ACCIDENT REPORT

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

Report on the investigation of the loss of the yacht *Cheeki Rafiki* and its four crew in the Atlantic Ocean, approximately 720 miles east-south-east of Nova Scotia, Canada on 16 May 2014

VERY SERIOUS MARINE CASUALTY REPORT NO 8/2015 APRIL 2015

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

Front cover image courtesy of United States Coast Guard

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CONTENTS

FIGURES

TABLES

ANNEXES

Annex A	-	Summary of timings and search areas covered by SAR assets during the first search period
Annex B	-	Summary of timings and search areas covered by SAR assets during the second search period
Annex C	-	Wolfson Unit report following its assessment of the keel structure of the Beneteau First 40.7 yacht *Cheeki Rafiki*
Annex D	-	Drawings of the Beneteau First 40.7 internal structure and keel attachment detail
Annex E	-	Extracts from Beneteau First 40.7 Owner's Manual
Annex F	-	Definition of 'pleasure vessel' from The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998
Annex G	-	Chapter 2 of the RCD Guidelines – Conformity Assessment
Annex H	-	*Cheeki Rafiki*'s Declaration of Conformity
Annex I	-	YDSA report on its 'Investigation into the feasibility of a Beneteau First 40.7 to be compliant to the MCA SCV Codes of Practice at area Category 0 level'
Annex J	-	MAIB Flyer to the Leisure Industry

GLOSSARY OF ABBREVIATIONS, ACRONYMS AND TERMS

ABS	-	American Bureau of Shipping
AIS	-	Automatic Identification System
BCU	-	British Canoe Union
BV	-	Bureau Veritas
C	-	Celsius
EPIRB	-	Emergency Position Indicating Radio Beacon
ETA	-	Estimated Time of Arrival
EU	-	European Union
F	-	Fahrenheit
ft	-	foot/feet
GEO	-	Geostationary Orbit
GMDSS	-	Global Maritime Distress and Safety System
GPS	-	Global Positioning System
Grib	-	Gridded Binary file
GRP	-	Glass Reinforced Plastic
gt	-	gross tonnage
IAMSAR	-	International Aeronautical and Maritime Search and Rescue
ICAO	-	International Civil Aviation Organization
ICNN	-	Institute for Certification and Normalisation in Nautical Field
IMO	-	International Maritime Organization
ISAF	-	International Sailing Federation
ISO	-	International Organization for Standardization
km	-	kilometre
LEO	-	Low Earth Orbit
m	-	metre
MCA	-	Maritime and Coastguard Agency

MGN	-	Marine Guidance Note
MHz	-	Megahertz
mm	-	millimetre
MRCC	-	Maritime Rescue Co-ordination Centre
N	-	Newton
nm	-	nautical mile
nm^2	-	square nautical mile
OSR	-	Offshore Special Regulations
PFD	-	Personal Flotation Device
PLB	-	Personal Locator Beacon
POC	-	Probability of containment
POD	-	Probability of detection
POS	-	Probability of success
RCC	-	Rescue Co-ordination Centre
RCD	-	Recreational Craft Directive
RPM	-	revolutions per minute
RYA	-	Royal Yachting Association
SAR	-	Search and Rescue
SCV	-	Small Commercial Vessel (Code) – MGN 280
SMC	-	Search and Rescue Mission Co-ordinator
UIM	-	Union Internationale Motonautique
UK	-	United Kingdom
UKHO	-	United Kingdom Hydrographic Office
US	-	United States
USCG	-	United States Coast Guard
USCGC	-	United States Coast Guard Cutter
USS	-	United States Ship
UTC	-	Universal Co-ordinated Time
VHF	-	Very High Frequency
YDSA	-	Yacht Designers and Surveyors Association Ltd

Terms

ARC	-	Atlantic Rally for Cruisers. Rally held annually, organised by the World Cruising Club, between Gran Canaria and St Lucia
Bay	-	A space surrounded by frames and longitudinals forming part of a hull's structure
Grib file	-	a concise data format commonly used in meteorology to store historical and forecast weather data
Intern	-	a trainee who, after paying a joining fee, performs a range of work-related tasks in exchange for receiving free training and experience
Matrix	-	(sometimes called 'liner') a lining on the inner surface of a hull's structure
Traveller	-	a device that allows for changing the position where the main sheet tackle connects to the vessel
Ugrib	-	software used to display Grib files (wind speed and direction, pressure and rainfall only)
Washer plate	-	(sometimes called 'backing plate') a plate to keep nuts secure
YB Tracking	-	yacht tracking system which utilises the Iridium satellite network
zyGrib	-	software used to display Grib files (provides additional data to Ugrib, such as wave height)

Times: all times used in this report are UTC unless otherwise stated

Photograph courtesy of Tim Wright / www.photoaction.com

Cheeki Rafiki

SYNOPSIS

At about 0400 on 16 May 2014 the UK registered yacht *Cheeki Rafiki* capsized approximately 720 miles east-south-east of Nova Scotia, Canada while on passage from Antigua to Southampton, UK. Despite an extensive search that found the upturned hull of the yacht, the four crew remain missing.

At approximately 0405 on 16 May an alert transmitted by the personal locator beacon of *Cheeki Rafiki*'s skipper triggered a major search for the yacht involving United States Coast Guard fixed-wing aircraft and surface vessels. At 1400 on 17 May, the upturned hull of a small boat was located; however, adverse weather conditions prevented a closer inspection and the search was terminated at 0940 on 18 May.

At 1135 on 20 May, following a formal request from the UK government, a second search was started. At 1535 on 23 May, the upturned hull of a yacht was located and identified as being that of *Cheeki Rafiki*. On investigation, it was confirmed that the vessel's liferaft was still on board in its usual stowage position. With no persons having been found, the second search was terminated at 0200 on 24 May. *Cheeki Rafiki*'s hull was not recovered and is assumed to have sunk.

In the absence of survivors and material evidence, the causes of the accident remain a matter of some speculation. However, it is concluded that *Cheeki Rafiki* capsized and inverted following a detachment of its keel. In the absence of any apparent damage to the hull or rudder other than that directly associated with keel detachment, it is unlikely that the vessel had struck a submerged object. Instead, a combined effect of previous groundings and subsequent repairs to its keel and matrix had possibly weakened the vessel's structure where the keel was attached to the hull. It is also possible that one or more keel bolts had deteriorated. A consequential loss of strength may have allowed movement of the keel, which would have been exacerbated by increased transverse loading through sailing in worsening sea conditions.

The yacht's operator, Stormforce Coaching Ltd, has made changes to its internal policies and has taken a number of actions aimed at preventing a recurrence. The Maritime and Coastguard Agency has undertaken to work with the Royal Yachting Association to clarify the requirements for the stowage of inflatable liferafts on coded vessels, and the Royal Yachting Association has drafted enhancements to its Sea Survival Handbook relating to the possibility of a keel failure.

A recommendation has been made to the British Marine Federation to co-operate with certifying authorities, manufacturers and repairers with the aim of developing best practice industry-wide guidance on the inspection and repair of yachts where a glass reinforced plastic matrix and hull have been bonded together. A recommendation has also been made to the Maritime and Coastguard Agency to provide more explicit guidance about circumstances under which commercial certification for small vessels is required, and when it is not. Further recommendations have been made to sport governing bodies with regard to issuing operational guidance to both the commercial and pleasure sectors of the yachting community aimed at raising awareness of the potential damage caused by any grounding, and the factors to be taken into consideration when planning ocean passages.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *CHEEKI RAFIKI* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Cheeki Rafiki*
Port of Registry	Shoreham
Flag	United Kingdom
Type	Beneteau First 40.7 – Bermudan Sloop
Designer	Farr Yacht Design Ltd
Builder	Chantiers Beneteau SA
Year of build	2006
Construction	GRP
Hull Identification Number	FR-BEY82689K607
Keel type/construction	Deep fin cast lead keel
Length overall	11.92m
Gross tonnage	15.54 (estimated)
Minimum safe manning	Not applicable
Registered owner	Fast Sailing Ltd
Manager	Stormforce Coaching Ltd
Authorised cargo	Not applicable
VOYAGE PARTICULARS	
Port of departure	English Harbour, Antigua
Port of arrival	Southampton, UK (intended)
Type of voyage	International
Cargo information	None
Manning	4
MARINE CASUALTY INFORMATION	
Date and time	16 May 2014 at approximately 0400
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	Approximately 720 miles east-south-east of Nova Scotia, Canada
Place on board	Unspecified
Injuries/fatalities	4 assumed fatalities
Damage/environmental impact	Vessel lost
Ship operation	On passage
Voyage segment	Mid-water
External & internal environment	Wind northerly 28 knots, significant wave height 4.7m
Persons on board	4

1.2 BACKGROUND

Cheeki Rafiki was manufactured in November 2006 by Chantiers Beneteau SA (hereafter referred to as 'Beneteau') at its Saint Hilaire De Riez facility in France. It was delivered to its owner, Fast Sailing Ltd, by Beneteau's UK sales representative in December 2006.

Cheeki Rafiki was initially commercially managed by Island Charters for skippered, race-only charters, operating primarily around the UK coast between spring and autumn. The yacht spent winters in Brighton/Shoreham where it underwent annual maintenance.

In 2011, the vessel's commercial management was changed to Stormforce Coaching Ltd (hereafter referred to as 'Stormforce Coaching'). In addition to a similar summer programme of skippered, race-only charters, *Cheeki Rafiki* was entered for the ARC trans-Atlantic Ocean races in 2011 and 2013, spending winters in the Caribbean Sea during 2011/12 and 2013/14.

Following the ARC trans-Atlantic Ocean race in December 2013, *Cheeki Rafiki* participated in the Round Barbados, Caribbean 600 and Antigua Sailing Week race events. Additionally, *Cheeki Rafiki* was used by its owner for a holiday in January 2014, and by Stormforce Coaching's principal/director for a holiday in April 2014.

On completion of Antigua Sailing Week, scheduled to run from Sunday, 27 April to Friday, 2 May 2014, Stormforce Coaching intended that *Cheeki Rafiki* would be sailed back to its base port of Southampton.

The principal/director of Stormforce Coaching had previously selected Andrew Bridge (a former intern and regular skipper at Stormforce Coaching) to be skipper, James Male (a current intern hereafter referred to as the 'mate'), and two other crew members for the trans-Atlantic Ocean crossing. The latter two crew members subsequently withdrew. Following an internet advertisement, Paul Goslin and Stephen Warren agreed to act as crew. The terms of this agreement were that they would each contribute to the cost of food and water for the voyage. They had previously planned to crew another yacht for a similar crossing; however, the voyage had been cancelled due to a defect on the vessel concerned.

1.3 NARRATIVE

1.3.1 Antigua Sailing Week

The principal/director of Stormforce Coaching skippered *Cheeki Rafiki* for Antigua Sailing Week, with Andrew Bridge as mate and James Male as one of the professional crew. Among those on board were four passengers who had paid for the opportunity to crew *Cheeki Rafiki* during Antigua Sailing Week.

Prior to the first race, Stormforce Coaching's principal/director and some of *Cheeki Rafiki*'s crew dived under the vessel to clean marine growth off the vessel's hull in preparation for racing. At the same time observations were made of the keel/hull interface, keel, sail drive, rudder and hull apertures, with no visible defects detected. On Wednesday of Antigua Sailing Week, the vessel's hull was cleaned again. At this time, a similar check was reported to have been made of the keel and apertures, again with no visible defects noted.

On Thursday, Paul Goslin and Stephen Warren arrived in Antigua, and joined the vessel on Friday for the last races of the series. *Cheeki Rafiki* and its crew won Antigua Sailing Week's Beneteau First 40.7 class. The vessel reportedly sailed very well during the week, with no reported defects or water ingress to the hull.

1.3.2 The voyage from Antigua

On completion of Antigua Sailing Week, Andrew Bridge took over as *Cheeki Rafiki*'s skipper. Andrew Bridge and the principal/director discussed routing and watches for the forthcoming trans-Atlantic Ocean crossing. During this discussion they decided to attempt the crossing without stops; however, it was agreed the vessel would divert to the Azores for additional spares or supplies if required. They also agreed that communications were to be limited to email, unless otherwise necessary.

Cheeki Rafiki was refuelled and stored for the anticipated 30-day passage, and then sailed from Antigua on 4 May.

When weather information or weather routing information was requested by the skipper, the principal/director responded on the basis of weather information available to him on the internet.

