordance with ISO 15027-3:2012, 3.10.5.1.*

1.36.4 The standards and tests for lifejackets

Section 2.2 of the LSA Code provides general requirements for lifejackets and includes:

2.2.1.5 An adult lifejacket shall be so constructed that:

.1 at least 75% of persons who are completely unfamiliar with the lifejacket can correctly don it within a period of 1 min without assistance, guidance or prior demonstration;

.4 the method of securing the lifejacket to the wearer has quick and positive means of closure that do not require tying of knots;

2.2.1.7 An adult lifejacket shall allow the person wearing it to swim a short distance and to board a survival craft.

Detailed test requirements are recommended in IMO Resolution MSC .81(70) and include:

Righting tests

2.9.5 The test subject should swim at least three gentle strokes (breast stroke) and then with minimum headway relax, with the head down and the lungs partially filled, simulating a state of utter exhaustion. The period of time should be recorded starting from the completion of the last stroke until the mouth of the test subject comes clear of the water. The above test should be repeated after the test subject has exhaled. The time should again be ascertained as above. The freeboard from the water surface to the mouth should be recorded with the test subject at rest.

Assessment

2.9.7 After each of the water tests described above, the test subject should come to rest with the mouth clear of the water by at least 120 mm… In the righting test, the mouth should be clear of the water in not more than 5 s. The lifejacket should not become dislodged or cause harm to the test subject.

1.37 COMPATIBILITY OF LIFE-SAVING EQUIPMENT

In June 2009, the MCA published Marine Guidance Note (MGN) 396 (M&F), titled *Compatibility of Life-Saving Equipment,* which highlighted that the current standards for lifejacket and immersion suit specifications:

do not fully address the wider issue of compatibility and suitability of lifejackets and immersions when worn together, such as buoyancy, flotation position and self-righting performance.

The MGN highlights that the LSA Code tests for immersion suits do not necessarily ensure that any given type of immersion suit is compatible with any given type of lifejacket. It also indicates that when considering using a lifejacket and immersion suit in combination, advice be sought from the chandler or manufacturers, or that compatibility tests be conducted.

The MGN also draws attention to the principles of the ISM Code and states:

> *...it should be noted that the shipowner or operator is responsible for ensuring, with advice from relevant manufacturers, that the LSA system as a whole is fit for purpose, in addition to SOLAS compliance of individual items of equipment. In particular, care should be taken that the full and free movement is available, that fixed gloves do not prevent operators from handling controls of LSA equipment, and that sufficient suits are provided in sizes appropriate for the crew on board…* [sic]

1.38 PRACTICAL TRIALS

1.38.1 Immersion suit – dexterity

In order to assess the dexterity afforded by the Parkway Imperial MQ254 and the Autoflug KS1 immersion suits, the MAIB conducted practical trials **(Figure 59a** and **59b)** in accordance with the requirements of both MSC 81(70) and ISO 15027-2:2012. During the trials, the wearer experienced no difficulty with either of the suits when picking up and securing an 8mm rope around his waist with a double overhand knot. However, he could only pick up an 8mm pencil from a flat surface by using two hands. Although this task became less difficult when a larger diameter pencil was used, two hands were still generally required. Once the pencil had been lifted from the flat surface, the wearer had no difficulty in writing his name.

1.38.2 Lifejacket fastenings

In view of the fact that the male bayonet attachment was missing from the only lifejacket from *Swanland* to be recovered, a serviceable Aquavel Mk2/UK was obtained from Torbulk. Unlike the recovered lifejacket **(Figure 58)**, the serviceable lifejacket had a male bayonet fitted to the webbing strap.

A basic donning trial highlighted that the male bayonet fitting moved freely along the webbing belt and could easily be pulled off the end of the webbing while being adjusted to fit a larger person.

1.38.3 Immersion suit/lifejacket compatibility

To test the compatibility between the Aquavel Mk2/UK lifejacket and the Autoflug KS1 immersion suit, the MAIB conducted basic practical trials to test the performance of the equipment when used together against the requirements for immersion suits and lifejackets detailed in the LSA Code and IMO Resolution MSC.81(70) **(Paragraph 1.36)**.

During the trials, the subject wearing the Autoflug KS1 immersion suit was able to don and secure the Aquavel Mk2/UK without difficulty. After swimming 3 strokes forward (breast stroke), the subject remained 'face-down' in the water **(Figure 60)**. The immersion suit and the lifejacket did not produce any self-righting moment in this respect. However, with effort, the subject was able to turn from a 'face-down' position in the water to a 'face-up position' within 5 seconds. Once in a 'face-up' position, the subject's mouth was kept clear of the water by 135mm. The lifejacket remained in position and did not harm the subject.

Figures 59a and **59b:** Dexterity trial conducted by MAIB using Parkway Imperial immersion suit

Figure 60: Immersion suit/lifejacket compatibility trial using Autoflug KS1 immersion suit and Aquavel Mk2//UK lifejacket

1.39 ABANDON SHIP DRILL

1.39.1 Regulatory requirements

SOLAS Regulation 19, 3.2 states:

Every crew member shall participate in at least one abandon ship drill and one fire drill every month. The drills of the crew shall take place within 24 h of the ship leaving a port if more than 25% of the crew have not participated in abandon ship and fire drills on board that particular ship in the previous month.

Regulation 19, 3.3.1 details the requirements for abandon ship drills, which include:

.1 summoning of passengers and crew to muster stations with the alarm required by regulation 6.4.2 followed by drill announcement on the public address or other communication system and ensuring that they are made aware of the order to abandon ship;

.2 reporting to stations and preparing for the duties described in the muster list;

.3 checking that passengers and crew are suitably dressed;

.4 checking that lifejackets are correctly donned;

.9 instruction in the use of radio life-saving appliances

1.39.2 Procedures on board *Swanland*

Swanland's onboard procedures regarding crew training were detailed in SMM08 which was also provided in Russian. In connection with the conduct of emergency drills, the procedures included:

The master is responsible for ensuring that 'emergency drills' are carried out as per the 'Emergency Drills Programme'.

If more than 25% of the vessels personnel change, an 'emergency drill' shall be held within 24 hours after leaving port.

The onboard procedures also included a checklist for 'abandon ship' which included the requirement to muster the crew and identify any missing personnel.

Both the AB and the second officer were not aware of any drills having been conducted since they joined *Swanland* on 5 August and 15 October 2011 respectively. They had also not practised donning any of the immersion suits carried on board the vessel during this period. It was not possible to verify the status of the Emergency Drills Programme on board *Swanland* at the time of the accident.

1.40 LOSSES OF GENERAL CARGO SHIPS

1.40.1 Overview

General cargo ship safety was raised at IMO in 2006 through a Russian submission (MSC 82/21/19). The submission highlighted that from 1999 to 2004, although general cargo ships accounted for only 17% of the world fleet, they accounted for 42% of vessel losses and 27% of fatalities. It also identified that, on average, approximately 73 general cargo ships were lost each year during the period and that the ship type had a comparatively poor PSCI record with regard to deficiencies and detentions. Further submissions at IMO prompted IACS to conduct a Formal Safety Assessment (FSA) of general cargo ship safety between 2007 and 2008.

1.40.2 FSA for general cargo ships

The statistical analysis of the IACS FSA was based on information provided from LR Fairplay ship register and casualty database. The scope of the analysis was limited to ships of gross tonnage greater than 499 with a maximum age of 25 years and classed by an IACS member. This resulted in the consideration of 4596 vessels of which 95% were categorised as *a single or multi deck cargo vessel for the carriage of various types of dry cargo.* The purpose of the FSA was to estimate the risk associated with general cargo vessels and to identify and evaluate possible risk control options (RCOs). At MSC 87 in 2010, the Islamic Republic of Iran registered its concern that a large number of vessels over 500gt classed by non-IACS societies had not been included in the IACS FSA study.

A summary of the FSA was submitted by IACS to MSC 88 (MSC 88/INF.8) in December 2010, which highlighted that the risk associated with general cargo ships was tolerable but could be reduced to as low as reasonably practicable (ALARP) by the verification and implementation of cost-effective control options. The study identified that foundering, collision and stranding were the three major risk contributors to general cargo ship safety, contributing to about 85% of ship losses and crew fatalities. Foundering accidents were mainly related to capsize (8%), loading error (5%), cargo shift (including listing) (45%) and water ingress (also due to structural failure) (42%).

The study identified 32 RCOs which included, inter alia: the improvement of cargo stowage arrangements particularly for bulk cargoes (other than grain) and heavy items; coating requirements for areas of low accessibility; the implementation of ESP on general cargo ships; and improved training for PSC inspectors. All of the RCOs, apart from the coating of areas of low accessibility, were assessed to be cost-effective.

1.40.3 Review of general cargo ship safety

A review of general cargo ship safety was included in IMO Resolution A.1038(27) – High Level Action Plan of The Organization and Priorities for the 2012-2013 Biennium. The action had a completion date of 2013, but this was extended to 2014 during Flag State Implementation (FSI) 21 in March 2013.

1.40.4 MAIB analysis of general cargo ship casualty data

In order to obtain an up-to-date and complete picture of vessel losses and fatalities connected with the operation of general cargo ships and bulk carriers, the MAIB analysed information from the IHS Fairplay casualty database for the period 2002 to 2011. The analysis included all vessels of 500 to 20 000gt regardless of whether they were classed with an IACS society, a non-IACS society, the class was unknown or the vessels were not entered in class[59].

[59] The IMO's SOLAS Convention also allows an equivalent level of safety to be provided by the applicable national standards of a flag Administration. In such cases, the vessel therefore does not need to meet the rules of a classification society and be maintained in "class".

Key findings of the analysis were:

- 568 general cargo ships and 66 bulk carriers were reported as lost or missing (excluding casualties due to war or hostilities).
- 248 general cargo ships were considered by the MAIB to have foundered resulting in 821 persons being killed or missing (this excludes 223 passengers who went missing following the loss of a cattle-carrier, *Teratai I*). 226 of these vessels were 15 years old or more and 139 were 27 years old or more **(Figures 61** and **62)**.

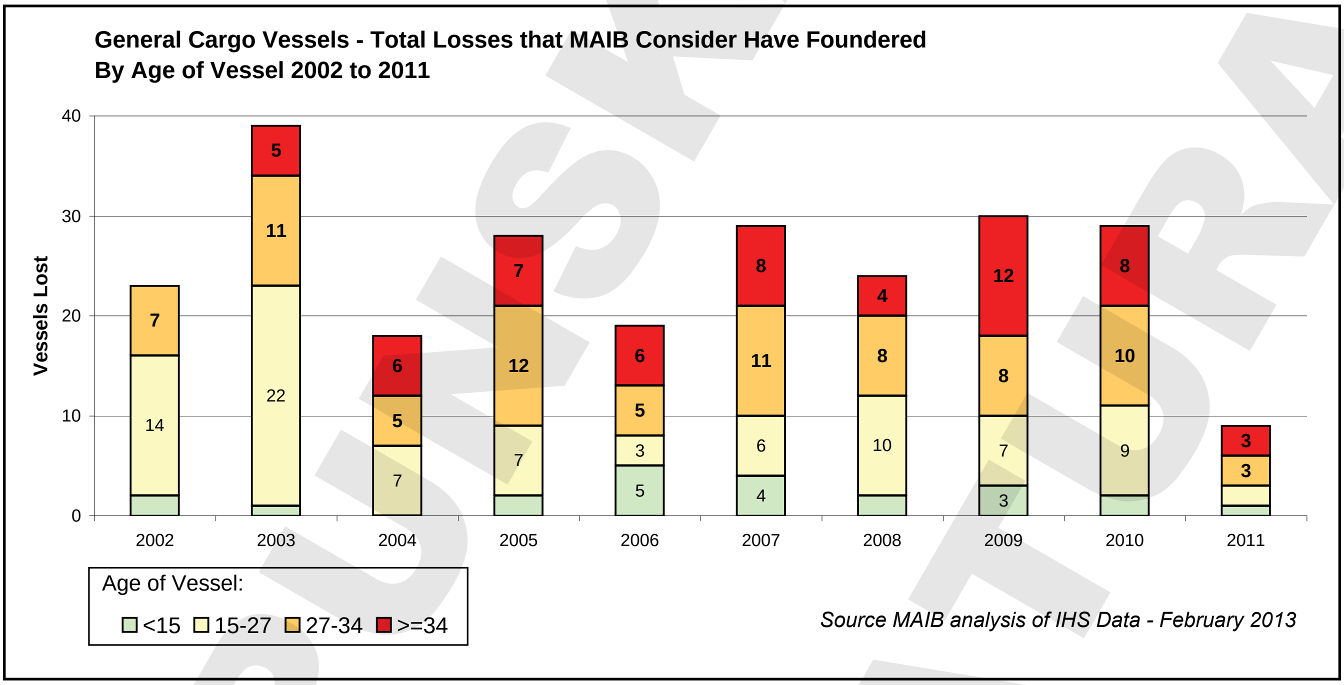


Figure 61: Selected global general cargo ship losses 2002 to 2011

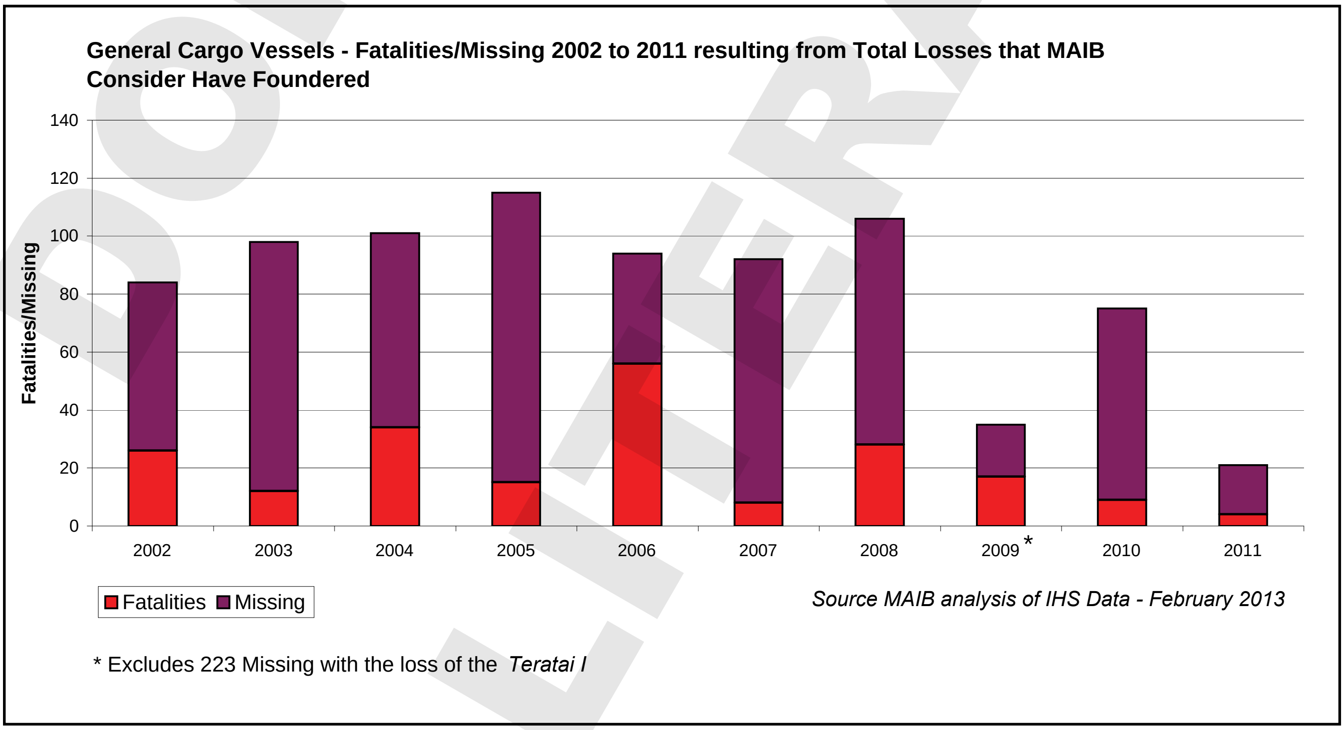


Figure 62: Numbers of fatalities resulting from selected global general cargo ship losses 2002 to 2011

- 17 bulk carriers were considered by the MAIB to have foundered, resulting in 68 persons being killed or missing (41 resulting from only 2 accidents). 14 of these vessels were 15 years old or more and 11 were 27 years old or more **(Figures 63** and **64)**.