A summary of email and voice communications between *Cheeki Rafiki*'s skipper and the Stormforce Coaching's principal/director, including relevant extracts from their content, follows:

Monday 5 May 2014

0834 – email, from *Cheeki Rafiki*

> *'our position at 0800 ut is 19 00.025N 061 28.932W. Got into a light patch. we now have a 5th crew member a bird has been sat on the coachroof most of the night. any weather routing info from you would be great as you can see the bigger picture. can you get…to send instructions on changing the email to mailasail.'* [sic]

1715 – email, from Stormforce Coaching

> *'You need to get some east and north in for the next 2 days, there is a band of SE4 coming in Tuesday afternoon to the east of you, it fairly quickly settles to E4 (force 4), I think for the moment head NE until you hit it then head NNE or even close to North, there is then moderate breeze (E4) across the area you will be sailing into for a couple of days. In the mean time suffer the pain of the light stuff*
>
> *I have requested the mailasail password but so far no reply…will provide all details once i have the password.'* [sic]

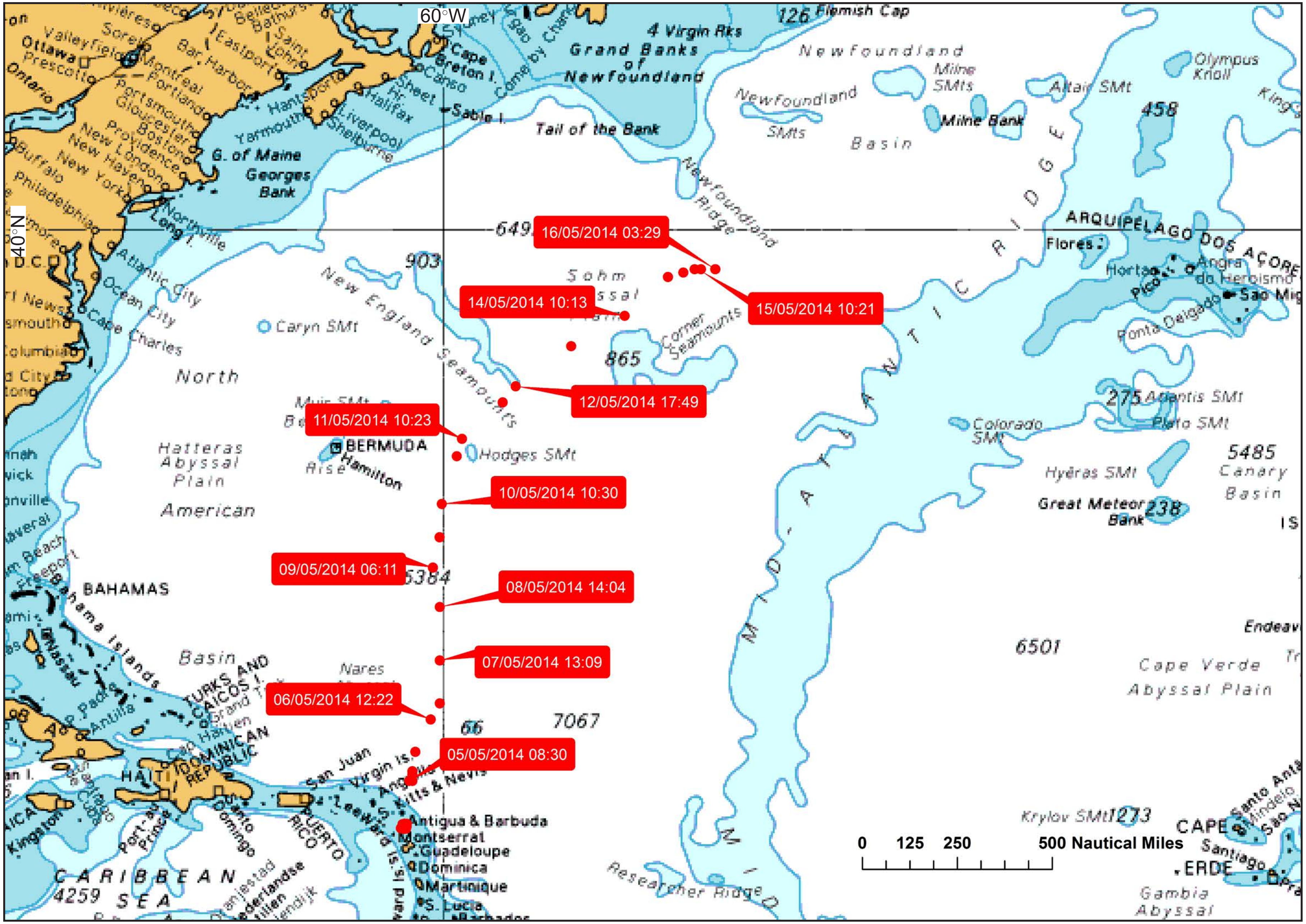

Figure 1: Chart showing *Cheeki Rafiki*'s positional data obtained from its Iridium satellite telephone records

Tuesday 6 May 2014

1224 – email, from *Cheeki Rafiki*

> *‘position at 1200ut is 21 27N 060 39W wind has been light and shite heading north. motored all of last night so we are now able to sail. we have a range of 900-1000 miles under engine if wind keeps dying Azores looks highly likely. any weather info from you would be great.’* [sic]

1359 – email, from Stormforce Coaching

> *‘Go North, Do not pass go, go north, do not collect £200, Go North.’*

2045 – email, from *Cheeki Rafiki*

> *‘Heading north. The gribs i got from UGrib look very light and shite to the north. we currently have sub 5 kts from behind so have the donkey on. looks like a day and a half with donkey 25% of our fuel gets us into decent breeze for a bit then a short blast to get through the next light patch.’* [sic]

Wednesday 7 May 2014

1015 – email, from Stormforce Coaching

> *‘Its all light today and tomorrow. It is worth cracking donk on*[1] *for Bermuda and then re fuelling there?’* [sic]

Thursday 8 May 2014

1406 – email, from *Cheeki Rafiki*

> *‘we are sailing upwind atm*[2] *1200ut position was 25 55’N 060 09’W. i cant see a chart for Bermuda so don’t rely want to go there. tank level is reading 3/4’* [sic]

1623 – email, from Stormforce Coaching

> *‘Im told alternative email is not an option ukless you have installation disc’* [sic]

Friday 9 May 2014

0652 – email, from Stormforce Coaching

> *‘You can dial/SMS…from your handset in order to check your current balance. Let me know the outcome.’*

Saturday 10 May 2014

1032 – email, from *Cheeki Rafiki*

> *‘position at 1000ut 30 05’N 060 08’W. Had some good sailing yesterday but had the engine on last night at 1600-1800rpm to give us some good apparent wind now sailing again…The Traveler is not fully attached to the boat (one of the rods*

[1] Cracking donk on, colloquial phrase for ‘running the engine’

[2] Assumed to mean ‘at the moment’

that ties it to the cockpit has sheered) its lashed down and as long as we keep it to the bottom of the track in strong winds when sailing on stbrd there shouldn't be a problem. We have 19 miniutes on the sat phone.' [sic]

Monday 12 May 2014

1210 – email, from Stormforce Coaching

'Ive topped you up with airtime, so you should be on 116 minutes now. delete my text if replying to emails. Progress looks good. lightish winds to wednesday worth starting to get a bit of East in now, perhaps steer NE, from then on you will be heading E and probably close hauled port tack with breeze' [sic]

1750 – email, from *Cheeki Rafiki*

'Cheeki Rafiki Blog Update. It has been 9 days at sea and we are all fairing well, the winds have been gentle whilst routing up northwards to the Eastern side of Bermuda. And yesterday we did it…we turned East for home and completing our first 1000 miles…We have had one stormy morning so far with beating rain and a force 5 wind which lasted a few hours, but we are still enjoying plenty of sunshine and warm temperatures…position update 34 24'N 056' 55W 1700 UT 12.05.14' [sic]

Wednesday 14 May 2014

1014 – email, from *Cheeki Rafiki*

'position update at 1000ut 37 00N 052 05W 24hour run 176miles…just hit a big wave hard and it fixed the stereo.' [sic]

Thursday 15 May 2014

2022 – email, from *Cheeki Rafiki*

'we have been taking on a lot of water yesterday and today. today seems worse i think stbd water tank has split so that is drained checked hull and sea cocks for damage but cant see any. i will go for a swim when weather improves in about 24 hours we are currently monitoring the situation horta is 900 miles away. our position is 38 38N 048 59W any thoughts from your end i will check emails in 2 hours' [sic]

No further data connections were made on board *Cheeki Rafiki* and so no further emails were received by the vessel.

2046 – email, from Stormforce Coaching (not received by *Cheeki Rafiki*)

'Is any water fresh or salty? That will tell u most if what u need to know' [sic]

2048 – email, from Stormforce Coaching (not received by *Cheeki Rafiki*)

'Loosen straps for liferaft. Check epirb and sat phone are accessible etc. Have everything ready in case of worst case' [sic]

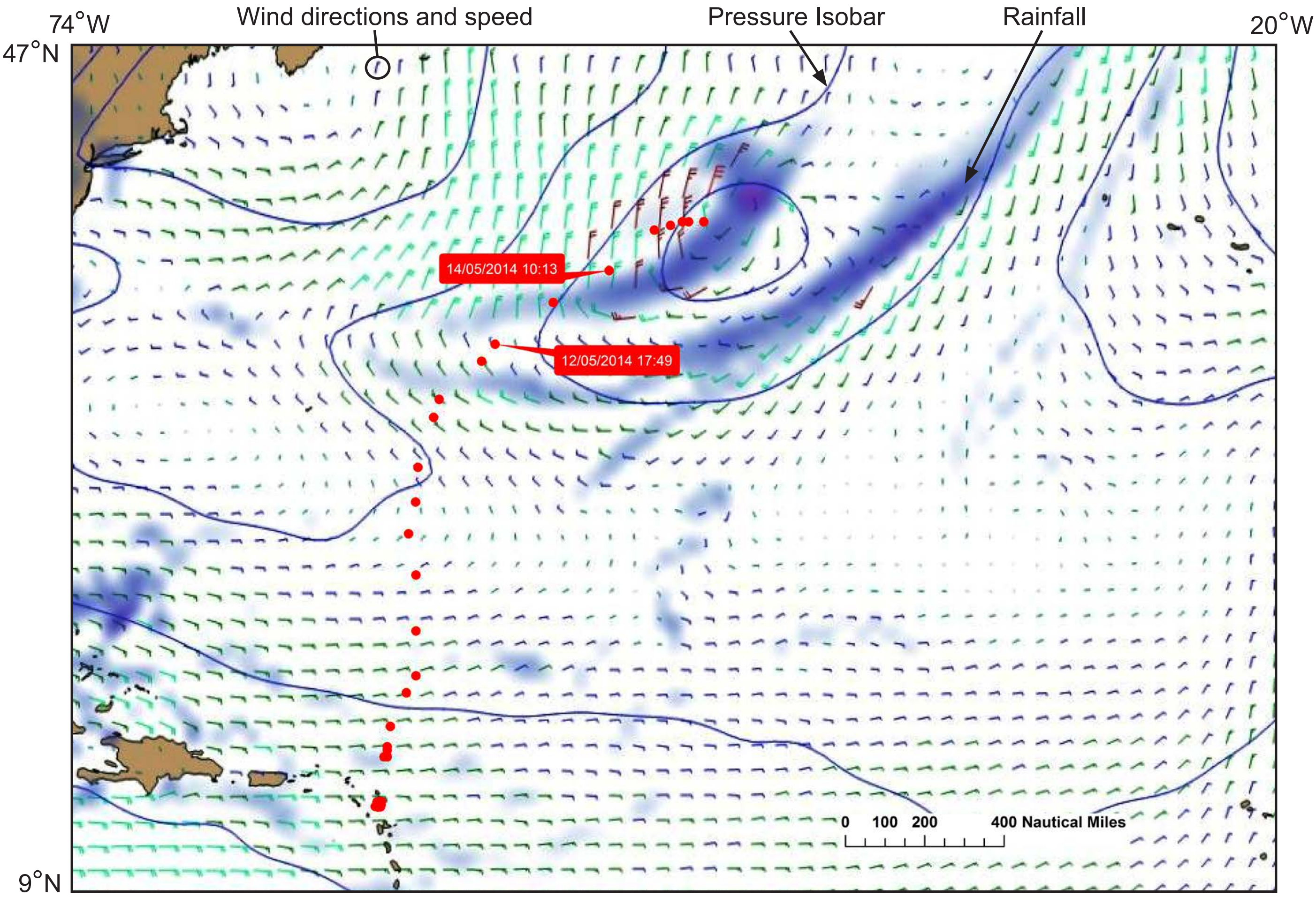

Figure 2: Ugrib forecast conditions for 0900 14 May 2014, as predicted at 0600 on 12 May 2014