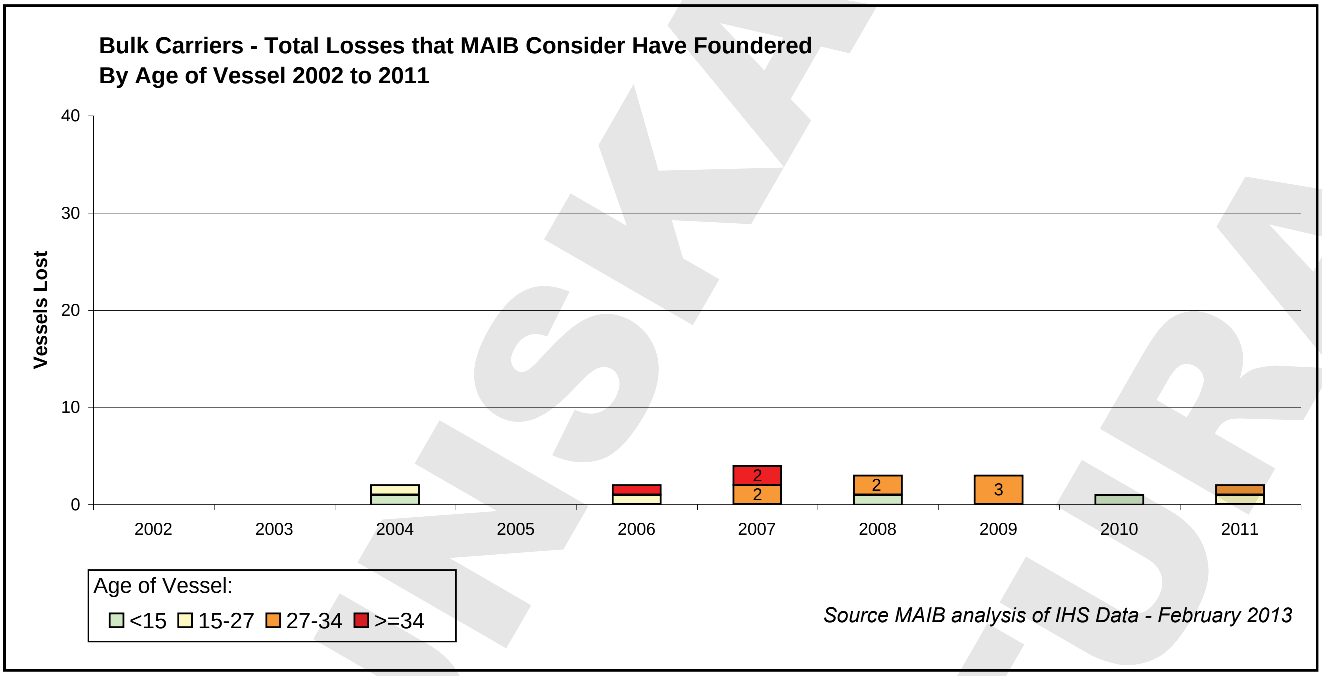


Figure 63: Selected global bulk carrier losses 2002 to 2011

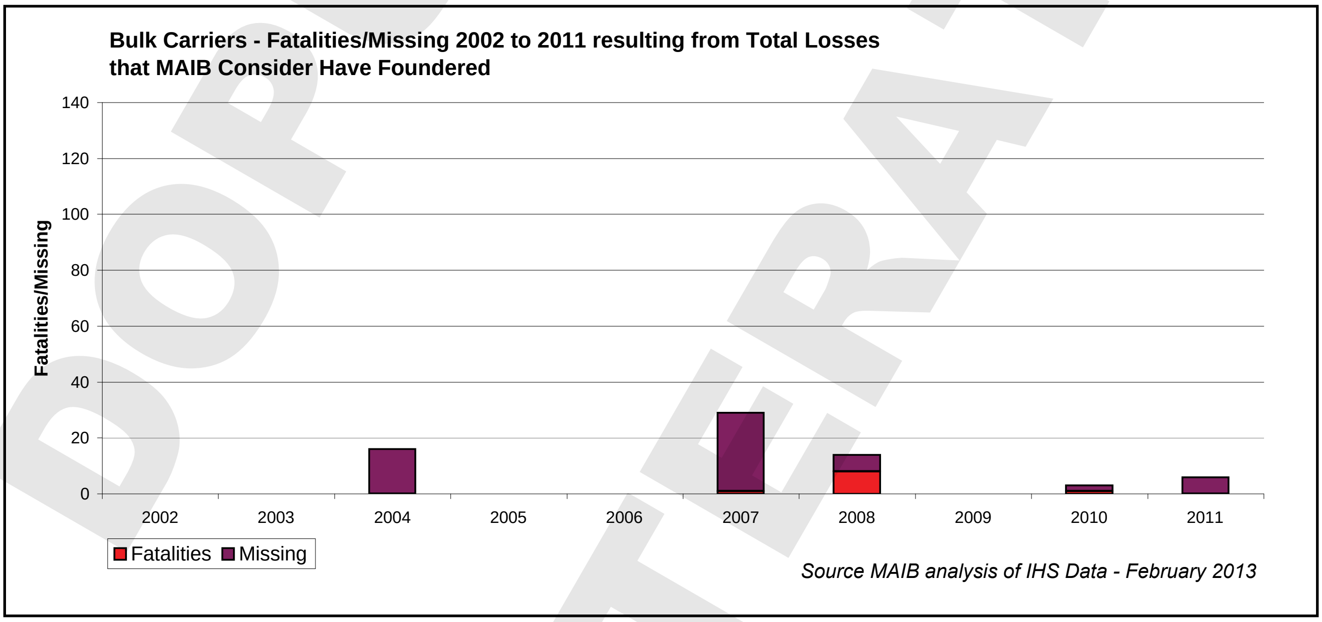


Figure 64: Number of fatalities resulting from selected global bulk carrier losses 2002 to 2011

- Of the 248 general cargo ships and 17 bulk carriers considered to have foundered, the class of 127 vessels (48%) is unknown, 90 (34%) are entered in class with IACS societies and 48 (18%) were entered in class with non-IACS societies **(Figure 65)**.

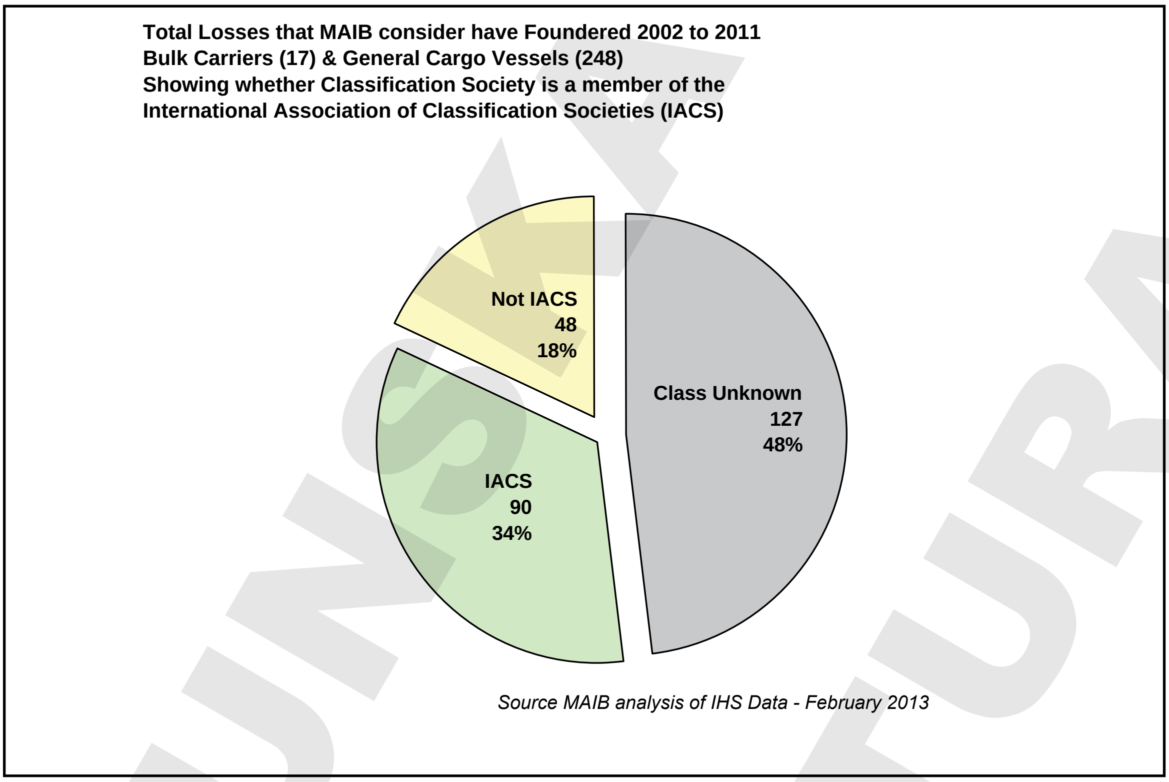


Figure 65: Selected total global losses of general cargo ships and bulk carriers between 2002 to 2011 showing classification status for vessels

In order to try and obtain further information regarding the circumstances of the 248 general cargo ships recorded as having foundered in the IHS Fairplay data, the IMO's Global Integrated Shipping Information System (GISIS) was interrogated. However, although 123 general cargo ship founderings were identified on the database which had not resulted from collision, contact or grounding, the majority of the casualty entries lacked sufficient detail to accurately determine the initial causes. 21 of the founderings were identified in GISIS as being the result of hull failure, 43 due to listing or capsize, 2 as a consequence of machinery damage and 2 due to heavy weather. However, the initial event for the remainder was listed as 'sinking' (8) or 'other' (41), while no initial event was recorded for six of the foundering casualties. The average age of the vessels listed as 'hull failure', 'capsize or listing' and 'sinking', for which age data was available, was 24 years.

SECTION 2 – ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 GENERAL OBSERVATIONS

The factors affecting the operation and condition of a general cargo ship, such as *Swanland,* are many and complex. The events leading up to the accident arguably cover the 34 years of her service life, as well as her original design and construction.

Swanland was a typical small hard-worked general cargo ship, carrying a variety of unglamorous dry bulk cargoes around the UK coastline. It is not unreasonable to suggest that her trade was at the lower end of the solid bulk cargo market. Her revenues were low and had been further diminished by the recent downturn in the shipping industry. Indeed, *Swanland* had been making a financial loss for some time and her owner had only continued to operate her in the hope that the market would eventually improve.

Nevertheless, *Swanland* was subjected to the standard regulatory framework laid down by the IMO and, at the time of the accident, she was certified as complying with all the applicable statutory requirements. The vessel had recently been inspected by her Flag State, her classification society and her managers, and had undergone numerous PSC inspections; no significant concerns had been raised about her condition or operation.

Yet, despite all of the layers of surveys, audits and inspections, *Swanland* suffered a catastrophic structural failure during a routine voyage while carrying a high density bulk cargo in rough seas. The vessel foundered within about 17 minutes and, although the crew were immediately alerted to the situation and LSA was available, tragically only two of the crew survived.

2.3 STRUCTURAL FAILURE MECHANISM

2.3.1 Overview

The available evidence, including witness accounts, underwater imagery of the wreck and technical strength analysis, indicates that *Swanland* suffered a catastrophic structural failure in way of her midships area. It also indicates that the most likely initial mechanism for the failure was the buckling of a section of the vessel's structure on the upper part of her starboard side.

2.3.2 Evidence of buckling

<u>Witness evidence</u>

The first indication of a problem during the voyage was at approximately 0200, when the vessel's bow was lifted on a large wave and the starboard bulwark near to *Swanland*'s midships appeared to fold outwards. At the same time, at least one of the hatch covers in the same area lifted up. The 'folding' of the bulwark and the lifting of the hatch cover was consistent with the upper part of the vessel's midships longitudinal structure being compressed.

The 'folding' of the bulwark was a classic indicator of buckling, which occurs when a structural member reaches a state of compressive instability. However, as the bulwark itself did not contribute to *Swanland*'s longitudinal strength, its failure alone would not have been sufficient to trigger a catastrophic structural failure. In addition, assuming that *Swanland*'s cargo hold hatch covers were properly closed and secured, a significant force would have been required to lift the dogged hatch cover. The damage to the bulwark and lifting of the hatch cover were therefore most likely the consequences of the structural failure rather than the cause.

The reports of the bow appearing higher than normal following the initial failure were consistent with buckling of the upper part of *Swanland*'s structure around her midships and the hull sagging.

Longitudinal strength analysis

The longitudinal strength analysis conducted by TMC confirmed that compressive and tensile stresses would have been generated in the upper and lower parts of *Swanland*'s longitudinal structure at the time of the accident. These stresses would have been created by a sagging bending moment acting on the vessel's structure induced by the combination of the weight of the cargo in the centre of the hold, and the sea conditions being encountered.

Output from TMC's analysis **(Figure 66)** represents *Swanland* in the sea conditions encountered at the time of the failure, and confirms that the maximum bending moment (**red** line) would have occurred at Frame 65, the middle of the transverse central beam. The positioning of the maximum bending moment in this area was to be expected given that Frame 65 coincided with the approximate longitudinal centre of the limestone cargo in the hold **(Figures 3**, **67a** and **67b)**.

As the structure beneath the transverse beam had been strengthened to form a portal frame **(Figure 36)** during the vessel's construction, a structural failure at this particular frame would have been unlikely. However, **Figure 66** also indicates that a large bending moment would have still been present in the general midships area, particularly between Frame 58 and Frame 69.

Figures 67a and **67b** represent *Swanland* in the sea conditions and the possible post-failure sagging condition respectively. Both of these figures include the distribution of cargo (TMC's condition 5b); **Figure 67b** also shows the most likely location of the initial structural failure on the starboard side, based on the underwater evidence described below.

TMC's calculations confirm that the largest stresses generated by the bending moment would have been the compressive bending stresses in the upper part of *Swanland*'s midships structure **(Tables 8** and **9)**. These stresses would have been larger than the tensile stresses in the lower structure due to the upper structure being further from the neutral axis[60] than the lower structure.

[60] A structural element undergoing bending experiences longitudinal compressive and tensile stresses in either its upper or lower structure, depending on whether the element is bending down (sagging) or up (hogging). At some intermediate plane in the structure, termed the neutral axis, the structure is therefore neither in tension nor compression. For an element which is non-symmetrical in the vertical plane, the position of this neutral axis is determined by the relative distribution of the cross-sectional area of the structure. *Swanland*'s neutral axis was therefore closer to the double bottom than the upper structure, due to the significant amount of midships longitudinal strength provided by her DB structure **(Figure 35)**.