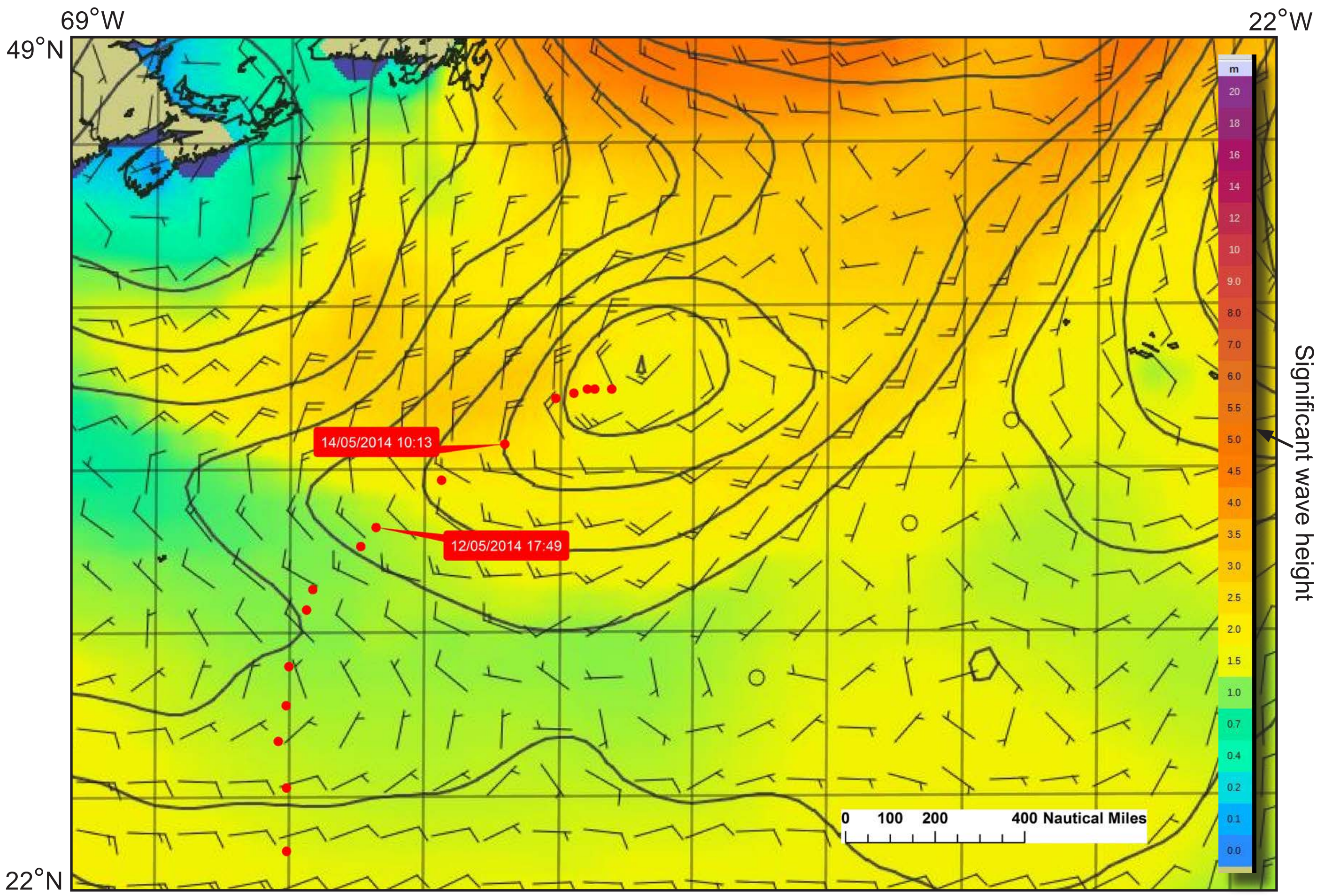

Figure 3: zyGrib forecast conditions for 0900 14 May 2014, as predicted on 12 May 2014

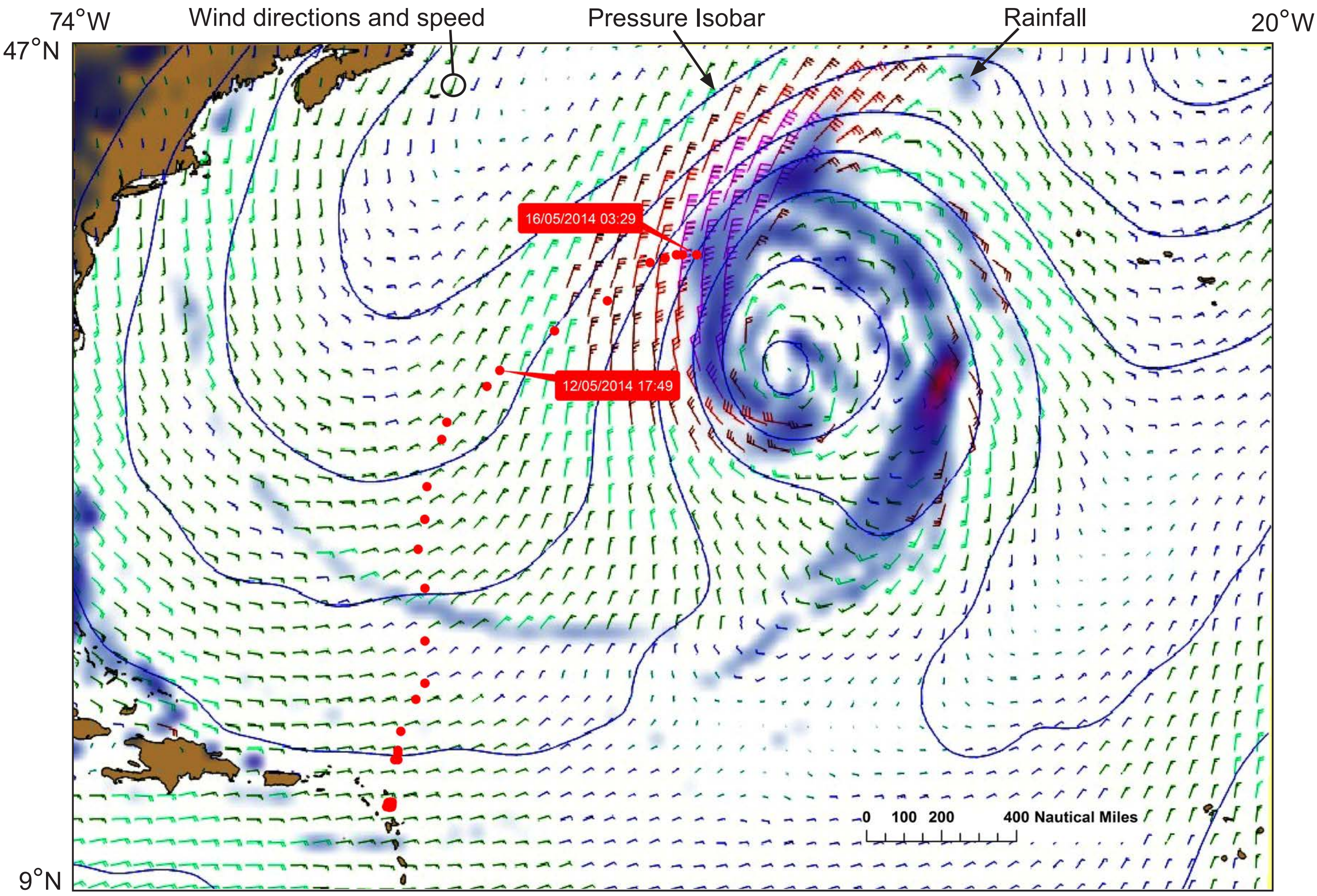

Figure 4: Ugrib forecast conditions for 0300 16 May 2014, as predicted at 0600 on 12 May 2014

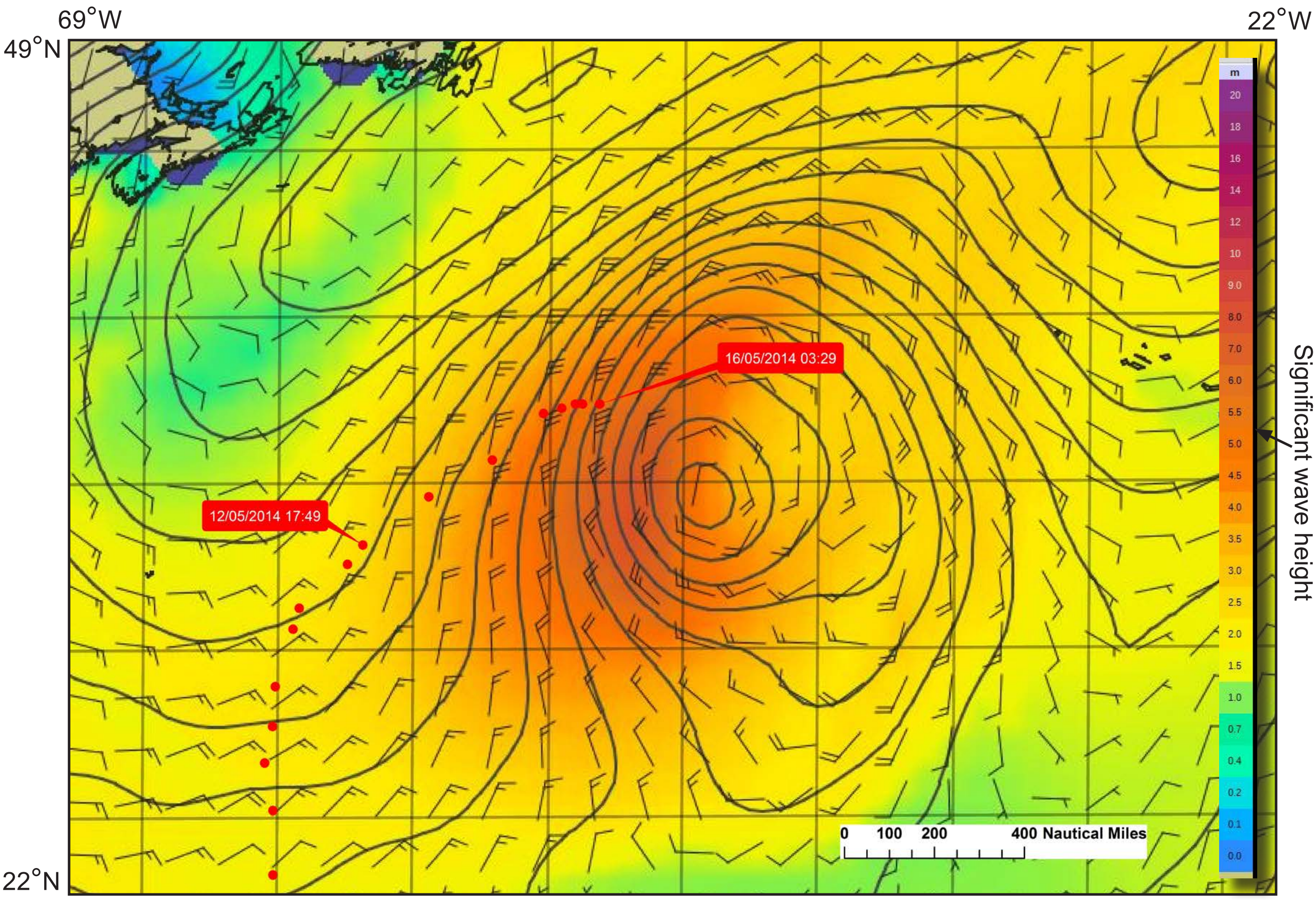

Figure 5: zyGrib forecast conditions for 0300 16 May 2014, as predicted on 12 May 2014

2221 – 55 seconds' duration satellite telephone voice call from *Cheeki Rafiki*'s skipper to Stormforce Coaching's principal/director and 2 minutes 46 seconds' duration return call on a different mobile telephone owing to low battery power.

The skipper described the situation (ie water ingress) as worse than before and that the water had been identified as sea water, the engine bilge had been found to be dry and that the leak could not be found.

2230 – email, from Stormforce Coaching (not received by *Cheeki Rafiki*)

> *'I need your position'*

2233 – attempted satellite telephone voice call from Stormforce Coaching's principal/director to *Cheeki Rafiki* (redirected to voicemail)

2246 – telephone call from Stormforce Coaching's principal/director to Maritime Rescue Co-ordination Centre (MRCC) Falmouth advised that *Cheeki Rafiki* was taking on water and that the pumps were coping with the ingress; the vessel's 2022 position was also given.

2332 – email, from Stormforce Coaching (not received by *Cheeki Rafiki*)

> *'I have spoken with Falmouth Coastguard who will in turn talk to the Yanks as you are within their SAR region.*
>
> *They have you sat phone number, email etc.*
>
> *Interns of the leak you need to focus on 3 things. Finding the leak, reducing the rate of ingress and getting rid of water on board.*
>
> *The leak*
>
> *Most likely place is the cooling system of the engine, you need to rip open all of the boards etc in the aft of the boat and meticulously follow the water supply from the sea cock in through the engine to the exhaust out and see if there is a small leak, nick in a pipe etc.*
>
> *Next port of call is each and every sea cock. Any you don't need simply close as it helps rule things out.*
>
> *Check the bilge pump piping to make sure you are not simply pumping the same water around the boat.*
>
> *Assuming all sea water circuits appear ok then its onto other skin fittings*
>
> *Log and depth transducers*
>
> *Steering post/rudder*
>
> *Sail drive leg*
>
> *If you can get the boat empty enough it may become easier to establish where the ingress is.*

IN terms of emptying you have the shower drain, which you can use as a second bilge pump, you will need to connect either the fridge out or shower drain out pipe into the bilge.

Meanwhile keep an ear open for your main bilge pump, it must not be allowed to block up and run dry at any time.

If you get really desperate you can close the engine water intake and stick the engine water intake hose into the bilge so the engine is pumping bilge water rather than sea water. Obviously this requires some care as the engine can not be allowed to run dry.

It would be useful to know what sort of weather you are experiencing and if there is an possibility you have hit anything at any stage. Don't be shy about pulling the interior apart to get to the interior of the hull where you can. Is the problem only there on one tack (i.e. is it above/below the waterline on a particular tack)?

Worth having a look at the keel bolts and make sure there is no cracking around them.

I would like to set up a 4 hour comms interval. Where you call me every 4 hours and confirm all OK or otherwise. I will leave you to make the first call to my mobile tonight on...After that will go for 4 hour intervals until you tell me problem is solved. I have my mobile with me and will keep it free.

FYI Falmouth Coastguard is on 0044 1326 317575, although I think this number is saved on the sat phone. Please save these numbers now if they are not already there.

Needless to say make sure everyone is wearing a LJ at all time, make sure the life raft and grab bag/water are ready and make sure if things get worse the EPIRB and sat phone are to hand and the sat phone is charged.

You are currently in a USA Search and Rescue area but out of range of aircraft. If you had to abandon then merchant vessels would be requested to divert to you.

Please keep us updated of you position, weather you are experiencing, ETA Azores, fuel reserves and the state of water ingress?' [sic]

2349 – attempted satellite telephone voice call from MRCC Falmouth to *Cheeki Rafiki* (redirected to voicemail)

Friday 16 May 2014

0330 – 1 minute 42 seconds' duration satellite telephone voice call from *Cheeki Rafiki*'s skipper to Stormforce Coaching's principal/director

Stormforce Coaching's principal/director had difficulty understanding what *Cheeki Rafiki*'s skipper was saying, but he understood the skipper to be saying, "this is getting worse". The principal/director told the skipper to check his emails, which he acknowledged.