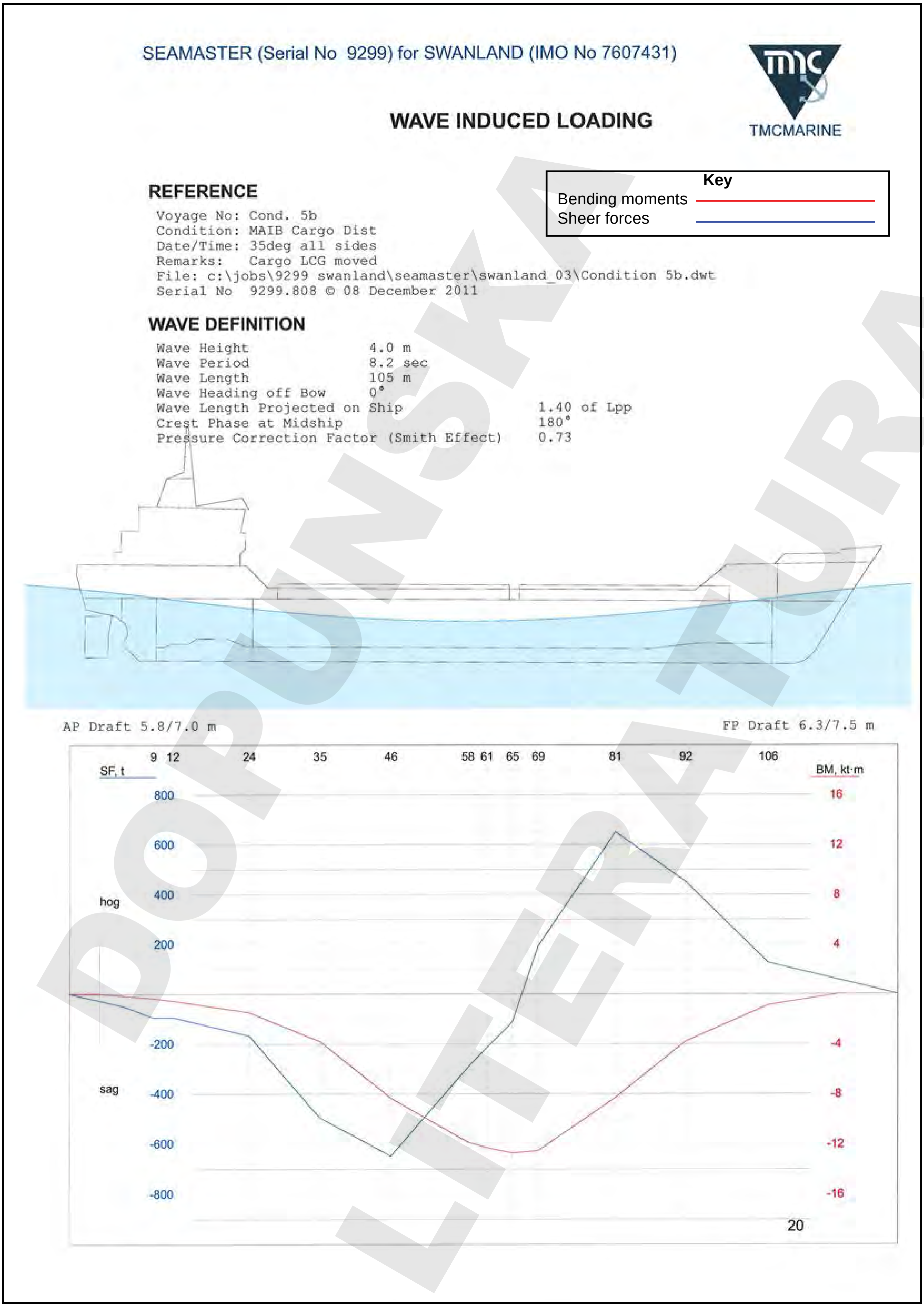
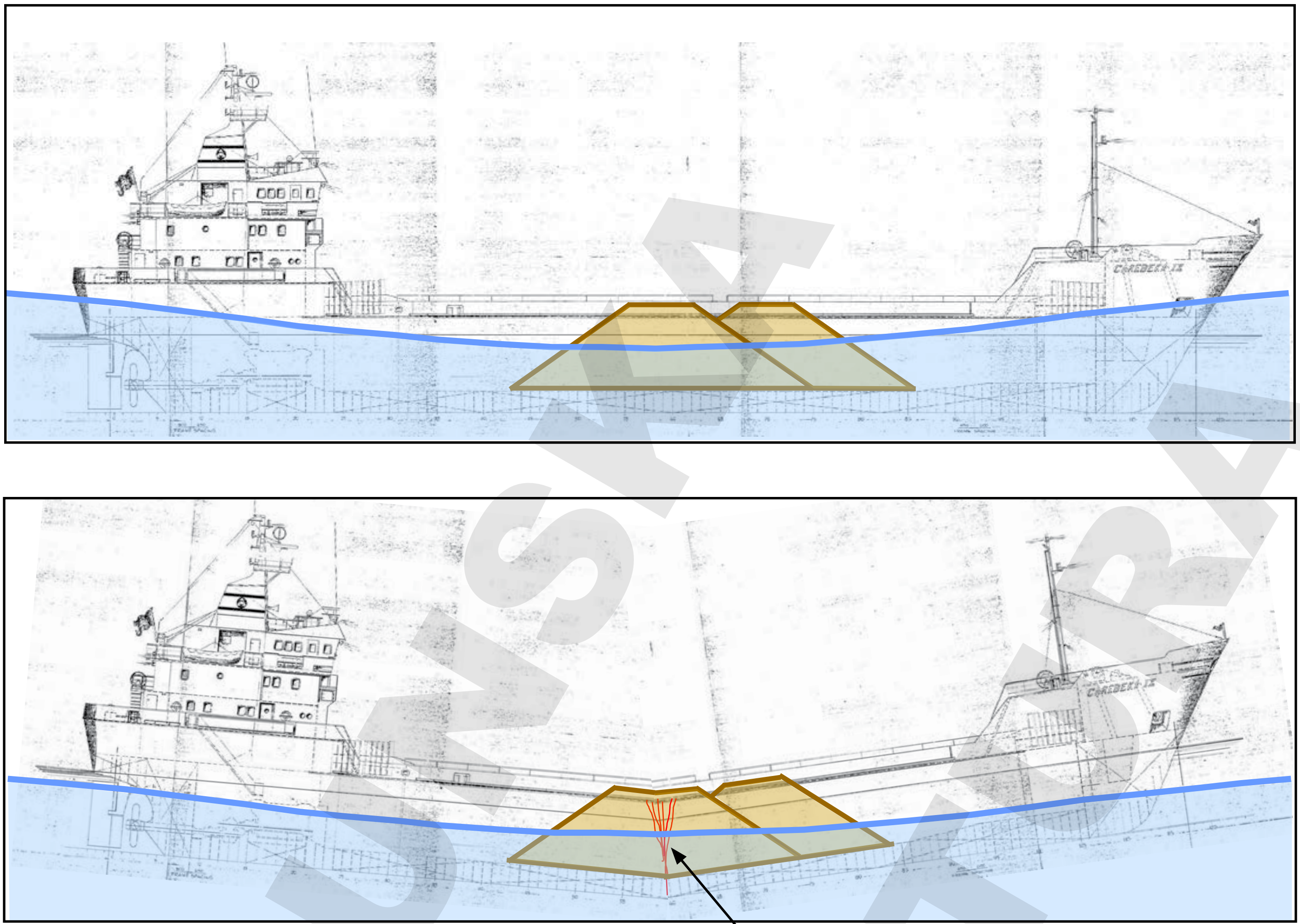


Figure 66: Output from TMC analysis showing *Swanland* in the estimated sea conditions encountered at the time of the failure and the calculated bending moments (condition 5b)



Figures 67a and **67b:** Representation of *Swanland* in the estimated sea conditions at the time of the initial failure and the possible post-failure sagging condition

As part of its analysis, TMC compared the average compressive stresses **(Tables 8** and **9)** with the stresses required to initiate buckling **(Table 5)** in the three main elements contributing to *Swanland*'s upper longitudinal strength: the main deck plating outboard of the hatch coaming; the hatch coaming itself; and the shear strake. As **Tables 5, 8** and **9** indicate, TMC considered both *Swanland*'s original as-built scantlings and the reduced scantlings, as measured during the 2009 intermediate survey, as part of this comparison.

Stress is a function of the force applied to a structural element divided by the element's cross-sectional area. Therefore, for an element with a reduced cross-sectional area (for example due to wastage caused by corrosion), not only will a smaller stress be required to initiate buckling, but a larger stress will be generated in the element for a given force. TMC's analysis confirmed that this would have been the case for *Swanland*, with larger stresses being generated in the 2009 structure than in the as-built scantlings.

Table 9 summarises the compressive stresses generated in the sea conditions at the time of the accident. Conditions 1 to 5b were modelled by TMC to represent the possible non-homogenous distribution of cargo loaded on *Swanland* at the time of the accident. In the case of the 2009 scantlings, the compressive bending stresses would have been large enough to initiate buckling in the hatch coaming and deck plating in each of the five scenarios. In the case of the 'as built' scantlings, the stresses generated in the deck plating would still have been large enough to cause buckling for three of the five possible cargo distributions. For the other two distributions, buckling could also have occurred provided a deck beam had become detached from the deck plating.

Underwater evidence

The underwater surveys of the wreck identified two main failure paths, one either side of the hull near to the Load Line mark (Frame 58). However, due to the inverted orientation of the wreck, it was not possible to gain access to all areas of the upper structure in way of each of the main fractures. Much of the midships upper structure, in particular the main deck plating, appeared in any case to have been either torn away or have simply disintegrated at some stage during the sinking.

The main fractures in the port and starboard sides of *Swanland*'s hull had opened the shell plating on each side to form inverted "V" shapes. Each fracture path showed characteristics of a fairly complex failure mechanism, with initial damage almost certainly followed by a number of consequential phases of damage.

The presence of folding in sections of the upper side shell plating adjacent to the main fracture paths confirmed that buckling had occurred. However, the missing sections of upper structure made it impossible to determine the area of the structure that had buckled first. It is feasible that the initial buckling occurred on the port side, which would have been partially obscured by the self-discharging conveyor **(Figure 8)**. However, as the buckling of the upper shell plating seemed more pronounced on the starboard side, it is more likely that the initial failure occurred on this side of the vessel.

Although some ROV images were captured of the main fracture surfaces, it was not possible to obtain any detailed close-up imagery **(Figures 68a** and **b** being representative of the best imagery obtained**)** which could have helped determine the nature of the fracture. Nevertheless, the ROV footage did confirm that some remaining sections of the upper structure in way of the main fracture path showed signs of ductile failure[61] **(Figures 69a** and **b)**, which was probably indicative of the initial buckling.

However, other areas of the main fracture appeared to have undergone a brittle failure[62] **(Figures 70a** and **b)**. Given that brittle fracture generally occurs rapidly in a tensile state, it is possible that this damage occurred while the vessel was flexing in the sea conditions following the initial failure. However, it is considered more likely that this brittle fracturing would have occurred when the vessel impacted on the seabed.

[61] Ductile fracture is a stable fracture that propagates through steel structures gradually and is characterised by significant plastic deformation of the structure before fracture. Ductile fractures are generally found at the ends of brittle fractures.

[62] Brittle fracture is an unstable fracture that propagates through steel structures almost instantaneously, without the structure first experiencing any appreciable deformation. Tensile stresses are generally required for brittle fractures to occur.

Due to the limited capabilities of the ROVs employed for the underwater survey, it was not possible to obtain any metallurgical samples or measurements, which could have been helpful in substantiating the condition of the structure in way of the failure paths. Although some areas of the shell plating appeared to be relatively thin, it was not possible to quantify to what extent this might have contributed to the failure. The apparent detachment of paint in a number of areas in way of the main fracture path **(Figure 71)** reflects the high stresses that were needed to exceed the steel's ultimate tensile strength (UTS)[63] and therefore to cause the shell plating to fracture.

Figure 71: Still from ROV footage showing evidence of paint detachment in way of the main fracture path

The ROV footage also confirmed that cargo hold side shell frames had appeared to have detached from the shell plating in way of the starboard main fracture **(Figures 15a, 15b, 15c, 22a** and **22b)**. Again, it was impossible to determine when the frames became detached, although **Figures 15b** and **15c** seemed to show evidence of possible wastage in way of the connection between at least one of these detached frames and the shell plating. If even one of these frames had detached during the voyage or earlier, perhaps due to grooving, it could have triggered the initial buckling.

[63] Ultimate tensile strength (UTS) is the maximum stress that a material can withstand while being stretched or pulled prior to failure.

The vertices of both of the main fracture paths aligned not only with an external rubbing bar but, more significantly, with the upper boundary of the DB structure. Although this structure had become damaged in way of the main fractures, it appeared to have largely remained intact. *Swanland*'s DB provided a significant contribution to her overall midships longitudinal strength and had undergone substantial repairs during the dry dock period in 2009 in Kaliningrad. Therefore, the DB would have represented an area of relative strength and would have arrested the flow of the fracture path on the side shell plating, both during the initial failure and the subsequent damage.

The residual strength of the DB was further evidenced in the bottom plating. This plating was also found to be undamaged, apart from a significant transverse crease running across the bottom between the two main fracture paths at midships. The structure in way of the crease was largely intact, apart from the localised damage caused by the protruding structural members **(Figures 27a** and **27b)**. As discussed below at **paragraph 2.3.3**, both the bottom crease and the localised damage are likely to have occurred after the initial structural failure.

During the initial ROV survey, limited footage was obtained of some areas of the internal tank top plating, which appeared to be largely intact. However, external ROV footage appeared to show that the tank top plating might have partially fractured in way of the main fracture paths. There was, therefore, not enough evidence to confirm or refute whether the tank top had failed.

2.3.3 Sinking mechanism

Given the prevailing rough seas, the initial buckling damage to the structure would have quickly worsened. It is likely that *Swanland*'s hull would have been flexing in the sea conditions, probably hinging to some extent in way of the stronger intact DB structure.

With *Swanland*'s hull breached and hatch covers displaced, sea water inevitably started to enter the cargo hold. The two large piles of cargo loaded towards the centre of the hold could have stemmed the ingress to a certain extent. However, the incoming sea water, combined with the increasing amount of water being shipped onto the deck and hatch covers, would have contributed to the rapid reduction in freeboard and buoyancy, and ultimately the vessel's sinking.

When the second officer and AB were knocked over on the port bridge wing, *Swanland* was clearly on the brink of foundering but she was apparently still upright. As *Swanland*'s final AIS transmission was at 0215.54 and the crew of *Bro Gazelle* observed *Swanland*'s lights and radar echo disappear at 0217, it appears likely the vessel became completely submerged between these times.

As shown at **Figure 72**, by the time of the final AIS transmission *Swanland* was on a heading of 193° but was being set in the same direction by the tidal stream. The final sequence of events leading to *Swanland* ending up inverted on the seabed on a heading of approximately of 008° **(Figure 16)** will never be known. However, it is evident that the vessel must have capsized at some stage after the two survivors were swept overboard. In view of the close proximity of the excavator carriage on the seabed to the vessel's last AIS position, it is evident that capsize must have occurred at about 0216.

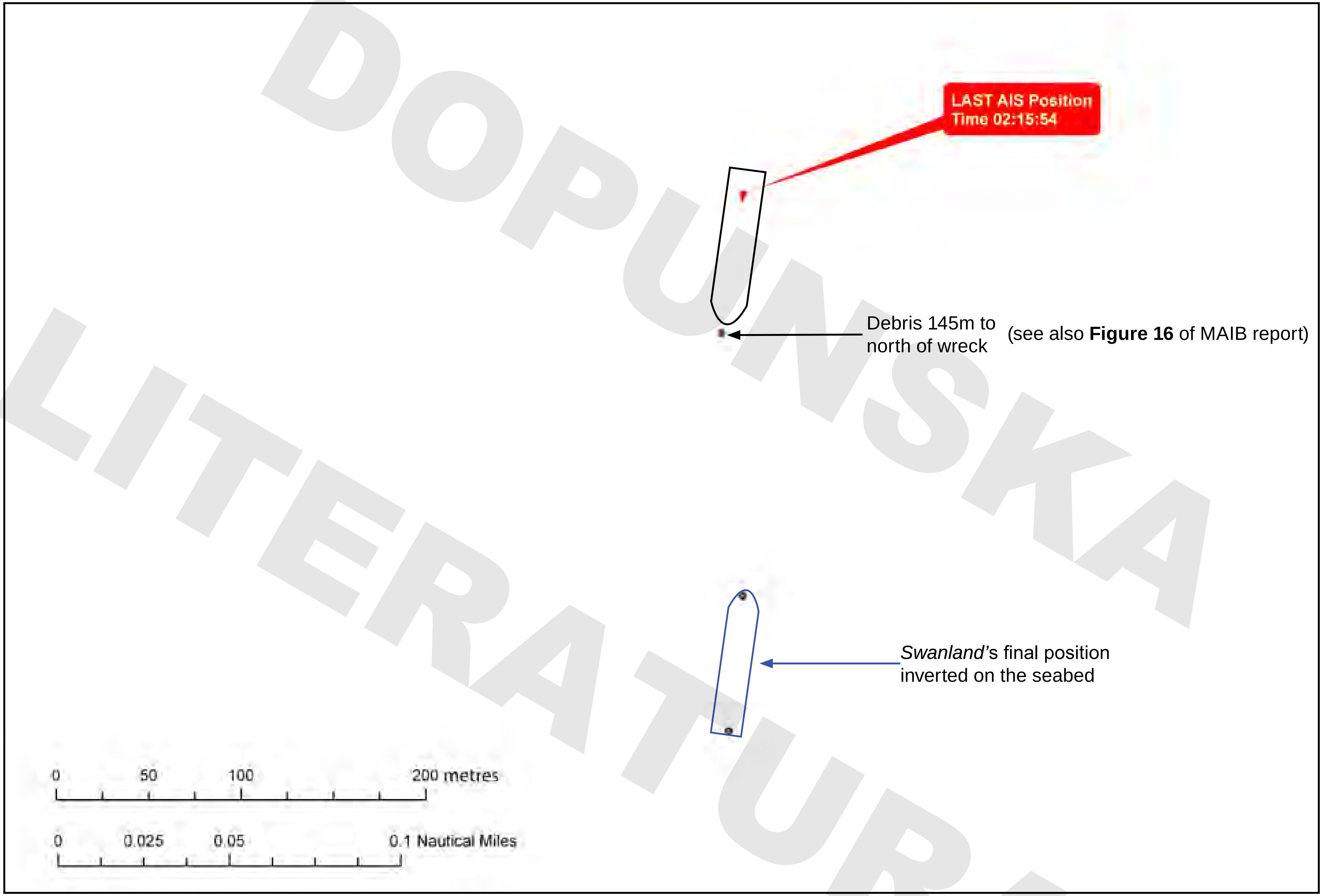


Figure 72: Chart showing *Swanland*'s last AIS position and heading relative to her location and orientation on the seabed

Although *Swanland* probably inverted before she was completely submerged under water, it is also possible that she inverted during her descent down to the seabed. With the intact buoyancy provided by the hold now lost, the relatively heavy top weight of the vessel due to the self-discharging equipment and the hatch covers, would have acted against the buoyancy provided by her empty DB tanks resulting in a turning couple. Although the majority of sunken vessels are found upright on the seabed, it is fairly common for battleships wrecks be found upside down[64]. This phenomenon has been attributed to the heavy upper weaponry and armament fitted to this type of vessel. Therefore, it is reasonable to assume that *Swanland*'s upper structure would have had a similar effect.