Cheeki Rafiki's approximate position at this time was 38º 37.0N 048º 06.7W. Thereafter, the satellite telephone was no longer connected to the satellite and no further signal was received from it.

1.3.3 Search and rescue

<u>Initial search and rescue effort</u>

After MRCC Falmouth received the principal/director's call at 2246 on 15 May 2014, it identified that *Cheeki Rafiki*'s 2022 position placed the vessel in the United States Coast Guard (USCG) Boston Search and Rescue Region. It therefore notified the Rescue Coordination Centre (RCC) Boston. It was agreed that while the flooding remained under control MRCC Falmouth would retain the role of Search and Rescue Mission Co-ordinator (SMC).

At 0410 on 16 May 2014, following an initial personal locator beacon (PLB) alert at 0405, RCC Boston received a PLB alert with positional data that was confirmed by MRCC Falmouth to be from the skipper's PLB. At 0415, RCC Boston sent an email to *Cheeki Rafiki* and MRCC Falmouth, stating:

> *'…We received 406 alert from your vessel. Please provide updates…'*

At 0432, having accessed *Cheeki Rafiki*'s email account, Stormforce Coaching's principal/director sent an email to RCC Boston, copied to MRCC Falmouth, stating:

> *'I am shore side contact for this vessel, and have picked up your email. The yacht as yet has not.*
>
> *The skipper…, called my mobile at 0329 UTC, we did not have a very good line, he said "this is getting worse." I asked if he had read an email from the night before, he said "No, i have not seen email for some time, i will download email and call you back" As of now 0428 UTC they have not downloaded your or my email to them. I will keep you informed if I hear from them again, likewise if they call again I will endeavour to get some more information from them…'* [sic]

RCC Boston then assumed the role of SMC from MRCC Falmouth and began to identify vessels that were in the vicinity of *Cheeki Rafiki*'s last known position and which could render assistance. Concurrently, it requested the launch of an HC-130 Long Range Surveillance Aircraft from its USCG Air Station Elizabeth City. The HC-130 aircraft launched with an Estimated Time of Arrival (ETA) on scene of 1030.

At 0633, following an initial alert at 0629, a second PLB alert with positional data was received by RCC Boston. The alert was from the mate's PLB and was received about 8 minutes before the final satellite-detected position received from the skipper's PLB. The mate's PLB position resolved at 0713 as approximately 0.5 mile from the last satellite-detected position received from the skipper's PLB.

At 1100, the HC-130 aircraft arrived on scene and commenced a search based on three drift calculations for: a swamped 39 foot (11.9m) sailing vessel, a liferaft and a person in the water. During the search, the aircraft's crew identified some small debris, including what was possibly a small white lifebuoy, a boat fender, pieces of shiny white wood and other miscellaneous items.

The search effort continued utilising HC-130 aircraft from the USCG, the US Air Force, and the Royal Canadian Air Force, and three merchant vessels. It initially concentrated around the PLB alert locations, and is summarised in **Annex A**.

At about 1400 on 17 May 2014, the container ship *Maersk Kure* located the upturned hull of a small boat, which was believed to be *Cheeki Rafiki*. Adverse weather conditions prevented launching the ship's lifeboat or rescue boat **(Figure 6)** to carry out a closer inspection.

Figure 6: Photograph showing the upturned hull of a small boat alongside the container vessel *Maersk Kure* taken on 17 May 2014 at about 1400

At 0940 on 18 May 2014, the search effort was terminated.

RCC Boston calculated the estimated survivability of the crew members based on their average descriptions, assuming that they were dressed in full foul weather sailing gear, immersed to the neck in water and wearing a personal flotation device (PFD). Using these criteria, the estimated functional[3] survivability and survival times[4] were 12.3 hours and 15.5 hours respectively.

Using similar parameters but assuming that the crew members had been submerged to the waist in water, sitting in a liferaft in heavy weather, produced estimated functional survivability and survival times of 14 hours and 21 hours respectively.

RCC Boston also calculated the probability of success (POS) of finding the following objects based on the probability of containment (POC) for the areas searched, and the probability of detection (POD) from searching those areas:

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[3] Functional survivability time: the time elapsed after initial exposure when a body's core temperature decreases to the end of mild hypothermia at 34ºC

[4] Survival time: the time elapsed after initial exposure when a body's core temperature decreases to the end of moderate hypothermia at 28ºC

- POS for a person in the water with a PFD: 6%
- POS for a swamped/capsized boat: 95%
- POS for an upright liferaft: 82%
- POS for a capsized liferaft: 92%

Second search and rescue effort

At 1135 on 20 May 2014, the search effort resumed following a formal request from the UK government. The second effort was again co-ordinated by RCC Boston, and the first search and rescue (SAR) assets began to arrive later that day. During this period, aircraft from the USCG, US Air Force, Royal Canadian Air Force and UK Royal Air Force, nine merchant vessels, United States Coast Guard Cutter (USCGC) *Vigorous*, United States Ship (USS) *Oscar Austin* and numerous additional yachts took part in the search. The search effort during the second search period is summarised in **Annex B**.

At 1553 on 23 May 2014, USS *Oscar Austin*'s embarked helicopter located an upturned yacht's hull. The vessel launched a small boat with a surface swimmer, who positively identified the hull as being that of *Cheeki Rafiki* **(Figure 7)** and confirmed that its liferaft was still on board in its usual stowage position.

At 0200 on 24 May 2014, the SAR effort was terminated.

Image courtesy of United States Coast Guard

Figure 7: Photograph of Cheeki Rafiki's upturned hull being inspected by the US Navy

1.4 PERSONAL LOCATOR BEACON ACTIVATIONS

1.4.1 General

When activated, PLBs and emergency position indicating radio beacons (EPIRBs) transmit a signal on 406MHz and 121.5MHz. The 406MHz signal can be received by international search and rescue satellites, either in low earth orbit (LEO) or geostationary orbit (GEO). Each EPIRB or PLB transmits a unique identification number that links it with its registration data. The 121.5MHz transmission is an anonymous audible tone that is used by SAR assets in the vicinity to home in on the device.

The position of the PLB or EPIRB can be derived by the LEO satellites using the Doppler effect as they pass over the beacon. To obtain a refined position, several passes of LEO satellites are required. If the PLB or EPIRB is fitted with its own global positioning system (GPS) transmitter, its position can be included in the alert message received by either an LEO or GEO satellite.

1.4.2 Transmission from crew's PLBs

The skipper had with him a Kannard Safelink Solo PLB, which had been registered with the Maritime and Coastguard Agency (MCA) in November 2013 **(Figure 8)**. The mate had with him a McMurdo Fastfind 220 PLB **(Figure 8)**, which had been registered with the MCA in April 2014. Both PLBs were waterproof and were provided with a buoyancy pouch and lanyard to prevent their loss when in water. They were both fitted with an integral global positioning system (GPS) transmitter capable of transmitting for a minimum of 24 hours once activated. Both units were manually operated and had to be held clear of the water with their antenna vertical to be able to transmit an alert.

Figure 8: Photograph of the McMurdo
Fastfind 220 and Kannard Safelink Solo Personal Locator Beacons

At 0405 on 16 May 2014, an initial alert from the skipper's PLB was detected with no positional data by a GEO satellite. Five minutes later, a second alert with a coarse position of 38° 45.0N, 048° 00.0W was received via the same satellite by RCC Boston, who confirmed with MRCC Falmouth that the PLB was registered to *Cheeki Rafiki*'s skipper.

At 0421, the PLB position was refined to 38° 38.6N, 048° 04.33W following detection by an LEO satellite. Only two further alerts were received from the skipper's PLB, the last at 0641 on 16 May, with a position of 38° 37.87N, 48° 06.53W.

At 0629, an initial alert from the mate's PLB was detected with no positional data by a GEO satellite. Four minutes later, a coarse position of 38° 45.0N, 048° 0.0W, was received by the same satellite. At 0713, the next signal was received by an LEO satellite which provided a refined position of 38°36.2N, 048° 17.1W. A further 23 alerts with positional information were received until 2248 on 16 May 2014, with the last position indicated as 38° 27.94N, 048° 29.06W. Two further alerts were received with no positional information, the last at 0236 on 17 May.

While en route to the scene, the initial HC-130 aircraft detected a 406MHz alert and a 121.5MHz homing signal.

1.5 ENVIRONMENTAL CONDITIONS

1.5.1 Met Office hindcast weather data

The marine weather data hindcast produced by the Met Office for 0300 on 16 May 2014 is shown in Table 1 below:

Wind			Significant wave[5] (model)		Wave Component 0			Wave Component 1			Wave Component 2		
Dir (ºtrue)	Speed(Kts)	Force	Height (m)	Period (seconds)	Dir (ºtrue)	Height (m)	Period (seconds)	Dir (ºtrue)	Height (m)	Period (seconds)	Dir (ºtrue)	Height (m)	Period (seconds)
006º	**28**	**7**	**4.7**	**9**	**012º**	**4.6**	**9**	**061º**	**1.2**	**12**	**147º**	**0.2**	**17**

Table 1: Met Office hindcast weather data for 0300 on 16 May 2014

1.5.2 On-scene weather conditions during initial search period

The on-scene weather conditions recorded by the USCG during the initial search period (16 – 18 May 2014) were reported as:

Wind	:	30 - 50 knots
Wave Height	:	12 - 15ft (about 3.7 - 4.8m)
Visibility	:	1.5 - 5nm
Ceiling (cloud)	:	500 - 2000ft (about 152.4 - 609.6m)
Air Temperature	:	59 - 63ºF (about 15 - 17ºC)
Sea Temperature	:	61ºF (about 16ºC)

[5] The significant wave height is defined as the average of the highest third of all waves within the wave train and represents the total obtained from the individual and swell components (Wave Components 0, 1 and 2 in Table 1). Individual wave heights will vary around these average conditions and the maximum wave height may be around two times the quoted significant wave height.

1.6 CREW

Skipper

The skipper, Andrew Bridge, was 22 years old and a UK national. He held a range of certificates issued by the Royal Yachting Association (RYA) including an RYA/MCA Yachtmaster Ocean certificate of competence, issued in October 2013, with Cruising Instructor for Sail and commercial endorsements. He had also completed the International Sailing Federation (ISAF) Offshore Safety Course.

Andrew had about 22,500 miles of yacht sailing experience, including almost 5,000 miles as skipper. His ocean experience included his Yachtmaster Ocean qualifying trip as mate on a passage from the Azores to Cork, and as skipper of *Cheeki Rafiki* on the ARC 2013 trans-Atlantic Ocean race from Las Palmas to St Lucia.

He had completed an internship with Stormforce Coaching in 2011 and divided his time, approximately equally, between yacht skippering, domestic construction and guitar building.

Crew members

James Male was 22 years old and also a UK national. He held a number of British Canoe Union (BCU) and RYA instructional qualifications, including RYA Keel Boat instructor. He had successfully completed an RYA/MCA Coastal Skipper/Yachtmaster Offshore shore-based course. In addition, he held an RYA/MCA Advanced Powerboat certificate of competence with commercial endorsement. He was undertaking an internship with Stormforce Coaching at the time of the accident.

Paul Goslin was 56 years old and a UK national. He had logged about 2,500 miles' yachting experience during approximately 135 days on board yachts. He had skippered charter vessels on 11 yacht holidays, and had acted as mate on a friend's yacht during three longer trips, two of which had been across the North Sea. He had completed the RYA/MCA Coastal Skipper/Yachtmaster Offshore shore-based course and is also understood to have completed an RYA Coastal Skipper practical course.

Stephen Warren was 52 years old and also a UK national. He had logged about 3,500 miles' yachting experience during approximately 100 days on board yachts. He had skippered charter vessels on yachting holidays and had crewed on board a yacht from Hamble to Las Palmas. He had completed the RYA/MCA Coastal Skipper/Yachtmaster Offshore shore-based course and is also understood to have completed an RYA Coastal Skipper practical course.

1.7 MANAGEMENT/CHARTER ARRANGEMENT

Cheeki Rafiki's management was transferred to Stormforce Coaching on 1 April 2011. The initial agreement meant that the owner was responsible for the cost of all maintenance and repairs to *Cheeki Rafiki*. These costs were deducted from any hire income earned by the owner through *Cheeki Rafiki*'s commercial activities managed by Stormforce Coaching.

In April 2013, a new agreement was reached between the owner and Stormforce Coaching whereby the company would bareboat charter *Cheeki Rafiki* for a fixed monthly fee. Under this agreement, the cost of routine maintenance became the responsibility of Stormforce Coaching, with the owner responsible for the cost of 'extraordinary maintenance' (i.e. that not normally carried out to a yacht of similar type and age).

Cheeki Rafiki's owner was permitted to use the vessel throughout the year; however, some restrictions and periods of usage had to be agreed by Stormforce Coaching to ensure that the vessel remained available for key race events. Under this arrangement, which was in place at the time of the accident, Stormforce Coaching was responsible for the commercial marketing and operation of the vessel, which included its itinerary and area of operations.

The principal/director of Stormforce Coaching first qualified as an RYA instructor in 1993, and established Stormforce Coaching in 2001. He was an RYA Ocean Yachtmaster Instructor and Examiner, held a range of qualifications, and had over 100,000 miles' yachting experience, including two ARC trans-Atlantic Ocean races.