Figure 73 shows a multi-beam sonar image of the elevation of the wreck on the relatively flat seabed. This is further interpreted in **Figures 74a** and **74b**, which suggests that *Swanland*'s final orientation would have been influenced by her enclosed foc'sle and aft superstructure block. Although both of these blocks of structure would have crumpled to some extent and become embedded as the vessel landed on the seabed, the structures would have also pushed *Swanland*'s keel upwards at the bow and the stern **(Figure 74a** and **74b)**. This is considered to be the most likely reason for the 'hogged' condition of the wreck on the seabed and probably accounts for the tensile brittle failure evident in some areas of the fracture. The impact on the seabed would almost certainly have led to a rapid widening of the main midships fracture paths, as indicated by comparing **Figure 67b** with **Figures 74a** and **74b**. It is also likely to have either caused or exacerbated the transverse crease in the bottom plating. **Figures 16**, **17a** and **17b** confirm that *Swanland* was intact on the seabed.

2.3.4 Other damage

There is no evidence to suggest that the localised crumpling damage identified on *Swanland*'s bow at the top of the stem and around 2m above the base of the stem **(Figures 29a**, **29b**, **30a** and **30b)** occurred before the initial structural failure at around 0200. As indicated in **Figures 74a** and **74b**, the damage at the top of the stem almost certainly occurred during the impact with the seabed.

However, it is unlikely that the lower section of the stem would have made contact with the seabed at any stage, given that the vessel landed upside down. It is more likely that this damage was due to implosion. The structure at the stem bounded the FP ballast tank, which was probably empty at the time of the accident. As *Swanland* sunk, the water pressure would have increased as the vessel descended into deeper water. Assuming that the FP tank remained watertight, the water pressure would have acted on the external structure of the tank until the difference in external and internal pressures became large enough to cause part of the tank's structure to collapse or implode. This type of failure is associated with excessive buckling of the structure and is often observed on wrecks, particularly when the ship has sunk rapidly before all internal compartments have filled with water[65].

[64] http://www.divernetxtra.com/wrecks/0302anatomy.htm

[65] HMAS *Sydney* II Commission of Inquiry – Report on Technical Aspects of the Sinking of HMAS *Sydney* and HSK *Kormoran*, Ref. No. DSTO-GD-0559 (http://www.defence.gov.au/sydneyii/DSTO/DSTO.003.0001_LR.pdf)

Implosion is also considered to be the most likely cause of the small hole in the bottom plating in way of number 1 WB DB port tank **(Figures 28a**, **28b**, **28c** and **74b)**. This hole appeared to have been formed when a "D"-shaped section of plating hinged inwards around a frame. There was no evidence of any localised impact damage and there was also no evidence to suggest that the tank had been damaged and flooded prior to the structural failure. As this tank would therefore have been empty at the time of the accident, the increasing water pressure as the vessel sank probably caused a weak area in the plating to fail. With sea water then rapidly filling the tank, the internal and external pressure would have equalised, thus preventing any further pressure damage.

Given the large force that would have been required for the two structural members **(Figures 27a** and **27b)** to punch down through the bottom plating, this damage is not considered to have occurred either before or during the initial failure. As the elements were found protruding through the radius of the crease, it is more likely that this damage occurred as the hull impacted the seabed, causing the structure to be pushed upwards and the crease to become more severe.

2.3.5 Other loss scenarios

During the final hour of *Swanland*'s voyage the weather conditions had been poor and the sea rough. This resulted in the vessel yawing up to 15° either side of her heading. However, the vessel's movements weren't reported as excessive, nor were they causing concern to the crew. Although *Swanland* was pitching, she was not slamming. Whipping[66] is therefore unlikely to have contributed to the loading on the hull. The phenomenon of springing[67] can likewise be discounted as a factor, as this is associated with larger vessels[68] operating in seas with shorter wavelengths.

Swanland's AIS data **(Figures 6** and **7)** confirms that there were no significant course alterations before the accident which might have contributed to the structural failure. The AIS data at **Table 1** also indicated that *Swanland*'s speed over ground (SOG) was fluctuating between 4.4 and 6.4 knots just before the initial failure. Although the upper speed might seem to be high given that the vessel was heading into the seas[69], *Swanland*'s SOG was increased by the tidal stream. As the predicted rate of the tidal stream was approximately 2 knots, *Swanland*'s speed through the water was between 2.4 and 4.4 knots. Therefore, *Swanland*'s speed at the time of the accident was not considered excessive or a factor in the vessel's structural failure.

It is possible that sea water had been gradually leaking into the cargo hold during the voyage. The weight of this water, in addition to that of the cargo, could have triggered the structural failure. As discussed previously, there is no reason to doubt

[66] Whipping is a transient hull girder vibration, triggered by rapidly increasing wave-loads, in particular when a ship is slamming into head seas. As the hull girder response does not decay quickly, whipping leads to an increase in the wave loading and stresses. Whipping is more likely to occur during large heave and pitch motions, as well as at higher ships' speeds, due to the greater frequency and severity of slamming.

[67] Springing occurs in beam or head seas, typically with short waves, where the frequency of encounter overlaps the lower natural frequencies of hull vibration, resulting in a steady state resonant hull girder vibration. Since relatively high encounter frequencies are needed for springing, the phenomenon is most pronounced for larger ships with high forward speeds and longer resonant periods operating in moderate sea states.

[68] Van Gunsteren, F.F., *Springing of Ships in Waves*, Delft University Press/1978, available at: http://repository.tudelft.nl/assets/uuid:9872113e-381e-4c4d-9a74-f0253291c3b8/P_1784_4434.PDF

[69] Around the time of the failure *Swanland*'s course over ground (COG) and heading were about 200° and 220° respectively, while the Met Office report **(Annex B)** predicted a wave direction of 220°.

that the hatch covers were properly closed and secured at the time of the accident. However, it is possible that water could have entered the hold through a breach in the vessel's structure, such as the hatch coaming, deck plating or shell plating.

It appears that the water ingress detection system in *Swanland*'s cargo hold did not alarm at any stage before the initial failure, and suggests that the hold was not flooding prior to the initial buckling event. However, there were also no reports of the hold's bilge alarm activating after water was seen entering the hold following the initial failure. It is possible that the alarm did sound, and was simply not noticed during the abandonment. Nonetheless, there is no certainty that the system was functioning correctly.

2.3.6 Summary

The available evidence suggests that the most likely structural failure mechanism was due to the buckling of either the deck plating or the hatch coaming near to *Swanland*'s midships on the starboard side. The buckling would have been generated by a sagging bending moment, induced by the distribution of cargo, piled up towards the centre of the hold and the sea conditions at the time of the accident. With buckling initiated, the vessel's overall midships strength would have been compromised and the hull breach would have gradually worsened in the sea conditions. As the cargo hold began to take on water, the vessel's buoyancy and freeboard would have rapidly reduced. It is, therefore, not surprising that *Swanland* sank so quickly.

2.4 STRUCTURAL LOADING

2.4.1 Effect of non-homogenous loading

The distribution of cargo on board *Swanland* at the time of the accident was clearly a major factor in creating the large sagging bending moment at midships. As **Figure 3** indicates, the limestone was intended to be loaded in two piles close to the central transverse beam which divided the cargo hold hatch into two openings. This distribution of cargo was similar to that loaded during *Swanland*'s previous visits to Raynes Jetty; there was therefore nothing unusual in the distribution of the cargo on this occasion.

TMC's consideration of the possible distribution of cargo, as summarised at **Table 6** and **Annex O**, confirms that the 2730 tonnes of limestone could have been loaded into *Swanland*'s hold in a variety of distributions. Conditions 1 to 5b were modelled by TMC in an attempt to replicate the most likely non-homogenous configuration of the cargo on board at the time of the accident. These conditions were useful in illustrating the variability in loading that could have been achieved to load the cargo in piles towards the centre of the hold, albeit with a large variation in trim. However, as discussed above at **paragraph 2.3.2**, TMC's analysis **(Tables 7**, **8** and **9)** confirmed that all of these conditions would have resulted in large bending moments and stresses, the latter being sufficient to induce buckling in the longitudinal structure.

Comparison of the loading plan at **Figure 3** with the witness accounts describing the loading of the cargo, suggests that the most realistic of the non-homogenous conditions modelled by TMC was condition 5b. **Annex O** confirms that this condition required only a small adjustment to the cargo centroids to give the required stern trim of 0.1m. Most significantly, **Tables 8** and **9** confirm that this condition resulted in the largest bending stresses of all the conditions modelled by TMC.

Table 8 indicates that the bending stresses in conditions 2, 3 and 5b would have theoretically exceeded the stress to cause buckling in still water. However, given that there were no reports of structural problems or buckling failures while the vessel was alongside or as she departed Raynes Jetty, the calculated values appear to be excessive.

Although TMC's analysis was based on proven classic "beam theory", the modelling incorporated, by necessity, a number of assumptions and simplifications, which might have led to the calculated stresses being exaggerated. TMC noted that as the calculation method assessed each plate individually, the stress would in reality be distributed to adjacent plates, thereby reducing the actual stress in the individual plate.

Irrespective of the possible reasons for the calculated stresses appearing to be too high, they are still considered indicative of the magnitude of bending stresses that would have been induced in *Swanland*'s upper structure. For example, using the 2009 scantlings, the bending stresses in the hatch coaming and deck plating for condition 5b in the estimated sea conditions **(Table 9)** exceeded the stress required to induce buckling by 35% and 79% respectively. Given the size of these margins, it seems likely that, even with some of the stress dissipating into adjacent plates, the residual stress would have still been large enough to induce buckling in the section of plating under consideration.

Condition 7 was also modelled by TMC for comparison to show the 2730 tonnes of cargo loaded in a hypothetical homogenous distribution. **Table 6** confirms that this distribution would have resulted in a level trim, not dissimilar to that for conditions 4 and 5b, and would have been perfectly acceptable from a ship-handling perspective. **Tables 7**, **8** and **9** confirm that, as expected, lower stresses would have been generated with the cargo loaded homogenously. Indeed, in the predicted sea conditions at the time of the accident **(Table 9)**, the calculated bending stresses in the upper midships structure would have been approximately half of those generated by Condition 5b. **Table 9** also confirms that the bending stresses for condition 7 in the estimated waves at the time of the accident would not have theoretically been large enough to induce buckling in any of the midships longitudinal structure, unless a deck beam had become detached.

Compared with the much higher bending stresses calculated for the "heaped" cargo distributions (Conditions 1 to 5b), it can therefore be seen that a homogenous distribution of cargo would have been far less likely to compromise the vessel's longitudinal strength.

2.4.2 Environmental effects

As discussed above, the sagging bending moment was created by the non-homogenously loaded cargo in combination with the sea conditions being encountered by *Swanland* at the time of the failure. The Met Office report commissioned by the MAIB **(Annex B)** estimated that the waves being encountered by *Swanland* at the time of the initial failure might have been 105m in length. Given that *Swanland* was 81m long and was heading directly into the oncoming seas, her midships section would have been in the wave trough when her bow was lifted by the large wave at the time of the initial structural failure, as illustrated at **Figures 66** and **67b**. It is also significant that Table 5.1 of the Met Office report **(Annex B)** confirmed that the estimated wave heights were at their maximum around the same time as the structural failure; the tidal stream and the seas were also in direct opposition, which would have caused the steepness of the waves to increase.

Buoyancy forces oppose the weight of a vessel and prevent it from sinking. The distribution of buoyancy varies along the length of a vessel and, among other things, this is dependent on a vessel's position relative to the sea waves. In this case, with *Swanland* being only marginally shorter than the wavelength, the vessel's bow and stern would periodically have been supported by the additional buoyancy provided by the wave peaks, whereas her midships section would have been relatively unsupported in the wave trough resulting in a sagging bending moment. This is supported by both general naval architecture theory and research[70], the latter demonstrating that peak vertical bending moments occur on board ships proceeding in head seas with a wave length nearly equal to the ship's length.

As part of its analysis, TMC also calculated *Swanland*'s longitudinal strength in slightly smaller waves to those predicted by the Met Office. This analysis confirmed that these conditions would have resulted in lower, but still critical bending stresses. The still water bending stresses at **Table 8** were also calculated as being large enough to induce buckling. However, for the reasons as discussed above, this seems unlikely.

Unfortunately, due to the limitations of the TMC analysis, it is not possible to comment on what the limiting sea conditions may or may not have been to initiate critical bending stresses in *Swanland*'s upper structure.

2.4.3 Tank top loading

The 1976 LR rule requirements **(**as referenced at **paragraph 1.27.2)** stipulated a maximum loading equivalent[71] to 5.375 tonnes/m^2 on *Swanland*'s tank top plating. Given that the limestone loaded at the time of the accident had a density of 1.85 tonnes/m^3, this would therefore have equated to a permissible static design head for the limestone in the hold of 2.85m.

Although the exact height of cargo loaded on board *Swanland* during her final voyage was not known, both the loading plan **(Figure 3)** and witness evidence suggested that the cargo was loaded up to the top of the hold. As the depth of the cargo hold was 5.06m, the cargo loaded in *Swanland*'s hold would therefore have exceeded the maximum allowable height of cargo and the tank top plating would have theoretically been overloaded.

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[70] *Midship Wave Bending Moments in a model of the cargo ship "Wolverine State" running at oblique headings in regular waves*, Ship Structure Committee Report: SSC-201, September 1969, downloaded from: www.shipstructure.org/pdf/201.pdf

[71] The allowable tank top loading would have been calculated by multiplying 1.4d, where d was the load draught of 5.364m, by the reciprocal of the quoted stowage rate of 1.39 m^3/tonne, i.e. 1.4 x 5.364m x (1/1.39m^3/tonne) = 5.375 tonnes/m^2.

The only significant damage observed to the tank top plating during the brief internal ROV survey showed the plating creased upwards, rather than having failed **(Figure 14b)**. However, although the external ROV footage appeared to show that the tank top had partially fractured in way of the main fracture paths, insufficient evidence was obtained to confirm if this was due to the weight of the cargo. As the DB structure was found still largely intact, this probably indicates that the tank top did not fail catastrophically. Instead, the damage to the tank top plating was more likely to have resulted from the initial buckling.

Had the limestone been loaded in a homogenous distribution, as modelled by TMC **(Annex O)**, it would have been loaded about 2.5m above the tank top. Therefore, not only would this homogenous loading distribution have significantly reduced the bending moments, but it would have also satisfied the LR rule requirement for tank top strength.

It is perhaps surprising that the tank top plating had not failed previously as Type 1 limestone had been loaded on board *Swanland* at Raynes Jetty in a similar non-homogenous distribution to **Figure 3** since 2003. However, it is likely that LR's tank top loading limit indicated on its notation included a factor of safety. It is apparent that, although there was no evidence to indicate that *Swanland* had been designed to carry 'heavy cargoes', the vessel's tank top plating and DB structure were constructed in excess of the rule requirements. At build, *Swanland*'s tank top plating was 17mm thick, while her earlier sister vessel's equivalent plating was only 14mm. The reason for this increased thickness could not be confirmed due to the lack of available records.

2.5 CARGO LOADING PRACTICE

2.5.1 Onboard instructions

Swanland's onboard instructions specified that it was the chief officer's responsibility to conduct 'strength and stability' checks prior to the commencement of cargo operations. However, Torbulk did not ensure that the information or means necessary for him to discharge this responsibility were held on board. *Swanland* did not carry a loading instrument, and Torbulk staff were of the opinion that she did not carry a loading manual. Therefore, it should have been patently evident to the managers that it was not possible for the chief officer to undertake any longitudinal strength calculations, and therefore the company instruction to do so had no practical meaning.

2.5.2 Onboard loading information

If *Swanland* was built under LR's 1976 'small' ship rules, the vessel's still water bending moments should have been calculated. However, the calculation of the vessel's wave bending moments was not required by either LR's 'small' or 'full' rules. In addition, *Swanland* was not strengthened to carry heavy cargoes and no evidence is available to show that the vessel was ever intended or had been approved to carry non-homogenous, high density cargoes or cargoes with a density greater than $1m^3$/tonne. Therefore, it is most unlikely that wave bending calculations were undertaken.

The contradictory evidence from both previous crew and recent surveys regarding the availability of a loading manual on board possibly indicates that loading information was carried but not in a dedicated manual. It is more likely that, like many other general cargo vessels of similar age and design, and as allowed by the BC and IMSBC Codes, the loading information on board *Swanland* was limited to that included in the vessel's stability booklet **(Paragraph 1.24.1** and **Figures 54** and **55)**.