1.8 COMMUNICATIONS EQUIPMENT

Cheeki Rafiki was equipped with an Iridium 9555 satellite telephone, which provided voice communication and was connected to a computer to allow data, including emails, to be sent and received through manual intervention.

The Iridium satellite constellation consists of 66 LEO satellites that facilitate worldwide communication. In addition to billing information i.e. voice and data network usage, the system records times and positions whenever data is transferred. Position accuracy for these purposes is +/- 10km 90% of the time to 90% of subscribers.

Use of the device was on a 'pay-as-you-go' basis, where the principal/director paid for a number of minutes to be credited to the account. These minutes were then used for either voice calls or data transfer. The satellite telephone was normally switched off when not in use to conserve battery power.

The Iridium data connection was being used to download Grib files containing weather forecast data, which could be displayed using Ugrib software. Ugrib software had the ability to display wind speed and direction, barometric pressure and expected rainfall.

1.9 BENETEAU

In 2007, Beneteau Group went through a period of restructuring designed to consolidate and centralise resources common to each of its brands. This led to the creation of BJ Technologie, which assumed design, quality assurance and development responsibilities for its Beneteau and Jeanneau brands. To ensure maintenance of brand identity, a small number of design staff were retained for each brand to refine final plans and specifications.

The Group's restructuring was driven by the desire to improve standards and to rationalise costs. Prior to the restructuring, all of the design, quality assurance and development activities had been carried out separately by each of Beneteau Group's brands.

Across all of Beneteau Group's boat-building activities, some 8000+ vessels are constructed annually, ranging from small outboard-powered craft to large custom-built motor and sail yachts. All Beneteau and Jeanneau branded yachts have been constructed utilising the same manufacturing method.

1.10 BENETEAU FIRST 40.7 DESIGN AND MANUFACTURE

1.10.1 Design

Beneteau commissioned Farr Yacht Design Ltd to design a 40ft (12.2m) yacht for its First racing/cruising yacht brand. The design was developed in collaboration between Farr Yacht Design Ltd and Beneteau, with Beneteau finalising the structural detail and internal finishes.

At the time of the First 40.7's design, there was no harmonised International Organization for Standardization (ISO) standard for keel design and attachment. Therefore, Farr Yacht Design Ltd was guided by the existing American Bureau of Shipping (ABS) classification society rules when completing this particular area of its design and associated calculations.

In 2012, the ISO published its standard 12215-9 'Sailing craft appendages', which specified load cases with criteria that the keel structure had to meet. This and other parts contained within the standard have become the recognised reference that designers and builders use to show that they have complied with the relevant essential requirements of the Recreational Craft Directive (RCD). As part of its safety investigation, the MAIB contracted the Wolfson Unit at the University of Southampton to carry out retrospective calculations to ascertain whether or not the Beneteau First 40.7 design would have complied with ISO 12215-9. The majority of the design was found to meet the standard and the resulting report is at **Annex C**.

The Beneteau First 40.7 was designed to meet the requirements for a Design Category A 'Ocean' vessel under the RCD (see section 1.19.1) using module Aa to confirm compliance. The design stability and buoyancy were approved by the notified body Institute for Certification and Normalisation in Nautical Field (ICNN) in 1998. Although not required under the RCD, the Beneteau First 40.7 structural design was approved by Bureau Veritas (BV).

1.10.2 Keel attachment

The Beneteau First 40.7 was available with two keel options: a shorter cast iron bulb type keel and a more popular deep fin cast lead keel. The lead keel was manufactured with stainless steel bolts cast into it. There were nine 24mm bolts: three designed to carry the fore and aft loading on the keel, and six primarily to carry the lateral loading **(Figure 9)**. The three bolts carrying the fore and aft loading were arranged with two single bolts at the forward end of the keel and one single bolt aft. The six bolts designed to carry the lateral loading were arranged in pairs. All of the 24mm bolts were secured to the glass reinforced plastic (GRP) hull with a washer (i.e. backing) plate and nut **(Figure 10)**.

In addition, the design provided for a 14mm bolt at the extreme forward end and at the after end of the keel, to prevent the GRP flexing away from the top of the keel. However, only the aft bolt was installed in the manufactured product owing to insufficient material being available in which to effectively install the forward bolt **(Figure 9)**. The Wolfson Unit's assessment of the keel structure **(Annex C)** was based on a Beneteau First 40.7 design incorporating only the aft 14mm bolt.

Drawings of the keel and the yacht's structure are reproduced at **Annex D**.

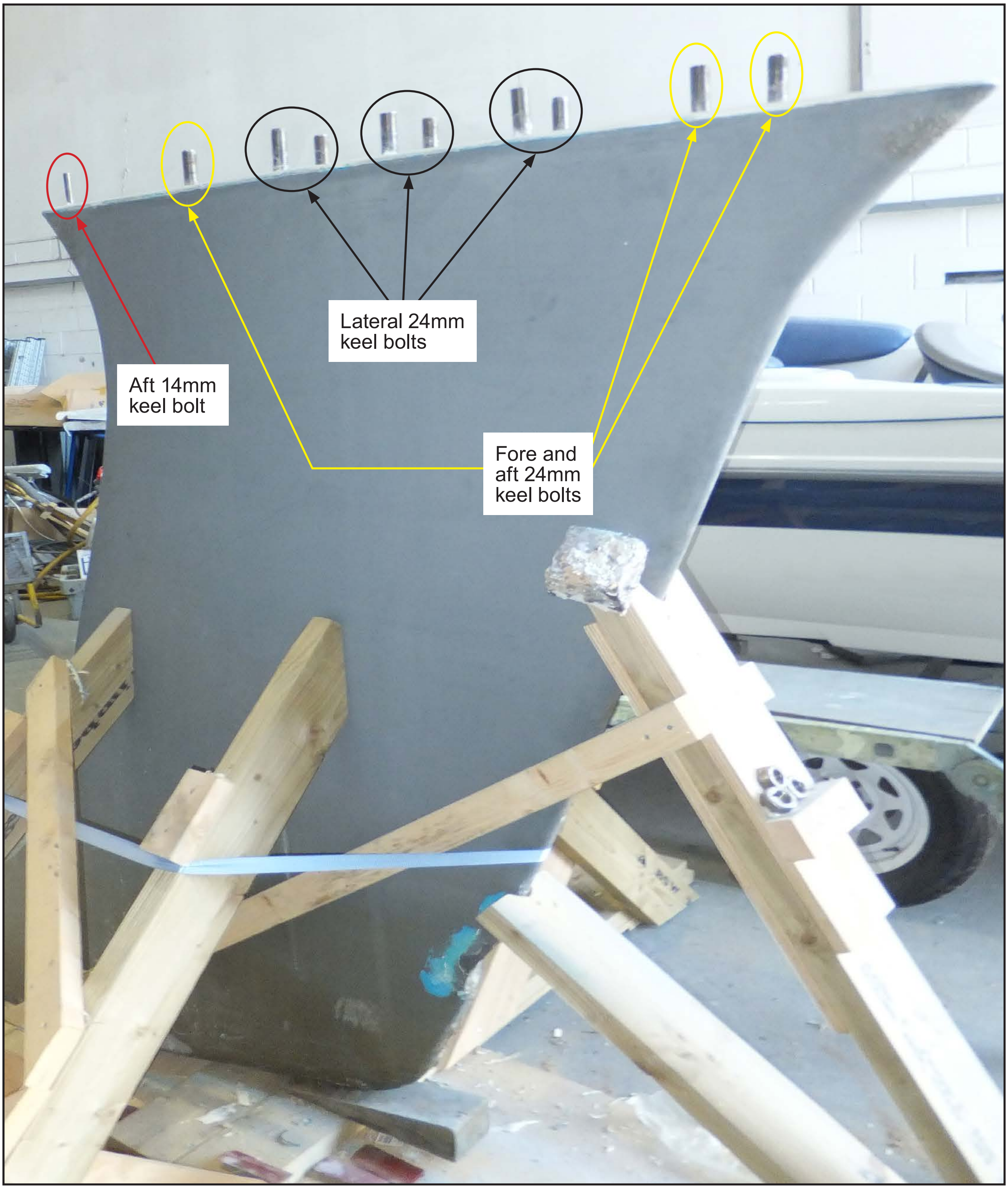

Figure 9: Typical Beneteau First 40.7 keel bolt arrangement (not *Cheeki Rafiki*)

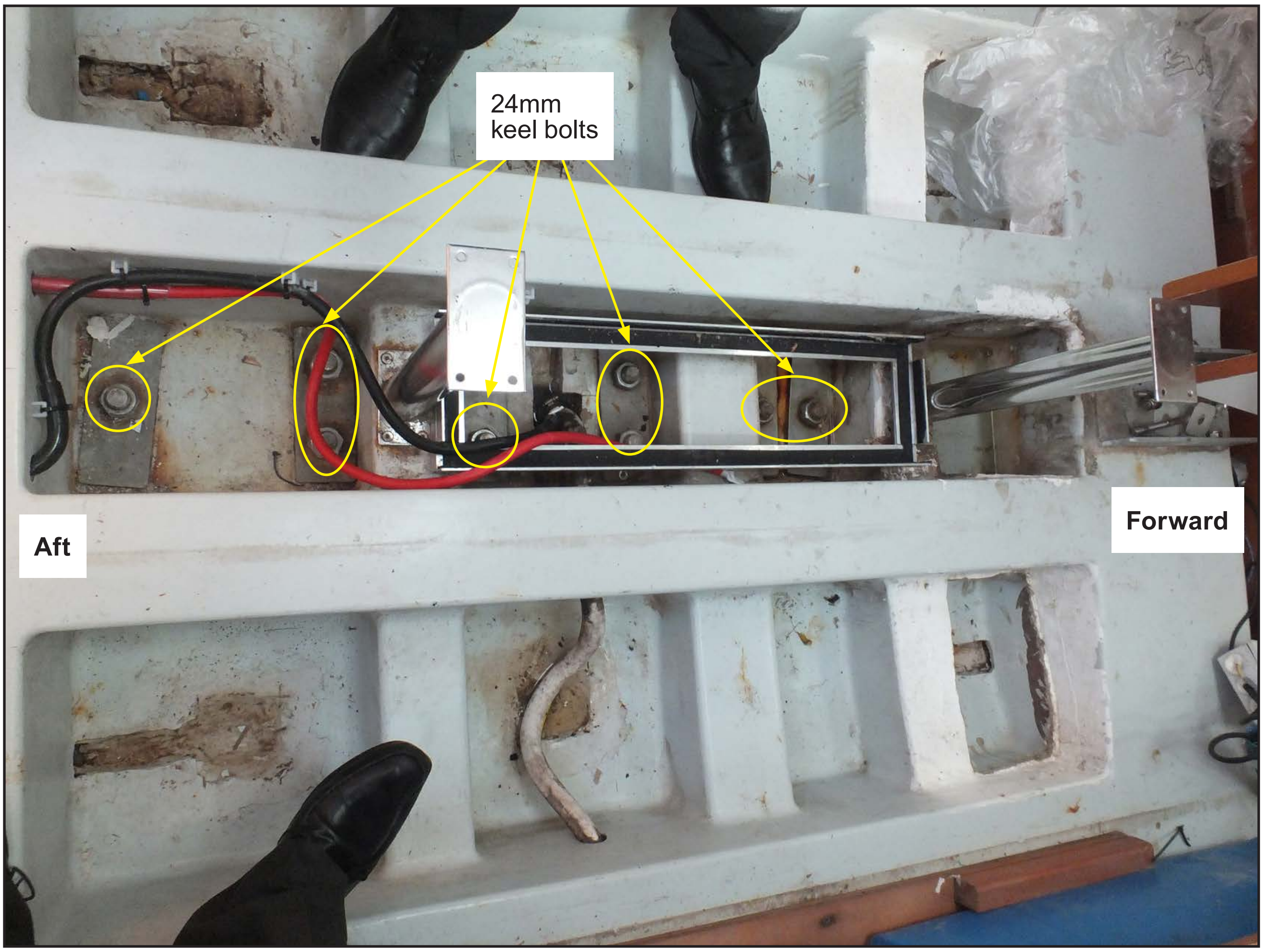

Figure 10: Typical Beneteau First 40.7 keel bolt arrangement (not *Cheeki Rafiki*)

1.10.3 Manufacturing process and quality assurance

Introduction

Although not explicitly required by the RCD, structural plans were reviewed, and the first manufactured hulls inspected by BV to assess their compliance with the design specification.

In addition to checks by external organisations, Beneteau had a system of internal quality control measures designed to ensure continued compliance with the approved design, and to ensure consistency of product quality.

Material tests

All materials used in the construction process were tested in Beneteau's laboratory prior to entering the manufacturing process. These included all adhesives, resins, glass fibres and metals.

Tests varied according to the particular material, but typically included exposure to high and low temperature extremes, resistance to ultra violet light, watertight integrity and resistance to corrosion.

Adhesives were tested by bonding together materials joined in the yacht's construction and then pulling them apart to ensure compatibility, and to check that the material failed before the adhesive.

Glass fibres and resin layup methods were tested to ensure sufficient strength and finish were achieved.

Bolts were tested to ensure strength and resistance to corrosion.

A new material was introduced to the manufacturing process only after it had been approved. Ongoing checks were made to all subsequent batches of material to ensure they continued to meet the applicable product specification.