2.5.3 Onboard practice

Swanland was intended only to carry cargoes homogenously and cargoes such as grain and woodchips, which have a high stowage factor, and would have invariably been loaded evenly over the full length of the tank tops. **Figures 52a** and **52b** appear to show other cargoes, such as aggregate (which has a stowage factor of approximately 0.7m^3/tonnes), reasonably spread along the length of the hold, other than under the covered areas forward and aft. Nonetheless, it is evident that when loading limestone at Raynes Jetty (which had a stowage factor of 0.54m^3/tonnes) it had become a regular practice to concentrate the cargo towards the centre of the hold. However, because the loading plan submitted by the chief officer on 26 November 2011 **(Figure 3)** was a freehand drawing of the cargo distribution, this cannot be taken as an accurate representation of what was intended or achieved.

Loading the cargo in the centre of the hold helped to slightly speed up cargo operations at Raynes Jetty; fewer hold hatch covers would have needed to be opened by the crew, and the loading arm on the jetty would not have needed to move far along the jetty. The need to move the loader any significant distance during the final trimming operations was also minimised. However, it is apparent that the crew did not fully recognise the potential dangers associated with loading solid bulk cargoes in what was, effectively, a single pile.

2.5.4 Overloading

<u>Load Line</u>

The International Convention on Load Lines 1966 and the Protocol of 1988 relating to the International Convention on Load Lines 1966 regulate the assignment of freeboard and load line marks allocated to a vessel. They define the areas and the seasons when the load line marks apply.

On sailing from Raynes Jetty on 26 November 2011, *Swanland*'s draught was reported to be 5.3m forward and 5.4m aft, giving a mean draught of 5.35m **(Paragraph 1.3)**. This was in excess of her mean winter draught of 5.254m derived from the vessel's Load Line Certificate **(Annex N)**. The vessel's intended passage plan to Cowes took the vessel through North Atlantic Winter Seasonal Zone II which, from 1 November to 31 March requires that a vessel does not load in excess of its allocated winter load line mark. *Swanland* was therefore overloaded when the marks were recorded.

The difference between the allocated mean winter draught and the observed mean draught was 96 millimetres (mm). At the summer draught the weight required to sink the vessel by 10mm was 9.5 tonnes. Based on the observed draughts, *Swanland* sailed from Llanddulas 91.2 tonnes overloaded. However, in view of the difficulty of reading drafts from a quayside it is likely that the recorded drafts were only accurate to within +/ – 2cm. In addition, given the accuracy of the weighing device on the shoreside conveyor, it is also possible that *Swanland* was loaded with up to 27 tonnes of limestone more, or less, than intended.

The loading operation at Raynes Jetty was tidally constrained and the vessel remained secured alongside for just over 3 hours. During this period, it would have been possible to pump out only about 480 tonnes of sea water from the WB tanks. As the tanks could hold up to 680 tonnes, and the tanks were normally kept full on arrival to aid the vessel's manoeuvrability, at least 200 tonnes of water ballast could have remained on board. Therefore, the vessel's overloading was possibly due to the inability to empty her WB tanks. The extent to which the defective valve in No.4 DB tank affected ballasting and de-ballasting operations is not known.

It is apparent that it had become usual practice to sail from Raynes Jetty before de-ballasting operations were complete. Any remaining ballast, which was usually retained in one of the peak tanks, was usually emptied after the vessel had sailed. Assuming that normal practice was followed, the majority of the ballast water remaining in the tanks would have been pumped out within between about 35 minutes and 1 hour and 15 minutes after sailing. Although sailing in an overloaded condition contravened the Load Line Convention, classification society rules and the vessel's onboard instructions, the practice seems to have been born from operational necessity when visiting Raynes Jetty.

Tank top

As discussed in **Paragraph 2.4.3**, the loading of Type 1 limestone centrally in *Swanland*'s hold caused the maximum allowable height of cargo to be exceeded. Therefore, the tank top plating would have theoretically been overloaded. As *Swan Diana* also regularly loaded limestone at Raynes Jetty in a similar non-homogenous distribution to *Swanland*, it would appear that the tank top load limits detailed in her loading manual **(Annex Q)**, albeit with an apparent error in the unit,[72] had either not been noticed or were ignored.

Although the Braemar report **(Annex D)** confirmed that *Swanland*'s tank top plating was regularly repaired, this was understood to be due to wastage, rather than any specific concerns due to excess loading. It is surprising that the routine overloading of *Swanland*'s tank top was never recognised by the managers or during any of the structural surveys, SMC audits or PSCIs conducted in the 8 years leading up to the accident. However, this may be partly explained by a general lack of appreciation by all concerned that the vessel was loading high density cargoes on a regular basis.

2.6 COMPLIANCE WITH LOADING REGULATIONS

2.6.1 Industry knowledge

In this case, it is evident that both *Swanland*'s owners and managers were unaware of the:

- Potential risks in carrying limestone in a high density form.
- Need to seek classification society approval for a vessel to carry high density cargoes.

[72] The allowable loads in this loading manual are incorrectly listed with the units tonne/m^3; the units should be tonne/m^2.

- Details of the loading information available on board its vessels, and
- Importance of obtaining cargo information such as density or stowage factor from shippers or cargo terminals.

During the course of this investigation it became apparent through discussions with industry stakeholders that many other ship owners and managers are potentially similarly uninformed. It is possible that many ship owners and managers consider that the IMSBC Code applies only to bulk carriers.

Therefore it is of serious concern that many general cargo ships are potentially currently carrying solid bulk cargoes, including high density bulk cargoes, but are not complying with the requirements of the IMSBC Code and have not been approved to carry solid bulk cargoes by their Flag States or classification societies. It is also possible that some of these vessels were not designed or constructed to carry these cargoes or have not been provided with adequate loading information.

2.6.2 Provision of cargo loading guidance

SOLAS Chapter VI Regulation 7 is clear in its requirement for vessels carrying solid bulk cargoes to be provided with a booklet to include, among other things, tank top limits and information regarding the loading, carriage and unloading of cargoes. The booklet is intended to enable the master to prevent excessive stresses in the vessel's structure. However, although the use of a dedicated booklet for this purpose was previously recommended in the BC Code and is now endorsed in the IMSBC Code, both Codes refer to sufficient information regarding the proper distribution of cargo also being available in a ship's stability booklet.

However, the loading information contained in *Swanland*'s stability book issued in 2003 lacked detail. In particular, the vessel's previous stability booklet, which was approved by BV in1988, indicated that the limiting stowage factor of a cargo was "49.6 CU.FT/TON" (1.383m^3/tonne). This was in line with the vessel's notation allocated by LR at build, but the 2003 stability book did not include this important information. Furthermore, the two loaded conditions illustrated in the stability book were both 'homogenous"; no information was provided on the carriage, or the dangers of the carriage, of part or non-homogenously loaded cargoes. It is evident from TMC's analysis **(Tables 7**, **8**, and **9)** that even on a vessel of *Swanland*'s size variations in the distribution of solid bulk cargoes can have a significant effect on still water and wave bending moments.

Whether loading information provided to masters is contained in a loading manual or a stability book, to be of use, and therefore to be used, the information must be both sufficiently comprehensive and easily understood. Given the limited loading guidance contained in *Swanland*'s stability book, it is not surprising that the vessel's crews continued to load limestone cargoes in a single pile.

By comparison, although *Swan Diana*'s loading manual **(Annex Q)** was comprehensive, its format was arguably over-complicated and, other than the tank top loading limits, it was of little practical use to her crew. Although the broad content of a loading manual is stipulated in UR S1 **(Paragraph 1.27)**, a manual's complexity will be dependent on several factors including a vessel's size, number of cargo holds, and the bending moment calculations undertaken. In the case of bulk carriers, where the information contained in loading manuals tends to be detailed and complex, the ships' crews have the benefit of a loading instrument to help them determine the safe distribution of cargoes.

Understandably, as relatively small single-hold vessels, *Swanland* and *Swan Diana* were not required to carry a loading instrument. However, the loading information required on board both vessels needed to be relevant to their operation. The need for clear loading guidance, particularly for vessels carrying high density cargoes, to ensure the stipulated limits for both longitudinal strength and local tank top loading are not exceeded cannot be underestimated.

2.6.3 Responsibility of shore terminals

In order to accurately load solid bulk cargo, a master of a general cargo ship must not only be aware of the loading limitations of his vessel, he must also know the properties of the cargo to be carried, including its density or stowage factor. In this case, neither *Swanland*'s master nor the chief officer had been informed of the density or the stowage factor of the limestone loaded at Raynes Jetty.

The shipper, CEMEX, failed to meet its obligations to forward this information as required by both SOLAS and the IMSBC Code. However, had it done so, in this case it is unlikely to have prompted a change to the loading plan which was based on custom and practice. Nonetheless, more effort is warranted not only to make shippers and cargo terminal operators aware of their responsibilities under the IMSBC Code to provide accurate cargo information to ships' crews, but also to keep the guidance provided in Appendix I to the IMSBC Code up to date. Although limestone was included in the Appendix **(Annex M)**, it was not identified to be a potential high density cargo.

2.6.4 Certification and inspection

Annex W shows that the ship risk profile, which is now used to target inspections within the Paris MOU port state control region, gives considerable weighting to the ship type. Significantly, a general cargo ship does not attract any weighting points. Consequently, even had Torbulk been a 'very low' performing company (it was not), the risk profile calculator shows that *Swanland* was a Standard Risk Ship (SRS). The vessel was therefore subject only to 'initial' and, if justified, 'more detailed' inspection at intervals of between 10 and 12 months.

Raising the weighting factor of general cargo ships, particularly those carrying high density cargoes, would increase the exposure of these vessels to PSCI. However, it might also be impractical given the large numbers of general cargo ships operating in the Paris MOU control region. Nonetheless, the circumstances of *Swanland*'s loss and the death of six of her crew indicate that a more concentrated PSCI regime for older general cargo ships carrying high density bulk cargoes is warranted. More frequent PSCIs would increase the likelihood of the inspectors detecting material degradation in the vessels targeted. More importantly it would enable checks to be made to ensure that the vessels comply with the IMSBC Code, particularly in relation to cargo loading and the provision of appropriate loading guidance and cargo information.

In 1992 BV had issued an attestation under the authority of Cyprus stating that *Artemis* (as *Swanland* was then named) **(Annex U)** was suitable to carry specified cargoes in bulk. One of the cargoes specified was limestone, but the attestation did not include cargo densities. However, such confirmation is not a mandatory requirement and it does not appear that similar documents were subsequently issued by LR or INSB.

The provision of an 'attestation', 'certificate of compliance' or 'document of compliance' to confirm the types and densities of solid bulk cargoes a vessel is authorised to carry and that the vessel has been provided with adequate loading information, would be of considerable benefit to owners, shippers and PSCI inspectors alike.

2.7 REDUCTION IN STRUCTURAL STRENGTH

2.7.1 Overview

Unfortunately, few records remain covering the period of *Swanland*'s construction in 1976 and 1977, and it was not possible to determine with any certainty which LR rules had been applied during build. However, there is no reason to doubt that *Swanland* was designed and constructed in accordance with the requirements of the time. There is also no indication of the vessel experiencing a previous significant structural failure during her 34 years in service. Therefore, it has been assumed that the original structural design was adequate, and that the vessel's construction would have been appropriately supervised by LR. Braemar confirmed **(Annex D)** that *Swanland*'s structural design was "*normal for a vessel of her size, type and trade*".

2.7.2 Design modifications

No information has been identified to suggest that the installation of the self-discharging equipment in 2003 would have adversely affected the vessel's longitudinal or midships strength. Although additional top weight structure was added, including the conveyor system on the port side of the main deck, this was not likely to be excessive. Indeed, as part of the modification some localised strengthening was added in the cargo hold, with improvements made to the connections of the transverse deck beams **(Figure 38)**. It can, therefore, be concluded that the addition of the self-discharging equipment in 2003 did not directly lead to the vessel's structural failure.

2.7.3 Ongoing repairs

Braemar's detailed analysis of *Swanland*'s structural survey history confirmed that the vessel was subjected to extensive and often repeated repairs to key structural members during much of her 34-year service life. Many of these repairs were undertaken in the cargo hold, in particular to the exposed transverse frames. Although from a survey and inspection perspective it is helpful to have the hold structure open and accessible, this makes the structure more susceptible to damage during cargo operations. From the reports, much of the damage to *Swanland*'s hold structure appears to have been caused by mechanical damage, presumably caused by grabs and other cargo discharging equipment. Such damage, particularly localised impact damage, would weaken the structure and damage its coatings, leading to corrosion and wastage. As many of the cargoes carried by *Swanland* were either abrasive or corrosive in nature, these would potentially have exacerbated both the damage to and diminution of the structure. Braemar's analysis of the voyages undertaken by *Swanland* noted that, due to the often quick turnarounds, it would have been difficult for her crew to effectively clean the hold's structure, further increasing the adverse effects of the corrosive cargoes carried.

Nevertheless, Braemar concluded that given the nature of the defects reported up until 2009, the various structural repairs carried out to *Swanland* appeared reasonable. However, as indicated in Appendix A to its report **(Annex D)**, not only were the required repairs extensive, but they also tended to be 'piecemeal' and reactive, generally focusing only on the immediate area of damage. Therefore, although the vessel's structure continued to meet class requirements, it is possible that the original structural strength would not have been regained; for example, the large number of joins between repairs would have created possible discontinuities, thereby increasing the risk of corrosion.

It is also significant that following the replacement of the upper deck beams in 2003, only limited repairs were conducted to these beams in the midships area. Figures A.2(j) to A.2(l) at **Annex D** confirm that during the following 8 years, various repairs were conducted to other areas of the midships structure. The upper deck beams were key structural elements intended to prevent buckling of the main deck plating, which were not as susceptible to mechanical damage as those lining the sides of the hold. However, as the upper deck beams were relatively inaccessible, it is less likely that they would be closely inspected, as was the case during the 2009 INSB survey in Kaliningrad.

Given the high bending stresses in *Swanland*'s midships main deck plating and the low stresses required to induce buckling in this plating, particularly if a transverse deck beam had become detached **(Table 5)**, the attachment of these beams to the deck plating would have been critical to maintaining the vessel's structural strength. It is therefore quite plausible that the failure of one of these deck beams triggered the initial buckling and structural failure.

2.7.4 Onboard maintenance

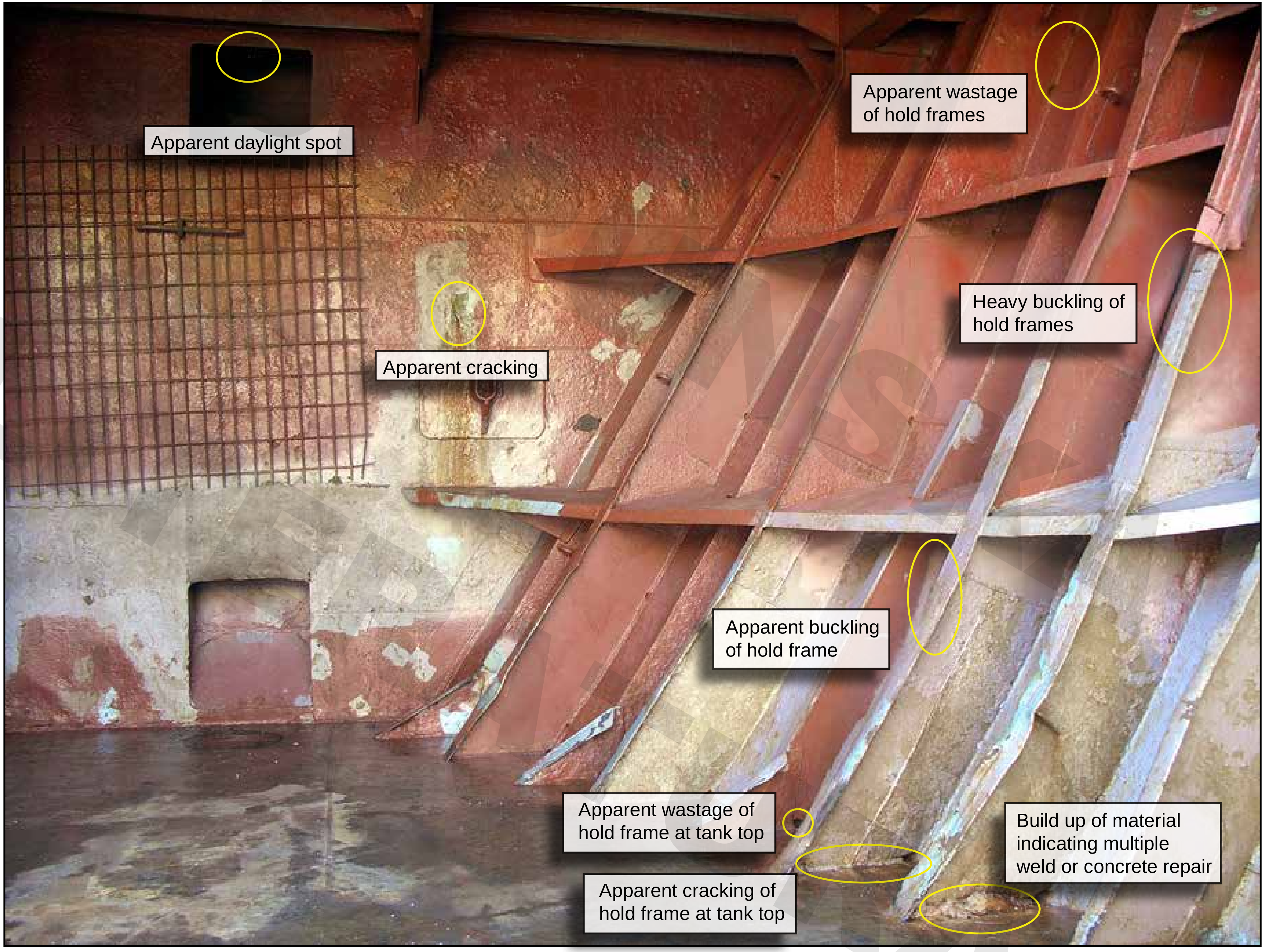
Braemar's report concluded that an apparent lack of focus on the management and maintenance of *Swanland*'s structural integrity would have allowed her primary structure to degrade over time. It also identified that this would have led to a critical reduction in longitudinal strength. The lack of planned maintenance on board *Swanland* had been highlighted during a P&I condition survey in 2002. More recently in 2009, the improvement programme agreed between Torbulk and LR shortly before *Swanland* transferred class to INSB, included a requirement to improve the implementation and management of the vessel's defect reporting system.