Manufacturing process

Hulls were layed up in a mould, using glass fibre and resin **(Figure 11)**. To ensure that the correct amounts of resin and glass fibres were used for each layer, glass fibre mat was pre-cut to size and the resin weighed. Matting placement and quantity of resin were detailed in operational procedures that described each stage of the manufacturing process. As a vessel progressed through the construction phases, the relevant operational procedure for the particular stage was placed on the associated trolley so that workers could refer to it prior to starting work.

The matrix, sometimes called 'liner', was manufactured separately in a mould. It was layed up in a similar way to the hull, and the process was quality assured using pre-measured materials and referring to detailed operational procedures **(Figure 12)**. In **Figure 12**, floors have been layed up between all frames in the matrix. To reduce weight, the First 40.7 did not have bays layed up in the forward and aft sections of the matrix. Once the matrix was complete, it was then ground to ensure a smooth surface in preparation for bonding it to the hull.

Once the hull and its matrix had been completed, and while still in their respective moulds, they were bonded together. A specially designed applicator was used to apply the bonding paste to pre-determined areas of the matrix. The applicator applied a bead of paste of a consistent size. The operational procedures detailed the number of beads of bonding paste to be applied in each area.

To ensure that a hull and matrix could be adequately bonded together according to the specification, the first three hulls and matrices of all new models were placed together using plasticene instead of bonding paste. The hull and matrix were then separated and the plasticene inspected to ensure that it had spread to enable full bonding according to the specification.

Once the bonding paste was applied, the hull and matrix were placed together and left until the paste was fully cured. The hull and matrix moulds were then removed **(Figure 13)**.

The next stage of the manufacturing process was for the various hull penetrations to be drilled out. The plugs removed from the hole-saws were sent to Beneteau's laboratory for measuring to verify that the hull and matrix at the sampling point were of the correct thickness. If a plug was found to be below the minimum required thickness, it was weighed and then burned in order to remove the resin. The

Figure 11: Hull being layed up in Beneteau's manufacturing facility (not a First 40.7)

Figure 12: A completed matrix being ground prior to bonding to the hull (not a First 40.7)

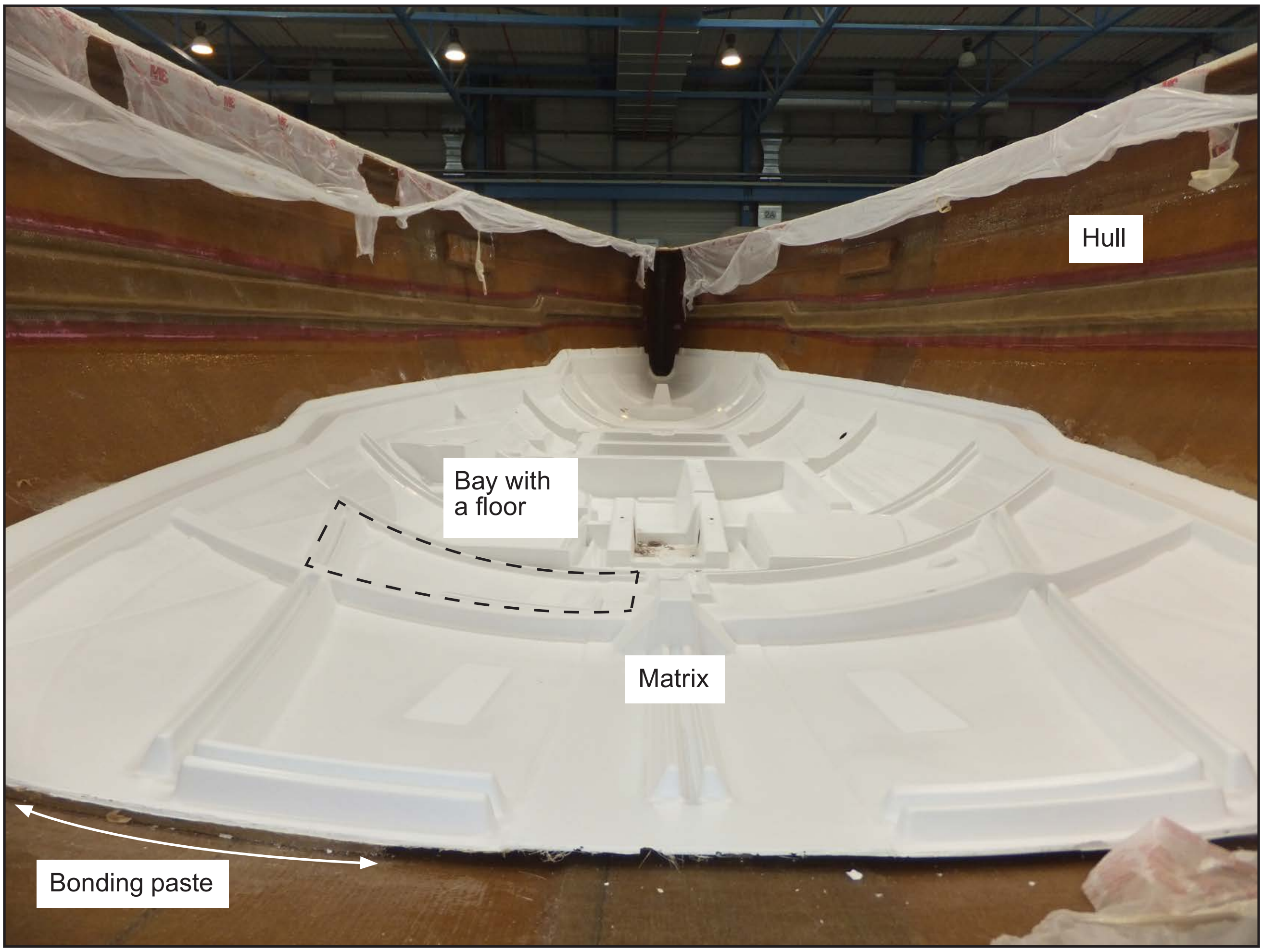

Figure 13: A hull and matrix bonded together (not a First 40.7)

remaining glass was then weighed and compared with the original weight to ensure the glass-to-resin ratio was within tolerance. If not within tolerance, the hull was removed from the manufacturing line and rectifying action taken.

Some of the areas drilled, notably holes for the keel bolts, were of insufficient diameter to yield a plug and therefore thickness tests were not carried out in these areas.

After drilling was completed, the engine was mounted and the hull internally and externally fitted out according to the customer's specifications, before the deck was added. The keel was then attached, and the hull floated in a tank to ensure its watertightness. A final quality control inspection was then undertaken before the completed yacht and its rigging were shipped to the dealer. Yachts that could not be shipped by road and/or ferry, i.e. those that had been manufactured for the Far Eastern or American markets, were shipped without their keels attached, the keel being attached by the dealer following receipt.

At the time of manufacturing the First 40.7 hulls, Beneteau relied on external verification of its manufacturing and quality control process. It has since developed an internal ISO 9001 quality assurance process, which is audited by BV.

1.10.4 Owner's Manual

Beneteau provided an Owner's Manual with its First 40.7 in accordance with RCD requirements. Extracts from this manual are reproduced at **Annex E**.

1.11 BENETEAU FIRST 40.7 MATRIX DETACHMENT AND REPAIR

1.11.1 MAIB enquiries to GRP repairers and Beneteau First 40.7 owners

During the course of the investigation, the MAIB received much anecdotal evidence regarding matrix detachments on Beneteau First 40.7 yachts. Areas notable for detachment were in the forward sections of the matrix, commonly attributed to the vessel slamming, and the area around and aft of where the keel is attached to the hull, commonly attributed to the vessel grounding.

MAIB inspectors visited four Beneteau First 40.7 yachts that had all suffered detachments of their matrix in bays around the aft end of the keel as a result of grounding. Additionally, two of these vessels had suffered, or were showing signs of, matrix detachment in the forward section.

One further Beneteau First 40.7 yacht was visited, which showed signs of matrix detachment in the forward and aft sections.

1.11.2 Request to certifying authorities

As part of its safety investigation, the MAIB requested all certifying authorities authorised by the MCA's Marine Guidance Note (MGN) 280 (M) to provide information regarding historical matrix detachment on Beneteau First 40.7 yachts.

Twelve responses were received, mainly based on anecdotal evidence. However, one response provided a specific example of matrix detachment in the forward section of a Beneteau First 40.7 yacht.

1.11.3 Matrix repair method

MAIB inspectors visited five GRP repairers who had undertaken repairs to Beneteau First 40.7 yachts following matrix detachment.

Of these five repairers:

1. Three were of the view that the matrix flanges should be removed and surfaces prepared in way of the detachment before the matrix was then re-glassed to the hull with a combination of appropriate matting.

2. One was of the opinion that any remaining bonding paste between the matrix flange and hull should be ground out, with the flange left intact, and fresh bonding paste re-applied before the matrix was then glassed to the hull with a combination of appropriate matting.

3. One considered that either of the two methods was valid.

Beneteau had provided advice on its recommended repair method in documentation issued to its after sales and dealer network. This advice recommended that a flange of at least 5cm be retained and that the bonding paste should be ground out and replaced before the matrix was then glassed to the hull, in order to retain the 'I' beam effect and matrix stiffness.

All of the repairers agreed that the keel should be removed when necessary to effect keel repairs, a point confirmed within Beneteau's advice. However, none of them was clear on the circumstances that would necessitate keel removal.

All of the repairers agreed that it was very difficult to identify areas and the extent of matrix detachment, particularly in the vicinity of the keel owing to the clamping effect of the keel bolts and washer plates. However, the single most agreed method for detecting matrix detachment was the use of a hammer to tap on the matrix and to listen for changes of tone.

Two of the repairers suggested a further method of landing yachts ‘lightly’ on their keels, and watching for deflection of the hull.

1.12 *CHEEKI RAFIKI* MAINTENANCE, DAMAGE AND REPAIR HISTORY

1.12.1 Maintenance

While under the management of Island Charters, *Cheeki Rafiki*’s annual maintenance was completed by its owner and generally consisted of visual checks of hull, rudder and keel for damage, replacement of anti-fouling, routine engine maintenance and general husbandry.

After the change of management in 2011, the vessel was kept at Stormforce Coaching’s moorings throughout the year, initially at Kemps Quay and then at Shamrock Quay marina, Southampton. Maintenance was initially intended to be completed by the vessel’s owner; however, owing to the owner’s other commitments, Stormforce Coaching subsequently assumed responsibility for completing routine and annual maintenance.

Stormforce Coaching’s yachts were assigned a regular skipper who was expected to monitor his or her vessel for defects and routine maintenance requirements. A clipboard-based defect reporting system was used to record defects and deficiencies with the vessel and when corrective action had been taken. A vessel’s equipment inventory was verified using a checklist, detailing loose equipment[6] and its stowage position on board.

All Stormforce Coaching’s vessels were lifted out of the water for maintenance at least annually. Where possible, the vessel’s regular skipper was engaged during the maintenance period. Unless a defect was identified, no records of inspection were kept, other than confirmation of an annual examination having been conducted in accordance with the MCA’s Small Commercial Vessel (SCV) Code (see section 1.19.3).

1.12.2 Groundings, damage and repairs

<u>August 2007 - grounding</u>

During Cowes Week in August 2007 *Cheeki Rafiki* suffered what was described as a ‘light grounding’ in Stanswood Bay, in The Solent. It was subsequently inspected by a GRP repairer who had the vessel lifted out of the water and temporarily rested it on its keel to enable inspection for signs of hull deflection. The matrix was then hammer tested in an attempt to identify detached areas. Repairs to the vessel were completed in September 2007.

[6] Loose equipment. Equipment which was not permanently attached to the vessel or part of the vessel’s structure and could be removed from the vessel. This included safety equipment such as liferaft, EPIRB etc.

The repair invoice detailed the following:

> *'Remove floor boards and pipe work in way of damaged areas. Cut flanges off six bays, grind back hull, laminate and sides of structural floors. Bond structural floor to hull with GRP, lightly rub down and apply wax gel. Drill off limber holes, refit pipes and floors. Clean vessel. Lift plate washers and re bed'.*

Cheeki Rafiki's keel was not removed to carry out these repairs.

<u>October 2007 – keel dressed</u>

In October 2007, *Cheeki Rafiki*'s keel was dressed. It is not known how or when the damage that required the repair occurred. The invoice detailed the following:

> *'Dress out damage to lead keel. Fill and fair with epoxy filler. Apply epoxy primer and two coats of patch antifouling.'*

It was reported that an inspection of the vessel and its matrix had probably been completed during the time the vessel was under repair, with no other defects detected. However, no documentary evidence could be found to support this.

<u>2010 Round the Island race – grounding</u>

During the 2010 Round the Island race, *Cheeki Rafiki* reportedly grounded at St Catherine's Point on the Isle of Wight, after it *'dropped on to the ground'* when in the trough of a wave.

<u>2011 Fastnet training event - grounding</u>

While completing a training event for the 2011 Fastnet, *Cheeki Rafiki* suffered a 'light grounding' on Ryde Sands, in The Solent.

<u>Other notable damage or repairs</u>

2010 – Removal and repair of pulpit following damage and repair to hull starboard side amidships.

2010 – Cutting out and repair of hull area in way of port aft cradle support, following some damage when the vessel was lifted out of the water.

2011 – A section of the matrix within the forward cabin was re-attached to the hull after it was found detached during its coding survey (see section 1.14).

2011 – The port quarter was repaired after *Cheeki Rafiki* was struck by another vessel during the 2011 Fastnet race.

<u>Shamrock Quay marina - groundings</u>

A shallow patch exists in the approach to Stormforce Coaching's moorings in Shamrock Quay marina that at low water, if not avoided, would have caused *Cheeki Rafiki* to touch bottom. The MAIB investigation identified at least two known 'light groundings' in this area of shallow water. These both occurred within 2 years of the vessel's loss.

Antigua Sailing Week 2014 – alleged grounding

There were reports that *Cheeki Rafiki* had grounded during Antigua Sailing Week prior to the accident and that this could be considered the most likely cause of its loss. Following an analysis of witness evidence, automatic identification system (AIS) data, and mobile phone-based navigation software from a crew member on board, it is concluded that *Cheeki Rafiki* did not ground during Antigua Sailing Week.

1.13 ATTITUDES TO GROUNDING

During discussions with a number of yacht owners and professional yacht skippers as part of the MAIB's safety investigation, a recurring theme emerged regarding attitudes to grounding, particularly when racing. Almost all agreed that groundings can occur when racing, and that if, in their opinion, it was a 'light' grounding, no inspection for damage was necessary.

A range of definitions of a 'light grounding' was offered, which included:

- a grounding where the vessel did not stop;
- where the vessel only 'bounced' over the bottom;
- where no person was knocked off their feet as a result of the grounding;
- where the vessel grounded at slow speed; and
- where the vessel grounded on a soft bottom e.g. sand.

1.14 COMMERCIAL CODING

In 2011, Stormforce Coaching obtained Category 2 coding for *Cheeki Rafiki* under The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998. Consequently, the vessel was required to comply with the SCV Code (see section 1.19.2). As an authorised certifying authority under the SCV Code, Yacht Designers and Surveyors Association Ltd (YDSA) was engaged to carry out the relevant surveys on *Cheeki Rafiki* to allow the necessary certification to be issued.

Cheeki Rafiki was inspected out of the water by a YDSA surveyor on 18 March 2011 for its initial survey. It was during this survey that the YDSA surveyor detected a detachment of *Cheeki Rafiki*'s matrix in the forward section. Following repair the vessel was issued a small commercial vessel certificate. *Cheeki Rafiki* was then due to be inspected by the certifying authority for its intermediate examination by 18 March 2014, at which time the vessel was still in the Caribbean Sea.

Stormforce Coaching asked YDSA to grant an extension to allow the survey to be completed when the vessel was back in the UK. YDSA passed the request to the MCA, who confirmed that no extension was permitted under the SCV Code. Owing to the cost of completing the survey while in the Caribbean Sea, it was not carried out and *Cheeki Rafiki*'s Category 2 coding expired.

On 26 March 2014, the MCA stated in an email to YDSA *'…not sure how it got to the Caribbean from the UK on a Cat 2 Certificate, especially as they are using it commercially out there?'* This email was forwarded by YDSA to Stormforce Coaching, who responded directly to the MCA on 27 March 2014 *'…Just to clarify, the yacht crossed the Atlantic in the racing division of the ARC under ISAF regulations. She will not be carrying any paying passengers for the way home…'*

On 28 March 2014, the MCA responded, stating *'Paying passengers are only one element of the definition. If the voyage is a relocation voyage for commercial purposes, the vessel is almost certainly not being used as a pleasure vessel.'* The definition of a 'pleasure vessel', a copy of which was attached to the email, is provided in The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998 and is reproduced at **Annex F**. On 31 March 2014, the principal/director telephoned the MCA to discuss the issue but the content and outcome of the conversation were not documented and cannot be verified.

Subsequent to the accident, the MCA has stated that for the return crossing of the Atlantic Ocean '*the vessel should have been appropriately coded or complied fully with the relevant merchant shipping legislation that would otherwise have applied*'.

1.15 YACHT ROUTING GUIDANCE

The United Kingdom Hydrographic Office (UKHO) produces a comprehensive range of navigational charts and nautical publications to assist with passage planning. This includes routing charts and sailing directions.

In addition to the UKHO publications, there are a number of commercially produced routing guides which are directed towards smaller vessels, particularly sailing yachts.

One range of such books, copies of which were are understood to have been available at Stormforce Coaching, has been authored by Jimmy Cornell. Relevant extracts from his various publications are provided below:

<u>World Voyage Planner</u>

In this publication, various voyage options are discussed. These include voyages from the Caribbean Sea to the UK; however, no option for a non-stop voyage is mentioned.

<u>World Cruising Routes</u>

In this publication, routing guidance exists for the Lesser Antilles to Bermuda and Lesser Antilles to the Azores. No advice exists for a voyage from the Lesser Antilles non-stop to the UK.

In the advice provided for the Lesser Antilles to Bermuda route:

> *'One of the favoured points of departure for this route is Antigua's English Harbour, where boats take their leave from the Lesser Antilles and head either north for Bermuda as part of a return trip to Europe or North America, or NE on a nonstop passage to the Azores.'*

In the advice provided for the Lesser Antilles to Azores route:

> *'For many years yacht captains were not prepared to challenge the accepted wisdom that a return voyage from the Caribbean to Europe should only be attempted along the classic route that passed through Bermuda on its way to the Azores.'*

and

> *'Boats on direct passages to the Azores should initially favour an ENE course. By staying south of 30ºN until they get east of 40ºW they will avoid getting caught up by passing depressions…'*

Advice for the passage from Bermuda to northern Europe suggests that non-stop passages to Europe are less popular, but are shorter than routing via the Azores. '*On leaving Bermuda, the recommended tactic is to sail an initial NNE course so as to reach as quickly as possible the area of prevailing westerly winds. To avoid the southern limit of ice, it is recommended that in June latitude 39ºN is not passed in the early stages of the passage and that the route should stay as far south as the winds will permit*.'

Advice for the passage from Bermuda to the Azores suggests that opinions are divided between quickly heading north up to latitude 40ºN to pick up westerly winds where there is a *'higher frequency of gales'* and a *'colder wetter passage,* or to forego the chance of these favourable winds for the more pleasant alternative by following a rhumbline to the Azores.

1.16 OTHER YACHTS EUROPE-BOUND FROM ANTIGUA

The investigation identified three other yachts that were being delivered back to Europe, from the Caribbean Sea, by a UK-based yacht delivery company at the time of *Cheeki Rafiki*'s loss. Two of the yachts were of a similar size to *Cheeki Rafiki* and were routed via Bermuda and the Azores. The third was a larger yacht of about 18.29m, which was routed from the Caribbean Sea directly to the Azores and then on to Europe.

All three yachts were being monitored by a shore-based support cell in the UK, which provided up-to-date weather information and, if requested, advice to its skippers. Grib file weather data was being viewed through Ugrib and zyGrib software. Ugrib software displays wind speed and direction, pressure and rainfall only. Zygrib software displays additional elements such as wave height.

Due to the presence of what was considered to be a deep area of low pressure that was generating strong winds and heavy sea conditions, the skippers of the two smaller yachts opted to wait in Bermuda for the weather system to pass.

In accordance with this particular company's procedures, all yachts were provided with a tracking system to enable remote monitoring of the vessels' progress from the company's support cell. One of the smaller yachts was provided with a YB Tracking system; its track is shown in **Figure 14**.

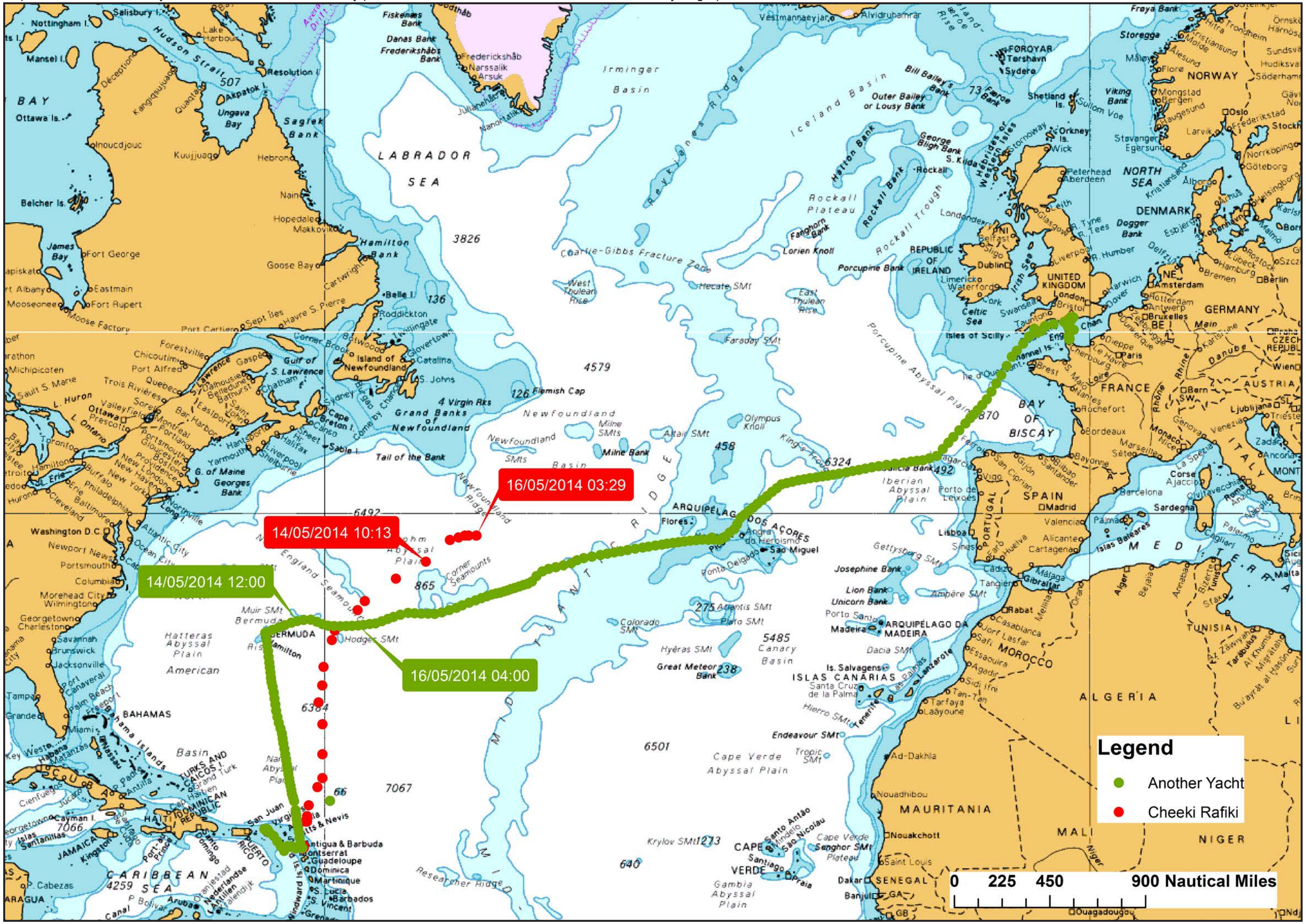

Figure 14: Track of another yacht routed via Bermuda recorded by YB Tracking
(Note: red track is that of *Cheeki Rafiki*)

1.17 RYA QUALIFICATIONS AND SYLLABI

1.17.1 Introduction

Skippers and certain crew members of vessels subject to the SCV Code are required to hold certificates of competence. The use of Yachtmaster Coastal, Offshore and Ocean certificates of competence is permitted for these vessels, provided that the certificates have been commercially endorsed.

All RYA/MCA Yachtmaster Coastal, Offshore and Ocean certificates of competence are gained by examination, conducted by examiners who are independent of RYA training centres.

To obtain a commercial endorsement, an applicant must obtain a Medical Fitness Certificate and a Professional Practices and Responsibilities Certificate, and attend a Basic Sea Survival course.

1.17.2 RYA/MCA Yachtmaster Coastal and Yachtmaster Offshore certificate of competence

The aim of the RYA/MCA Yachtmaster Coastal certificate of competence is that holders are able to *'skipper a yacht on coastal cruises but does not necessarily have the experience needed to undertake longer passages'*.

The aim of the RYA/MCA Yachtmaster Offshore certificate of competence is that holders will be a *'competent skipper on a cruising yacht on any passage during which the yacht is no more than 150 miles from harbour'*.

The joint syllabus is divided into 8 sections:

1. International Regulations for Preventing Collisions at Sea
2. Safety
3. Boat Handling
4. General seamanship, including maintenance
5. Responsibilities of skipper
6. Navigation
7. Meteorology, and
8. Signals.

Section 5, Responsibilities of skipper, includes emergency and distress situations, for which one of the source references is the RYA Sea Survivial Handbook.

The handbook includes a section on actions to take in the event of hull damage:

> *'A relatively small hole can let in a large amount of water in a very short time. The amount of water will depend on the size of the hole and its depth below the waterline. For example, a 75mm (three-inch) diameter hole about 30cm (one foot) below the waterline will let in about half a tonne of water in a minute – too much for bilge pumps to cope with.*
>
> *Reducing the area of the hole even by partially blocking it will significantly reduce the flow rate. Block the hole with any materials you have available, braced against the opposite side of boat.*

An alternative method is to cover the hole from outside using a sail or other waterproof fabric cover. Whether this is possible will depend on the position of the hole, the shape of the hull and the weather conditions.

Make sure the bilge pumps are able to reach all parts of the hull. Electric pumps will only continue to pump so long as they have electricity. Engine-driven pumps can shift considerable amounts of water. Ensure manual pumps are operational. All pumps should be fitted with strum boxes (filters) to prevent blockage.

Attach an appropriate-sized softwood bung to each seacock. If the skin fitting or hose breaks and a seacock has seized, the bung can be used to stem the flow.'

1.17.3 RYA/MCA Yachtmaster Ocean certificate of competence

The aim of the RYA/MCA Yachtmaster Ocean certificate of competence is that holders are *'experienced and competent to skipper a yacht on passages of any length in all parts of the world'*.