It is evident that over the years various structural repairs were conducted by *Swanland*'s crew, including the unauthorised repairs identified during the annual LR survey in 2008 **(Table 4)**. Although defect reports had regularly been raised for *Swanland* until May 2011, very few of these defect reports identified issues with the vessel's structural integrity, particularly in way of the cargo hold.

Photographic evidence confirmed that *Swanland*'s accommodation superstructure and hull sides appeared to be reasonably maintained, but the cargo hold structure does not appear to have been treated in a similar manner. As **Figure 48** indicates, this was possibly due to both the actual and budgeted expenditure on hull maintenance being reduced during *Swanland*'s final years of service.

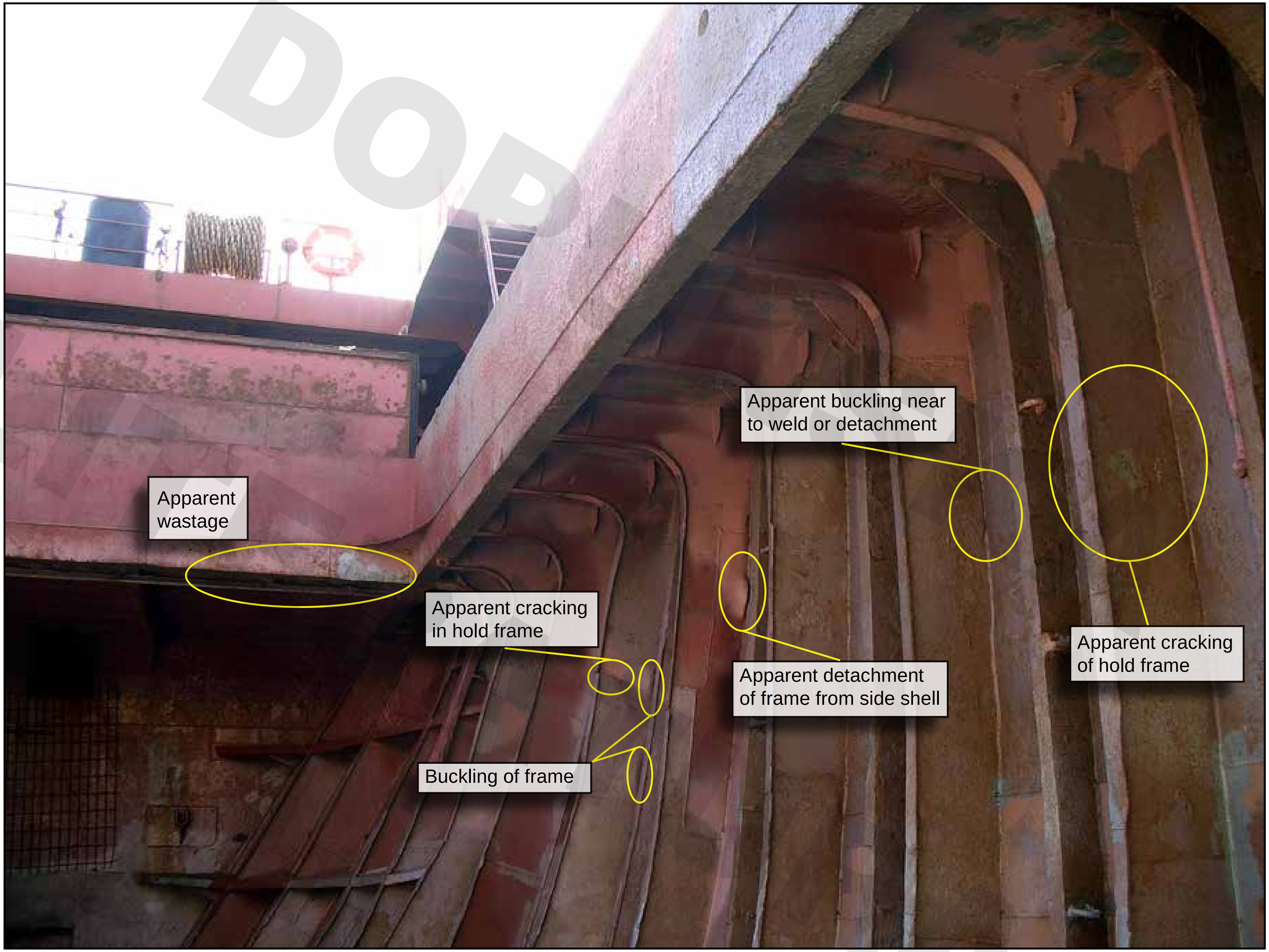
It is apparent that following an intensive period of carrying salt cargoes in late 2010, the condition of the hold necessitated its pressure washing and painting in July 2011. However, as can be seen in **Figures 75a, b, c, d, e and f** the hold coating appeared to be in a poor condition. Closer examination of these photographs appears to show that in addition to mechanical damage, there were areas of coating loss, instances of frame detachment, substantial cracks in some frames, and areas of significant pitting and general corrosion. It also appears that scale (much of it heavy) had simply been painted over.

Figures 75a: Photograph of *Swanland*'s hold in September 2011 showing apparent structural defects



Figures 75c: Photograph of *Swanland*'s hold in September 2011 showing apparent structural defects

Figures 75e: Photograph of *Swanland*'s hold in September 2011 showing apparent structural defects



Figures 75f: Photograph of *Swanland*'s hold in September 2011 showing apparent structural defects

2.7.5 Reduction in midships strength

Braemar's analysis of *Swanland*'s structural condition not only identified that the vessel's original strength was likely to have been generally degraded by the 'piecemeal' repairs, it also concluded that after *Swanland*'s intermediate survey in 2009 the vessel's longitudinal strength was likely to have been significantly weakened by corrosion and wastage[73].

No repairs were undertaken during the final 2½ years of *Swanland*'s life **(Table 4)** and the corrosive cargoes carried during this period could not have failed to stimulate corrosion of the cargo hold structure. Indeed, Braemar's estimation of the relative section modulus values for *Swanland*'s midships section at **Figure 46** paints a sobering picture. The estimated up to 18% reduction in the vessel's upper structural strength at the time of the accident indicates that her structural capacity and ability to withstand bending stresses was significantly reduced. **Figure 45** likewise suggests that, by the time of the accident, although the diminution levels remained within the range permitted by class, the diminution in significant elements of the midships structure might have been approaching the 30% limit which would have triggered their renewal[74].

In the face of such overwhelming evidence, it is difficult not to agree with Braemar's conclusions **(Annex D)** that the lack of maintenance and oversight of *Swanland*'s cargo hold and surrounding structures is likely to have been a major contributing factor to the vessel's structural failure.

2.8 FINANCIAL PRESSURES

The financial pressures faced by Swanland Shipping Ltd **(Paragraph 1.8.2)** in keeping *Swanland* in service are common within the shipping industry. *Swanland* was only one of thousands of general cargo ships operating on small profit margins that, as they become older, also become increasingly expensive to operate. It should therefore not be surprising that, like Swanland Shipping Ltd and Torbulk, numerous shipowners and managers try to reduce vessel running costs wherever possible.

The transfer of *Swanland* to INSB was intended to save money. However, although the savings made on the costs of survey and audit fees would have been immediate, it is recognised that many ship owners also enter their vessels with non-IACS societies expecting that the surveys and audits conducted will be less robust. In effect, significant long term savings are possible through reduced cost of repairs and the rectification of deficiencies. **Table 4** and **Figure 48** illustrate that this was certainly the case for *Swanland* following her transfer of class to INSB in May 2009.

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[73] In taking account of the corrosive effects of the salt cargoes carried on board *Swanland*, the wastage rate calculated by Braemar was inevitably significantly higher than the general wastage rates used by classification societies. Consequently, it could be viewed as a 'worse case' situation. However, this is offset by the fact that Braemar's analysis did not take into account the potential for pitting and grooving corrosion and corrosion due to other potentially corrosive cargoes carried.

[74] Braemar's use of a tank top plating thickness of 17mm is considered to be reasonable given that the differences between *Swanland*'s 'as built' scantlings, the assumed 'modified' scantlings identified in 1997, and her approved 'as built' drawings were never properly verified or resolved.

2.9 QUALITY OF SURVEY AND AUDIT

2.9.1 Conduct of survey

Following *Swanland*'s transfer from LR to INSB in May 2009, it is apparent from Braemar's conclusions **(Annex D** and **Paragraph 1.13.10)** that the conduct of the vessel's intermediate survey, and the subsequent annual surveys in 2010 and 2011, lacked rigour. In addition, the lack of specific information on the condition of individual structural members contained within the INSB survey reports together with the simple and frequently contradictory grading of structures was potentially confusing.

During *Swanland*'s intermediate survey, the attending surveyor's absence during the initial UTMs of the DB tanks, his reliance on the vessel's technical superintendent to confirm that the scope and quality of the repairs conducted in the DB was satisfactory, and his inability to closely examine the upper areas of the cargo hold indicate that the survey was deficient in several important areas. In addition, the use of an incorrect drawing to check the diminution of the tank top plating during *Swanland*'s intermediate/entry survey in 2009, which appears to have been the continuation of a practice started by BV and LR during previous surveys, potentially jeopardised the integrity of the vessel's survey and repair regime.

It is significant that, following *Swanland*'s annual surveys in 2010 and 2011, no repairs or deficiencies were identified. **Table 4** shows that between 2003 and 2009, frequent repairs had been carried out to the vessel's WB tanks and side shell frames in the cargo hold. Although *Swanland* had undergone extensive repairs in Kaliningrad in 2009, her trading pattern and operation had not changed, and she had continued to frequently carry corrosive and abrasive cargoes. In such circumstances, it is difficult to envisage that the structures within the cargo hold had not been adversely affected by corrosion, wastage or mechanical damage to a noteworthy degree. The condition at the hold in September 2011 **(Figures 75a, 75b, 75c, 75d, 75e and 75f)**, only 3 months after the last annual survey and 2 months after being pressure washed and painted by the crew, strongly indicates this to have been the case. Therefore, as noted by Braemar **(Annex D)** the INSB surveys had not been as focused as LR on key areas of the vessel's structure. LR had issued an MOC for *Swanland* that had required additional inspections and thickness measurements of the vessel's WB tanks and various transverse frames in the midships area of the cargo hold. Similar requirements for the cargo hold had evidently not been considered to be necessary by INSB during the annual survey conducted in 2011.

2.9.2 Survey regime

The INSB survey regime applied to *Swanland* from 2009 onwards shares many of the features in the equivalent regime applied by IACS societies, including requirements for thickness measurements. However, it is apparent from **Annex J** that in some respects the INSB regime is not as rigorous.

In particular, UR Z7.1, applicable to IACS general dry cargo ships, required close-up examinations[75] of the lower part of the cargo hold structure. For example: at annual surveys, 25% of the hold frames should be subjected to close-up examinations; and, during intermediate and special surveys, all such frames, including their upper end attachments and adjacent shell plating are to be examined "within the close visual inspection range of the surveyor". However, INSB Rules include no such requirement for a general cargo vessel.

The upper deck beams in *Swanland*'s cargo hold were, therefore, not examined at close hand from 2009 onwards and, as discussed above, no significant repairs had been conducted to the deck beams in the midships area since 2003. It could be argued that a vessel of the size of *Swanland* with only a relatively small hold would not have benefited from such a close-up examination. However, given that the deck beam attachments were 5m above the tank top plating, and the average surveyor is less than 2m in height, this means that the condition of critical structural elements in the upper hold would have to be assessed from a distance of 3m. Given the critical nature of these beams, in an area in which the catastrophic structural failure on *Swanland* was initiated, this does not seem satisfactory.

It is of interest to note from **Annex J** that the ESP regime applied to bulk carriers of a similar size and age as *Swanland* has very similar requirements to those for general dry cargo ships, detailed in IACS UR Z7.1. The key difference between the two regimes appears to be the increased level of planning required prior to conducting an ESP survey. For vessels over 10 years of age this includes full consideration of previous surveys, thickness measurements, repairs and cargo history to help identify critical structural areas for inspection.

Based on the findings of this investigation, it is clear that a more holistic approach to *Swanland*'s structural integrity**,** such as currently applied to bulk carriers under ESP, would have enabled appropriate plans for condition improvement to have been developed taking account of the vessel's overall strength, rather than just focusing on the localised area requiring immediate repair. Given the high casualty rates associated with general cargo ships, often due to structural failure and foundering, it is considered that there is a strong argument to either include general cargo ships under a similar ESP regime or to incorporate the survey planning requirements of ESP into a future revision of UR Z7.1.

2.9.3 Audit

It is apparent that the ISM-related audits of Torbulk conducted by INSB were not as robust as the audits conducted by Flag States and other ROs. Whereas between 2009 and 2011 the DOC audits of Torbulk conducted by Cayman Islands

[75] IACS UR Z7.1 defines a Close-up Survey as a survey where the details of structural components are within the close visual inspection range of the surveyor, i.e. normally within reach of hand.

and LR identified 15 separate non-conformities and numerous observations, no non-conformities or observations were raised by INSB during the three audits it conducted during the same period.

Similarly, no non-conformities or observations were raised during *Swanland*'s SMC audit in July 2009. By itself this is not necessarily significant, but in the context of the quality of INSB's surveys and DOC audits, the thoroughness of the SMC audit must also be questioned. In April 2009, LR had considered the safety management of *Swanland* was sufficiently in need of improvement to place the vessel on a QIP (based on the submission of a second PR17 report prompted by the 16 deficiencies raised during the PSCI in Warrenpoint). Ten deficiencies had also been raised during a PSCI on board *Swanland* in August 2009, 6 weeks before the SMC audit.

2.9.4 Training and approach of surveyors

It is of concern that *Swanland*'s annual surveys in 2010 and 2011, the vessel's initial SMC audit in 2009, and the DOC audits of Torbulk in 2009, 2010, and 2011, all of which appeared to have lacked rigour, were conducted by the same surveyor. Although the surveyor had served in the RN, his responsibilities as an electrical mechanic would not have provided him with sufficient background to survey and audit commercial vessels or safety management systems.

Furthermore, the surveyor had not worked in a marine environment for 17 years when he joined INSB in 2009. Given the limited 'on the job' and formal training the surveyor had received in certification, ship survey and ISM, the very scant monitoring of his performance that followed, and the lack of any continuation training **(Paragraph 1.32.3)**, his ability to conduct annual surveys and ISM audits to an acceptable standard must be questioned.

The surveyor's preference to discuss issues rather than to issue non-conformities possibly explains why some of the survey and audit reports lacked content, but it also demonstrates a failure to recognise the importance of informing key stakeholders of his findings.

INSB's QMS had been verified to meet ISO 9001:2008 by an independent certification body. During the audit of the RO conducted in February 2011, no non-conformities were identified. Nonetheless, the deficiencies identified by PMA in 2008 regarding INSB's training of its surveyors, which were reported to have been addressed, appear relevant in this case. The quality of the surveys and audits conducted in relation to *Swanland* strongly indicates that a concerted effort to improve the training and performance of its surveyors is needed if INSB is to conform to the detailed requirements of the forthcoming RO Code **(Paragraph 1.33)**.

2.10 ROLE OF THE FLAG STATE

2.10.1 Change of register

As discussed in **Paragraph 2.8**, it is common practice for older general cargo ships to be transferred into class with non-IACS ROs in order to save money. As many Flag States, such as the UK, do not accept non-IACS ROs to act on their behalf, the change of class from an IACS member to a non-IACS member often requires a vessel to also change register. In many cases, this results in vessels moving into class with lesser performing ROs and lesser performing Flag States (as graded by the Paris and Tokyo MOUs).

Swanland was only able to be classed with INSB if she was registered with a Flag State which authorised INSB to act on its behalf. However, although MCI accepted *Swanland* onto the Cook Islands register, the vessel did not meet some of the register's entry criteria. In particular, *Swanland* was over 25 years old and the vessel's PSCI record was not 'good'.

MCI's Quality Manual stated that vessels over 15 years old must be subject to IACS ESP or an equivalent, however this requirement was not applied to *Swanland*. An ESP would have instigated a greater level of scrutiny of *Swanland* and the surveys would have been planned in more detail. Given the conclusions made by Braemar, as summarised at **paragraphs 1.13.10** and **2.7.3**, had an ESP been applied it might have triggered repairs or other actions that could have prevented *Swanland*'s structural failure.

Furthermore, as *Swanland* was more than 15 years old and was to be classed with INSB, adherence to the Quality Manual would have also required the vessel's acceptance onto the Cook Islands register to have been justified. No evidence is available to indicate that justification was provided. Indeed, the initial inspection carried out by an MCI surveyor in May 2009 was of a general nature only and was not sufficiently detailed or extensive to accurately determine the vessel's material condition or her suitability to be accepted on to the Cook Islands register.

2.10.2 Oversight of INSB

MCI had a formal agreement with INSB for the RO to act on its behalf. However, it had not verified the RO's procedures or performance and instead had relied on an audit carried out by PMA in 2008 without ensuring that the non-conformities identified during that audit had been addressed.

The draft RO Code is due to be adopted in December 2013 and, among other things, it provides Flag States with a standard against which to assess and authorize ROs. It also provides Flag States with mechanisms for the consistent oversight of ROs and requires Flag States to establish an oversight programme of ROs acting on their behalf to ensure that they meet the various requirements of the draft Code.

This investigation has raised a number of questions over the performance of INSB during its stewardship of *Swanland.* As such, there appears to be a compelling need for MCI to conduct a thorough audit of the INSB's activities as an RO ahead of any measures that may be introduced by the forthcoming RO Code.

2.11 CREW ACTIONS AND ABANDONMENT

2.11.1 The voyage

Swanland's owner and master were aware that the weather and sea conditions were going to be poor during the vessel's passage to Cowes, and they had discussed the issue before the vessel sailed from Raynes Jetty. Although it is highly likely that the owner would have wanted the vessel to sail, there is no evidence to suggest that any pressure was exerted on the master during this conversation, particularly as on other occasions the vessel had either sheltered or delayed sailing due to heavy weather.

Although it is likely that the master's decision to sail and proceed as planned would have been influenced by commercial pressures to some degree, it is highly likely that the master had previously sailed in conditions similar to those forecast on many occasions without difficulty. Indeed, even after the weather and sea conditions deteriorated appreciably between 2000 and midnight, they did not appear to unduly concern *Swanland*'s master or crew.

Swanland was fully laden, which probably made her movement in the seas more comfortable than if the vessel had been in ballast. It is apparent from the master's instructions to the second officer on handing over the watch that his priority was to prevent the vessel rolling. Such preference was likely to be based on comfort rather than safety. It is unlikely that any consideration was given to *Swanland*'s age or to the potential effect of the head seas on the bending moments produced.

It should be noted that, during the passage, *Swanland*'s transit of the inshore traffic zone of the Off Skerries TSS and the absence of an additional lookout on the bridge during the hours of darkness contravened Rule 10 of the International Regulations for the Prevention of Collisions at Sea, as amended (COLREGS)[76] and the STCW[77] respectively.

However, it is not uncommon for vessels to contravene rule 10 when in the vicinity of the Off Skerries TSS and it is possible that the master opted to use the inshore traffic zone in order to avoid a beam sea.

2.11.2 Initial response

When the second officer saw the damage in way of *Swanland*'s midships section, his sounding of the general alarm was a prompt and appropriate action. The general alarm quickly alerted the master and most of the crew to the impending danger.

2.11.3 Distress message

When the master arrived on the bridge, his transmission of a 'Mayday' message via VHF radio channel 16 indicates that he had quickly recognised *Swanland*'s perilous situation and the need to request immediate assistance. However, as shown in **Table 2**, the initial VHF transmission only provided the vessel's name and position; key information such as the nature of the distress, the number of crew on board and the assistance required, which are included in the format recommended to be used, were not given. As a result, over the next 4 minutes the master's attention was frequently diverted from managing the emergency situation on board while he passed the missing information to the coastguard. This could have been avoided by the siting of a simple 'aid-mémoire' showing the correct 'Mayday' format next to the VHF radio.

[76] Rule 10(d) (i) states "A vessel shall not use an inshore traffic zone when she can safely use the appropriate traffic lane within the adjacent traffic separation scheme. However, vessels of less than 20 metres in length, sailing vessels and vessels engaged in fishing may use inshore traffic zones."

[77] It is implicit in STCW Section A-VIII/2 that an officer of the watch may not be the sole lookout on the bridge during the hours of darkness.

It is noteworthy that the master did not use the DSC to transmit a distress alert. Although the GMDSS system has been the intended primary means of commercial vessels sending distress messages for several years, it is apparent than many masters still prefer to use VHF radio. This is possibly due to the fact that many masters feel more comfortable using VHF radio and the confirmation that a ‘Mayday’ has been received is reassuring.

2.11.4 Manoeuvring

At the time of her structural failure, *Swanland* was heading almost directly into the oncoming seas. The resulting repeated hogging and sagging of the vessel’s hull would have quickly worsened the damage. Therefore, the master’s decision to reverse course to run down sea to stop the waves breaking over the bow and onto the cargo hatches was understandable. Reversing course would also have significantly reduced the vessel’s period of encounter with the waves and reduced the stresses on the vessel’s hull. Nonetheless, in view of the damage to the hull, it is unlikely that the vessel’s loss could have been delayed or prevented, regardless of the manoeuvring action taken.

When *Swanland* was under helm to port, **Figure 7** shows that between 0202 and 0206 the vessel’s starboard side was exposed to the oncoming waves. In such a situation, *Swanland* would probably have been rolling heavily and also shipping a significant amount of sea water over her decks and into the hold through the damaged structure. While an alteration to starboard might have provided the damage on the starboard side with some protection from the seas, water would still have been shipped into the hold.

It is also evident from **Figure 7** that *Swanland*’s movement from about 0206 was erratic, probably due to the ongoing activity on the bridge. The vessel passed through the ‘down sea’ heading, again presenting a beam aspect to the oncoming seas, and did not head in a north-easterly direction as intended until approximately 0209. By this time, the vessel’s SOG had reduced to 3.5 knots. Although the helm was reportedly put ’amidships’, *Swanland*’s heading appears to have been constantly altering to starboard during her final minutes. With the engine now probably having stopped or slowed, this movement was possibly due solely to the influence of the wind and the waves.

2.11.5 Muster and abandonment

The time taken from *Swanland*’s structural failure to her foundering was only about 17 minutes. As most of the crew were initially asleep in their cabins, this was a very short period of time to assess the damage, request assistance and to prepare for abandonment in a ship that was rolling heavily in very rough seas.

Seven of *Swanland*’s crew assembled on the bridge soon after the general alarm was sounded, but they soon returned to their cabins to collect warm clothing and valuables. Given that the immersion suits were stowed two decks below the bridge, that the crew were only dressed in night clothing, and that the master was occupied on the VHF radio and had not yet ordered the vessel’s abandonment, this action was understandable.

Nonetheless, the actions which followed appeared to be uncoordinated and lacked positive direction. In particular, as the crew were not formally mustered, the absence of the cook was not noticed and it is likely that he remained in his cabin throughout. In addition, the chief engineer was not seen again after returning to his cabin and the preparation of the liferafts for launching was prompted by the second officer.

Swanland's master's exchange with MRCC Holyhead **(Table 2)** and his collection of ship's documents from his own cabin indicate that he recognised the danger his vessel and crew faced. However, because the crew had not been properly mustered and an order to 'abandon ship' had not been given, the chances of the crew leaving the vessel in a controlled manner rapidly diminished. As a result, the crew who were assembled on the bridge wings were swept off their feet and submerged by a breaking wave as their vessel sank beneath them, with the master and the remaining crew trapped inside. The mustering of the crew is one of the primary purposes of an abandon ship drill, which *Swanland*'s crew had not regularly conducted.

It is generally accepted within the shipping industry that it is usually safer for a vessel's crew to remain on board during an onboard emergency; abandonment is a measure of last resort. However, it is clear from this accident that there are occasions where immediate preparations for abandonment and an early decision to abandon are pivotal to crew survival.

2.12 SURVIVAL

2.12.1 The survivors

As *Swanland* foundered, the second officer and the AB were able to surface and swim to the liferaft that had inflated nearby. The buoyancy provided by the Parkway immersion suits **(Figure 57)** worn by the men, was sufficient to keep them afloat, and the suits' thermal protection probably prevented them from suffering the effects of cold water shock. As a result, the second officer and the AB were able to swim to and climb into the liferaft in high seas and, although cold, they did not appear to become hypothermic.

Nonetheless, although the buoyancy and thermal protection provided by the immersion suits were essential to the second officer's and the AB's survival, the gloves fitted to the suits limited their digital dexterity and made it extremely difficult for the men to complete fundamental tasks such as activating the SART and releasing flares. Similar difficulties were reported by the crew from *MSC Napoli* following their abandonment in the English Channel on 18 January 2007[78].

The dexterity tests detailed in IMO Resolution MSC.81(70) and ISO 15027-2:2012 appear to be comprehensive, and the basic practical tests conducted by the MAIB on the Parkway and Autoflug suits largely confirmed that they complied with these standards. Therefore, the difficulties experienced by *Swanland*'s second officer and the AB in completing tasks that were fundamental to their safety and survival due to the design and construction of the gloves fitted to the Parkway Imperial immersion suit are of concern.

[78] http://www.maib.gov.uk/publications/investigation_reports/2008/msc_napoli.cfm

2.12.2 The chief officer

When the body of the chief officer was located, he was floating on his back. The Autoflug KS1 immersion suit **(Figure 57)** that he was wearing was fully zipped, but he had drowned. The Autoflug KS1 immersion suit was intended to be worn in conjunction with a lifejacket and, although the chief officer was seen to don an Aquavel Mk2/UK lifejacket **(Figure 58)** before *Swanland* foundered, he was not wearing it when he was found.

There is no way of determining what happened to the lifejacket the chief officer had donned, but it is feasible that he was unable to properly secure the lifejacket after he had put it on due to the male element of the securing buckle being missing or becoming detached. The construction of the webbing strap fitted to the Aquavel Mk 2/UK lifejacket does not prevent the male element of its securing buckle from easily sliding off the end of the strap. In addition, the male element of the securing buckle was missing from the only lifejacket from *Swanland* to be recovered **(Figure 58)**. Although it is impossible to determine whether this lifejacket was the lifejacket that had been worn by the chief officer, the absence of the male element of the securing buckle highlights the potential for it to be removed unintentionally, potentially rendering the lifejacket ineffective.

2.12.3 Immersion suit/lifejacket compatibility and performance requirements

Notwithstanding the MCA's concerns regarding the potential incompatibility between immersion suits and lifejackets, which were highlighted in MGN 396(M+F) **(Paragraph 1.37)**, the MAIB's wet trials on the Aquavel Mk2/UK worn in conjunction with the Autoflug KS1 immersion suit **(Paragraph 1.38)** indicated that the combination met the applicable performance requirements detailed in the LSA Code. In particular, the subject was able to turn from 'face-down' to 'face-up' within 5 seconds and the subject's mouth was kept over 120mm from the water.

However, it is noted that the performance requirements for immersion suits, including immersion suits worn in conjunction with lifejackets **(Paragraph1.36.3** and **Annex Y)**, are less onerous than the performance requirements for lifejackets alone with respect to self-righting **(Paragraph 1.36.4)**. Whereas a lifejacket must be able to right a subject within 5 seconds, no corresponding requirement exists for immersion suit/lifejacket combinations. Therefore, any person wearing an immersion suit, or an immersion suit with a lifejacket, who is unconscious and 'face-down' in the water **(Figure 59)** would possibly remain in that position and drown.

2.12.4 Standardisation of onboard equipment

Like many of Torbulk's other vessels *Swanland* had been provided with a mix of immersion suits from different manufacturers and of varying types **(Annex X)**. Notably, lifejackets needed to be worn in conjunction with five of the 14 suits carried. The extent to which this adversely affected the crew's chances of survival cannot be quantified. However, given the conditions on the night of *Swanland*'s loss and the apparent lack of recent abandon ship drills, the availability of the two types of suit was potentially confusing. This was perhaps demonstrated by the second officer having to point out to the chief officer that he needed to wear a lifejacket in conjunction with his Autoflug suit.

In common with other LSA, the performance requirements for immersion suits have been amended over the years and the design of the suits has improved considerably. Modern suits tend to be fitted with integral buoyancy and some have glove systems that provide improved dexterity (such as a five finger glove with a removable over-mitten).

However, it is unreasonable for shipowners to have to renew LSA to keep pace with these changes. An immersion suit or a lifejacket does not suddenly become unfit for purpose and the financial costs involved in the continual updating of this equipment would be significant. Even where an immersion suit is found to be defective and in need of replacement, it is inevitable that only the suit in question is replaced. The retention of older immersion suits of different makes and types, such as on board *Swanland* and Torbulk's other vessels, is therefore likely to be a common practice.

2.12.5 The need for a 'goal-based' approach

The survivors' difficulty in operating key safety equipment, the possible consequences of the loss of part of the securing buckle from the Aquavel Mk2/UK lifejacket, the potential confusion caused by the carriage of different types of immersion suits, and the differences in the performance requirements between lifejackets and immersion suits make a case for the adoption of a goal-based standard for life-saving appliances compelling.

Abandonment seldom occurs in benign conditions. All too often, as in this case, crews have to abandon their vessels in heavy weather and at night. In such circumstances, stress levels inevitably increase considerably, and on a rolling deck and in the dark, tasks which would normally be easily achieved, such as donning an immersion suit and manipulating objects through immersion suit gloves become far more difficult. It is therefore critical to crew survival that, wherever possible, the LSA provided is easy to use and it functions as expected.

It is clear from this accident that, in order to achieve these requirements, demonstrating compliance with SOLAS and the LSA Code alone is not always sufficient. MGN 396(M+F) highlights the need to ensure that the LSA system as a whole is fit for purpose. This means that all elements of the system, such as immersion suit gloves and SART activation cords, and lifejackets and immersion suits, should be compatible. Picking up a pencil is not equivalent to activating a SART, firing a flare, or releasing liferaft lashings. The real and the potential problems identified with the use of the LSA on board *Swanland* endorses the need for a more 'goal-based' approach towards the design, provision and assessment of LSA being taken by industry regulators shipowners and ships' managers alike.

2.13 SHIP MANAGEMENT

The application of a robust safety management system is vital to vessel safety. The number and severity of the deficiencies identified in Torbulk's safety management of its vessels during this investigation strongly indicates that the ship manager has still to develop a robust safety culture both on board its vessels and ashore.

In April 2009, following *Swanland*'s detention in Warrenpoint, LR considered it necessary to place Torbulk on an improvement programme which covered key areas such as ship visits, ISM training, the implementation and management of the defect reporting and, improved onboard application of the ISM Code. As *Swanland* was transferred to INSB shortly after the programme was agreed, it was never implemented. The subsequent DOC audits conducted by Cayman Islands and LR in August 2009, 2010 and 2011 continued to highlight defect reporting as a concern. Among other things, the failure of Torbulk-managed vessels to maintain an additional lookout at night was also identified.

There are a number of safety issues relating to *Swanland*'s operations identified during this investigation that need to be addressed. These include, but are not limited to: compliance with the IMSBC Code; the need to seek classification society approval to carry high density cargoes; the provision of appropriate loading information; the distribution of cargo; overloading (Load Line and tank top); defect reporting; guidance for masters operating in heavy weather; the conduct of emergency drills, and; bridge manning at night. In addition, in view of the apparent defects shown in **Figures 75a, 75b, 75c, 75d. 75e** and **75f**, the crew's assessment of the condition of the paintwork in the hold as satisfactory throughout 2011, was inaccurate.

Although the non-conformities identified during INSB's audit in February 2012 were subsequently accepted by INSB to have been addressed, the need to ensure that Torbulk's safety management of its vessels is monitored through thorough and robust auditing remains compelling.

2.14 CARGO SHIP SAFETY

The global losses of general cargo ships highlighted in **Paragraph 1.40** are extremely disturbing. The 248 losses between 2002 and 2011 for which foundering was attributed as the initial cause and which resulted in the death of over 800 seafarers are of particular cause for concern. It is frustrating that the majority of these losses appear not to have been properly investigated; indeed the most basic circumstances of many are unknown.

It is apparent that general cargo ships tend towards being entered in class and registered with lower performing societies and Flag States as they near the end of their service life. The reasons for this are mainly financial, although it is recognised that many of the better performing Flag States set age limits on the vessels accepted onto their registers. Older vessels are potentially more prone to fatigue, corrosion and other sources of structural failure; many years of safe operation are no guarantee of a vessel's structural condition.

Figure 65 shows that a significant number of the 248 foundered vessels were not entered in class with IACS members. Many were also over 25 years old. Therefore, the vessel parameters used in the IACS FSA conducted between 2007 and 2008 (classed with IACS member and not more than 25 years old) did not accurately represent the full scope of the problem. As a result, the FSA's conclusion that the risk associated with the operation of general cargo ships was 'tolerable' was potentially over-optimistic.

There is no justifiable reason why the safety record of general cargo vessels should be allowed to lag behind other vessel types, such as bulk carriers, without vigorous attempts being made to redress the balance. The ongoing work at the IMO to introduce the RO Code and to identify suitable RCOs such as improved stowage arrangements for bulk cargoes, and the implementation of an ESP to reduce the risk to general cargo ships, is a positive step in this respect and should be given a priority.

Concerns surrounding the safety and high loss rates of general cargo ships, such as *Swanland,* have been repeatedly raised at the IMO. However, progress to address the problems appears to have been slow. The factors and conclusions discussed above, including cargo loading, the carriage of bulk cargoes, non-compliance with the IMSBC Code, the effectiveness of survey and repair, maintenance, safety management, financial pressures and problems using LSA are sadly not new.

The wide-ranging safety issues identified during this investigation highlight the important roles to be played by many industry stakeholders including ship owners, ship managers, Flag States, port states, ROs, vessel crews and shippers in ensuring the safe operation of general cargo vessels. It is hoped that the loss of *Swanland* and her six crew members will be a catalyst for the work already underway at the IMO to tackle the global issue of general cargo ship safety. In this context, the extension of IMO's review of general cargo ship safety until 2014 is an opportunity not to be missed.

SECTION 3 – CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. The distribution of limestone cargo on board *Swanland*, which was loaded in two piles close to the centre of the single hold, was a major factor in causing large stresses in way of the vessel's midships area. [2.4.1]

2. The sagging bending moments caused by the distribution of the limestone cargo combined with the sea conditions induced sufficient compressive force to cause the upper part of *Swanland*'s structure to buckle. [2.4.2]

3. As the limestone cargo had not been loaded homogenously, the tank top plating in *Swanland*'s hold was theoretically overloaded. [2.4.3]

4. Many general cargo ships are potentially carrying solid bulk cargoes, including high density bulk cargoes, but are not complying with the requirements of the IMSBC Code and have not been approved to carry solid bulk cargoes by their Flag States or classification societies. [2.6.1]

5. The upper deck beams were key structural elements intended to prevent buckling of the main deck plating, which were not as susceptible to mechanical damage as those lining the sides of the hold. However, as the upper deck beams were relatively inaccessible, it is less likely that they would be closely inspected. [2.7.3]

6. An apparent lack of focus on the management and maintenance of *Swanland*'s structural integrity would have allowed her primary structure to degrade over time, leading to a critical reduction in longitudinal strength. [2.7.4]

7. No structural repairs had been undertaken since *Swanland*'s intermediate survey in 2009. Since then, it is estimated that the vessel's upper longitudinal strength was likely to have been weakened by corrosion and wastage by up to approximately 18%. [2.7.5]

8. The lack of maintenance and oversight of *Swanland* is likely to have been a major contributing factor to the vessel's structural failure. [2.7.5]

9. Following *Swanland*'s transfer from LR to INSB in May 2009, it is apparent that the conduct of the vessel's intermediate survey, and the subsequent annual surveys in 2010 and 2011 lacked rigour. [2.9.1]

10. It is apparent that, in some respects, the INSB survey regime applied to *Swanland* from 2009 onwards was not as rigorous as the equivalent survey regime adopted by IACS members. [2.9.2]

3.2 OTHER SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION ALSO LEADING TO RECOMMENDATIONS

1. *Swanland* was approximately 91.2 tonnes overloaded when she sailed from Llanddulas, probably because not all the WB in the DB tanks had been pumped out. [2.5.4]

2. The provision of documentation confirming the types and densities of solid bulk cargoes that vessels are authorised to carry would be beneficial. [2.6.4]

3. Given the high casualty rates associated with general cargo ships, it is considered that there is a strong argument to incorporate the survey planning requirements into their survey regime, similar to those required under an ESP for bulk carriers or by revising UR Z7.1. [2.9.2]

4. The ISM-related audits of Torbulk conducted by INSB were not as robust as the audits conducted by Flag States and other ROs between 2009 and 2011. [2.9.3]

5. The quality of the surveys and audits conducted by INSB in relation to *Swanland* strongly indicate that improvement is required in the training and performance of its surveyors if INSB is to conform to the detailed requirements of the forthcoming RO Code. [2.9.4]

6. *Swanland*'s crew were not properly mustered. It appears that *Swanland*'s crew did not regularly conduct abandon ship drills, and hence were not provided with regular opportunities to practise mustering. [2.11.5]

7. The number and severity of the deficiencies identified in Torbulk's safety management indicates that the ship manager has still to develop a robust safety culture both on board its vessels and ashore. [2.13]

3.3 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE BEEN ADDRESSED OR HAVE NOT RESULTED IN RECOMMENDATIONS

1. *Swanland* suffered a catastrophic structural failure in way of her midships area. The most likely mechanism for the failure was the buckling of a section of the vessel's structure on the upper part of her starboard side. [2.3]

2. Insufficient information was provided on board to enable *Swanland*'s crew to conduct longitudinal strength checks as part of the cargo loading process, despite this being a requirement in the vessel's onboard instructions. [2.5.1]

3. *Swan Diana*, which was also owned by Swanland Shipping and managed by Torbulk, also loaded limestone at Raynes Jetty in a similar non-homogenous distribution to *Swanland*. The vessel's hold tank top plating would therefore also have been theoretically overloaded. [2.5.5]

4. The loading information contained in *Swanland*'s stability book issued in 2003 lacked detail. It did not include tank top loading limits and no information was provided on the carriage of part or non-homogenously loaded cargoes. [2.6.2]

5. Neither *Swanland*'s master nor the chief officer had been informed of the density or the stowage factor of the limestone loaded at Raynes Jetty. [2.6.3]

6. Until 2009 *Swanland*'s repairs had been extensive and tended to be 'piecemeal' and reactive, generally focusing only on the immediate area of damage. Therefore, although the vessel's structure continued to meet the class requirements, it is possible that the vessel's original structural strength would have never have been regained. [2.7.3]

7. Many shipowners enter their vessels with non-IACS societies expecting that the surveys and audits conducted will be less robust. In effect, significant long term savings are possible through reduced cost of repairs and the rectification of deficiencies. [2.8]

8. A more holistic approach to *Swanland*'s structural integrity, such as that currently applied to bulk carriers under ESP, would have enabled appropriate plans for condition improvement to have been developed taking account of the vessel's overall strength, rather than just focusing on the localised area requiring immediate repair. [2.9.2]

9. Although *Swanland* was accepted onto the Cook Islands shipping register, the vessel did not meet some of the register's entry criteria. Stipulated control measures to ensure the vessel's material condition were also not implemented. [2.10.1]

10. MCI had not verified INSB's procedures or performance. Instead, it relied on an audit carried out by PMA in 2008 without ensuring that the non-conformities identified during that audit had been addressed. [2.10.2]

11. During *Swanland*'s final voyage, it is unlikely that any consideration was given to the vessel's age or to the potential effect of the head seas on the bending moments produced. [2.11.1]

12. As the 'Mayday' message transmitted by *Swanland*'s master lacked detail, the master's attention was distracted from managing the emergency situation on board while he passed the missing information to the coastguard. [2.11.3]

13. Although the GMDSS system has been the intended primary means of commercial vessels sending distress messages for several years, it is apparent than many masters still prefer to use VHF radio. [2.11.3]

14. Following the initial buckling, it is unlikely that the vessel's loss could have been delayed or prevented in the prevailing sea conditions. [2.11.4]

15. The limited digital dexterity afforded by the gloves fitted to the immersion suits worn by the survivors made it extremely difficult for the crew to complete fundamental tasks such as activating the SART and releasing flares. [2.12.1]

16. The construction of the webbing strap fitted to the Aquavel Mk 2/UK lifejacket does not prevent the male element of its securing buckle from easily sliding off the end of the webbing strap. The absence of the male element of the securing buckle from the only one of *Swanland*'s lifejackets to be recovered highlights the potential for the male element of the buckle to be removed unintentionally. [2.12.2]

17. The performance requirements for immersion suits, including immersion suits worn in conjunction with lifejackets, are less onerous than the performance requirements for lifejackets alone with respect to self-righting. [2.12.3]

18. *Swanland* had been provided with a mix of immersion suits from different manufacturers and of different types. The retention of older immersion suits of different makes and types is not ideal but is likely to be a common practice. [2.12.4]

19. It is critical to crew survival that, wherever possible, the LSA provided is easy to use and functions as expected. It is clear from this accident that, in order to achieve these requirements, demonstrating compliance with SOLAS and the LSA Code alone is not always sufficient. [2.12.5]

20. The IACS FSA conducted between 2007 did not accurately represent the full scope of the problem regarding general cargo ship safety. As a result, the FSA's conclusion that the risk associated with the operation of general cargo ships was 'tolerable' was potentially over-optimistic. [2.14]

21. There is no justifiable reason why the safety record of general cargo vessels should be allowed to lag behind other vessel types, such as bulk carriers, without vigorous attempts being made to redress the balance. [2.14]

SECTION 4 – ACTION TAKEN

4.1 MAIB

The **Marine Accident Investigation Branch** has:

- Issued a safety flyer **(Annex Z)** to the shipping industry to highlight the need for all vessels carrying solid bulk cargoes to comply with the requirements of the IMSBC Code. Attention is also drawn to key aspects of the IMSBC Code, particularly the need for vessels to be provided with sufficient loading guidance and cargo information, and for all cargoes to be loaded in accordance with best practice.

- Issued a safety flyer **(Annex AA)** to the shipping industry to promulgate the issues identified with the use of the LSA on board *Swanland* and to highlight the importance of ensuring that the LSA provided should be compatible and is fit for purpose.

Following its investigation into the grounding of *'Carrier'* on 3 April 2012[79] the MAIB recommended **CEMEX UK Materials Limited** to:

2013/117 Establish better control of maritime operations at Raynes Jetty by developing and implementing a safety management system, which incorporates logical elements of the Port Marine Safety Code, and:

- *Provides support to jetty staff when making effective operational decisions about berthing and loading ships safely.*

- *Delivers advice, or access to sources of advice, about maritime operations including weather forecasting, mooring arrangements and ship manoeuvring in the vicinity of the berth.*

4.2 ACTIONS TAKEN BY OTHER ORGANISATIONS

The **Cook Islands Flag Administration** has undertaken to:

Present the findings of this investigation to the International Maritime Organization (IMO) at the earliest opportunity to:

- Highlight the risks associated with general cargo ships carrying solid bulk cargoes, particularly high-density cargoes, and the need for owners, operators and crews to ensure that such cargoes are loaded and carried in accordance with the International Maritime Solid Bulk Cargoes Code (IMSBC Code) to ensure the structural integrity of the vessels is maintained at all times.

- Contribute to the current ongoing discussions at IMO regarding general cargo vessel safety with particular emphasis on the survey regime applied to general cargo vessels that routinely carry high-density cargoes.

[79] MAIB investigation report 8/2013

- Contribute to the discussions regarding goal-based standards for lifesaving appliances, including the:
    - standardisation of immersion suit types on board vessels;
    - compatibility of immersion suits with buoyancy aids;
    - dexterity afforded by immersion suit gloves.

The **Maritime Cook Islands (MCI)** has:

- Reviewed its vetting procedures and requirements for Flag State inspections for older ships, particularly those not in IACS Class prior to registration. All older ships are undergoing Flag State inspections at the time of registration and records of these inspections, including photographic records, are being kept. MCI has reviewed the implementation of Flag State inspections on its existing ships and has conducted more than a dozen such inspections in the last 2 months.

- Issued Circular 51/20/2013 on 13 February 2013 reminding all responsible for the operation of Cook Islands registered vessels of the requirements of STCW in respect of watchkeeping at sea – and in particular the need to maintain a proper lookout and to have a helmsman and a lookout on duty at night.

MCI has also undertaken to:

- Conduct an audit of INSB.

- Issue a circular on the need for general cargo ships that carry high-density cargoes to comply with the requirements of the IMSBC Code.

- Issue a circular on the importance of ensuring that life saving appliances provided should be compatible and fit for purpose and emphasises the need for regular drills that should include the donning of immersion suits.

- Establish a technical office in Europe that will draw on the expertise of a number of very well qualified and experienced naval architects, engineers, surveyors and auditors to improve its ability to meet its obligations as a Flag State in ensuring that its surveyors, ROs and vessels comply with all of the relevant IMO instruments. The technical office will be charged with, inter alia:

    - Auditing INSB and establishing procedures for the oversight of ROs.

    - Establishing a system for the appointment, training, control and review of Flag State surveyors and auditors.

    - Establishing and maintaining procedures for the implementation of annual Flag State inspections.

    - Casualty Investigations outside of the Cook Islands exclusive economic zone (EEZ).

The **Maritime and Coastguard Agency (MCA)** has:

Proposed that the Paris Memorandum of Understanding issues a circular informing inspecting authorities to pay particular attention to cargo ships' compliance with the IMSBC Code, particularly with respect to the provision of sufficient loading information, the density of the cargo carried and the cargo distribution.

Torbulk Limited has:

- Issued cargo booklets to all its vessels in accordance with the requirements of SOLAS Regulation 7.
- Taken steps to ensure that the immersion suits carried on board are of a common type (either with built-in buoyancy or requiring an additional lifejacket, but not both).
- Highlighted the need for crews to be familiar with the design and operation of all lifesaving appliances when wearing immersion suits and to report any defects or compatibility/suitability issues.
- Issued a memorandum to its vessels emphasising the requirement for an additional bridge lookout during the hours of darkness.

SECTION 5 – RECOMMENDATIONS

Torbulk Limited is recommended to:

2013/119 With respect to vessels managed by the company, take action to ensure that the limits of structural strength are not exceeded at any time for vessels carrying high density cargoes, with particular regards to:

- the distribution of the cargo across the tank top;
- the carriage of the cargo being in accordance with the requirements of the IMSBC Code;

2013/120 With respect to vessels managed by the company, take measures to ensure that:

- where applicable, classification society approval is gained prior to carrying high density cargoes;
- vessels do not sail in an overloaded condition;
- effective emergency drills are being conducted in accordance with the requirements of SOLAS and the company's SMM.

The International Naval Surveys Bureau (INSB) is recommended to:

2013/121 Review the conduct and auditing of structural surveys and inspections conducted on behalf of Flag States to ensure that the required standards are robustly applied. This review should take into account the experience, qualifications and training of the society's surveyors.

2013/122 Review the society's Rules and Regulations to ensure that its requirements for in-service general dry cargo vessels employed in the carriage of high density cargoes in bulk are aligned with the standards applied by IACS societies for this type of vessel.

2013/123 Ensure that future ISM audits of Torbulk and its vessels (where applicable) are thorough and robust and that the safety management deficiencies identified are properly addressed.

Lloyd's Register (LR) is recommended to:

2013/124 Propose to the International Association of Classification Societies (IACS) that it promulgates guidance to industry stakeholders highlighting:

- That the International Maritime Solid Bulk Cargoes Code (IMSBC Code) became mandatory for all vessels carrying solid bulk cargoes from January 2011.
- That the operators of all vessels carrying solid bulk cargoes must ensure that the cargoes are loaded and carried in accordance with the requirements of the IMSBC Code to maintain the structural integrity of the vessels at all times.
- The responsibility of cargo vessel operators to ensure that all cargoes are carried in accordance with the requirements of their classification society.

Marine Accident Investigation Branch
June 2013

Safety recommendations shall in no case create a presumption of blame or liability