The examination has oral and written elements:

'Oral The candidate must provide the examiner with:

a) *A narrative account of the planning and execution of the qualifying passage.*

b) *Navigational records, completed on board a yacht on passage, out of sight of land, showing that the candidate has navigated the yacht without the use of electronic navigational aids. The records must include as a minimum: planning, reduction and plotting of a sun-run-meridian altitude sight and a compass check carried out using the bearing of the sun, moon, a star or a planet.*

During the oral test the candidate may be required to answer questions on all aspects of ocean passage making in a yacht, including passage planning, navigation, worldwide meteorology, crew management and yacht preparation, maintenance and repairs.

Written The written exam will include questions on sights and sight reduction and worldwide meteorology.'

1.17.4 MAIB discussions with RYA/MCA Yachtmaster examiners

During the course of the investigation, three RYA examiners were consulted for their views on grounding. All three suggested that while the aim of all training is designed to equip candidates with the skills and knowledge to prevent grounding, vessels are at times allowed to ground during courses and examinations for the following reasons:

- Grounding provides an opportunity to discuss how candidates should respond to the grounding event; and

- Where a candidate grounds a vessel during an examination it provides indisputable evidence that can be used to explain why the examiner failed the candidate.

All three examiners agreed that candidates would only be allowed to ground a vessel where it would result in a 'light grounding'. Three different definitions of a 'light grounding' were offered. However, all agreed that such groundings would probably not require a subsequent inspection of the vessel and would be unlikely to cause any damage to warrant concern.

1.18 THE INTERNATIONAL SAILING FEDERATION

ISAF is the world governing body for the sport of sailing. As such, ISAF is responsible for promotion of the sport internationally, developing the racing rules of sailing for all sailing competitions, and the training of race officials.

ISAF currently has 137 member nations, who are its principal members and who are responsible for the decision-making that governs yacht racing activity worldwide.

1.19 REGULATIONS AND GUIDANCE

1.19.1 Recreational Craft Directive

General

Directive 94/25/EC, known as the Recreational Craft Directive (RCD), harmonised the European Union (EU) Member States' differing national legislation for recreational craft, which are defined as boats intended for sports and leisure purposes of a hull length between 2.5 and 24 metres. Directive 94/25/EC was subsequently amended by Directive 2003/44/EC.

In the UK, The Recreational Craft Regulations 2004 transposed the RCD into UK law. The Regulations require manufacturers and suppliers of recreational craft in the UK to demonstrate that, at the point of sale, their products conform with the RCD's essential requirements.

Build module choice

Before producing or placing a vessel on the market, the manufacturer or his authorised representative must select a build module designator **(Annex G)**, which describes how they will demonstrate that their product conforms with the RCD.

Module selection is based on the length of the vessel and the physical conditions it might encounter in use. This is known as the design category as set out in Table 2 below.

Design category	**Wind force (Beaufort scale)**	**Significant wave height (m)** (see footnote 5 on page 16)
A – "Ocean"	exceeding 8	exceeding 4
B – "Offshore"	up to, and including, 8	up to, and including, 4
C – "Inshore"	up to, and including, 6	up to, and including, 2
D – "Sheltered waters"	up to, and including, 4	up to, and including, 0.3

Table 2: RCD design category wind force and significant wave height limits

Design Category A is defined in the RCD as:

'Designed for extended voyages where conditions may exceed wind force 8 (Beaufort scale) and significant wave heights of 4m and above but excluding abnormal conditions, and vessels largely self-sufficient.'

ISO 12215-9 defines Design Category A as:

'category of craft considered suitable to operate in seas with significant wave heights above 4m and wind speeds in excess of Beaufort Force 8, but excluding abnormal conditions such as hurricanes.'

Modules range from Module A (Internal production control and self-assessment by the manufacturer), to Module H (Full quality assurance with the intervention of a notified body to approve and control the manufacturer's quality system).

The Beneteau First 40.7s were built to Design Category A. They are under 12m length overall and therefore fall under build Module Aa. The criteria for build Module Aa are defined in Table 3 below.

Design category	Module	Title	Description
A	A	Internal production control	Internal conformity assessment and production control by the manufacturer who draws up a written declaration of conformity in accordance with Annex XV of the RCD.
	Aa	Internal production control plus tests	This is Module A, plus tests of stability and buoyancy carried out on the responsibility of the notified body[7], which issues an examination report.

Table 3: RCD build module criteria for Design Category A vessel

<u>Declaration of Conformity</u>

The Declaration of Conformity for *Cheeki Rafiki*, reproduced in **Annex H**, was issued on 7 November 2006 and indicated that Module Aa had been used for the yacht's construction assessment.

<u>Owner's Manual</u>

An Owner's Manual is required to provide guidance to the vessel's owner on safety issues and should cover all risks applicable to the type of vessel. It should also include a trouble-shooting section and draw particular attention to the risks of fire and flooding.

The format and content requirements for the Owner's Manual are laid down in ISO standard 10240 *'Small craft – Owner's manual'*.

[7] Notified bodies are appointed by EU Member States to support the implementation of directives, including the RCD. Notified bodies will have been assessed to ensure their competence in determining whether or not a product complies with the requirements laid down in the regulations.

One requirement is to provide *'information connected with the risk of flooding and stability'*, which includes:

> *'Openings in hull*
>
> *Give the following information.*
>
> *a) Location of seacocks and through-hull fittings, by a plan, sketch…*
>
> *b) Advice on keeping seacocks, cockpit drains, bungs and other opening/closing devices in the hull closed or open, as appropriate, to minimize the risk of flooding…*
>
> *c) Advice on keeping portlights, windows, washboards, doors, hatches or ventilation openings closed when appropriate, e.g. in rough weather…'*

It also requires information to be provided regarding bilge pumping and bailing, including a requirement for a warning that the *'bilge system is not designed for damage control'* (unless specifically designed for that purpose) and that the Owner's Manual includes details of bilge pump location, capacity and, if relevant, operating instructions.

The standard requires a section on fire prevention and fire-fighting equipment, and for the means of escape to be identified. Specifically related to electrical systems, it requires warning of the *'risks of fire, explosion or electric shocks'*.

'Other information that is relevant for the safe operation of the craft' is also required to be included.

1.19.2 Small Commercial Vessel (SCV) Code

Background

The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998 apply to UK vessels wherever they may be and other vessels operating from UK ports while in UK waters, except pleasure vessels and vessels carrying more than 12 passengers. Regulation 6 enables alternative standards contained in the MCA's Small Commercial Vessel (SCV) Code to be used to fulfil the requirements of the Regulations. The SCV Code is annexed to MGN 280 (M).

Section 2 of the SCV Code defines 'charter' as '*an agreement between the owner / managing agent and another party which allows that other party to operate the vessel, and the 'charterer' is that other party…'* and 'bare boat charter' as '*a charter for which the charterer provides the skipper and crew*'.

Section 3.1.1 states:

> *The Code has been developed for application to United Kingdom (UK) vessels of up to 24 metres Load Line length which are engaged in activities at sea on a commercial basis, which carry cargo and/or not more than 12 passengers, or provide a service in which neither cargo nor passengers are carried…'.*

Section 3.1.1 states:

> *'Pleasure vessels are excepted from the Code…'.*

The terms 'engaged in activities…on a commercial basis' and 'operated commercially' are not defined in the SCV Code.

The SCV Code categorises areas of operation from '0' to '6', where '0' is unrestricted service and '6' is within 3 miles from a nominated departure point. Category 2 is defined as up to 60 miles from a safe haven.

The SCV Code defines a certifying authority as either the MCA or one of the organisations authorised by the MCA. One of the listed certifying authorities is YDSA.

As part of the investigation, a YDSA surveyor, with experience of coding surveys on Beneteau First 40.7 yachts, was engaged to determine whether these vessels could achieve Category 0 coding, as required under the SCV Code for a trans-Atlantic Ocean passage. The report produced by the surveyor concludes that, with modification, it would be possible for these vessels to achieve Category 0 coding **(Annex I)**.

<u>Vessels operating under ISAF Offshore Special Regulations</u>

Section 28 of the SCV Code states:

> *'28.1 A coded vessel chartered or operated commercially, for the purpose of racing need not comply with the provisions of the Code whilst racing, or whilst in passage directly to or from a race, provided that the vessel complies with the following:-*
>
> 1. *It complies with the racing rule provisions of either the International Sailing Federation (ISAF) or the Union Internationale Motonautique (UIM).*
>
> 2. *It complies with the racing rule provisions of the affiliated Member National Authority, of either the ISAF or UIM, in the country where the race takes place.*
>
> 3. *It complies with the safety rule provisions of the race Organising Authority affiliated to the Member National Authority and thereby recognised by the ISAF or UIM to organise races in the country where the race takes place.*
>
> 4. *If it is a yacht racing offshore, it complies with the appropriate parts of the ISAF Offshore Racing Committee's special regulations or the similar requirements of the affiliated race Organising Authority.*
>
> 5. *When on charter and in passage in any Area Category to and from the race, the race equivalent safety cover shall be in force, or the vessel is to be in its coded condition for the passage.*

28.2 A non-Coded vessel may be chartered or operated commercially for the purpose of racing, or whilst in passage directly to or from a race, provided that it is registered and licensed by an ISAF or UIM affiliated Member National Authority as a vessel chartered or operated commercially for the exclusive purpose of racing and provided the vessel also complies with the provisions of 28.1.1 to 28.1.5…

28.3 The relief from the compliance with the provisions of the Code…, does not apply to a vessel taking part in an event created and organised with the intent to avoid the provisions of the Code.’ [sic]

1.19.3 Comparison of Category 0 and Category 2 requirements

The SCV Code details structural, stability and safety equipment requirements for each of the various areas of operation.

The SCV Code requirements include the following:

<u>Liferafts</u>

Category 0 -Vessels to be provided with liferafts of such number and capacity that, in the event of any one liferaft being lost or rendered unserviceable there is sufficient capacity remaining for all on board. It further requires liferafts to be equipped with an inflatable floor and canopy. Liferafts are required to be able to float free and inflate automatically.

Category 2 - Vessels to be provided with sufficient liferaft capacity for at least the total number of persons on board. Liferafts to be stowed on deck and fitted with float-free arrangements, or stored in a locker where they are readily accessible.

Although not applicable to *Cheeki Rafiki,* section 13.2.6 of the SCV Code requires that liferafts provided on sailing multihull vessels should be located so that they are accessible when the vessel is either upright or after an inversion.

<u>EPIRBs</u>

Category 0 - EPIRBs should be installed in an easily accessible location and capable of floating free and automatic activation if the vessel sinks. It permits stowage in a position where it cannot float free where stowage in such a position is not practicable and fewer than 16 persons are on board.

Category 2 - Category 2 vessels are not required to carry an EPIRB. However, *Cheeki Rafiki* was equipped with a manually operated EPIRB, which had last been serviced on 31 July 2013 and which was normally stowed in a designated bracket inside the vessel.

<u>Personal Locator Beacons (PLBs)</u>

There are no PLB carriage requirements irrespective of area of operation.

Vessel examination

Category 0 - Vessels are required to be examined by an authorised person annually.

Category 2 - Vessels carrying fewer than 16 persons are required to be examined by an authorised person prior to issue of the coding certificate (initial inspection) and at least once during the life of the certificate (intermediate examination), in order that the interval between successive examinations by an authorised person does not exceed 3 years. Annual examinations in the intervening years may be carried out by the owner or managing agent within 3 months either side of the anniversary date of the initial/renewal examination at intervals not exceeding 15 months.

The annual examination is to confirm that the arrangements, fittings and equipment provided on board are in a satisfactory condition and remain as documented in the report form SCV2, and that the vessel, its machinery, fittings and equipment are in a sound and well maintained condition. The owner or managing agent is to enter a record of a successful examination on the form SCV2, and to report the results of the examination to the certifying authority.

An intermediate examination is normally conducted with the vessel in the water. It may be of a general or partial nature and include the vessel, its machinery, fittings and equipment. In consideration of the hull's construction material or the age, or type and service of the vessel, the certifying authority may instead require an out-of-water examination, in which case the hull, shell fittings, external steering and propulsion components may also be examined.

Manning requirements

Category 0 - The Code requires a skipper to hold an MCA recognised Yachtmaster Ocean certificate of competence, and states that there should be on board another person holding at least a Yachtmaster Ocean or Yachtmaster Offshore certificate of competence.

Category 2 - The Code requires a skipper to hold an RYA/MCA Yachtmaster Offshore certificate of competence and for a second person to be on board, deemed by the skipper to be experienced.

1.19.4 ISAF Offshore Special Regulations

The ISAF Offshore Special Regulations (OSR) are an internationally accepted uniform minimum set of safety requirements that can be invoked by a race organiser. ISAF OSR categories are not the same as SCV Code categories.

The OSR cover both monohulls and multihulls racing in Category 0 – trans-oceanic races, through to Category 6 – inshore racing. The SCV Code invokes the ISAF OSR for yachts operating commercially. Vessels can only use the OSR in lieu of the SCV Code requirements if the Flag States or national regulations permit them to. The concept of 'operating commercially' is not defined in the ISAF OSR.

The OSR specify mandatory and permissive requirements covering structure, stability, fixed and portable equipment, personal equipment and training.

For OSR Categories 0, 1 and 2, yachts are to be designed and constructed in accordance with ISO 12215, but do not require an inspection to be carried out by an authorised person.

At least 30% but not fewer than two of the crew are required to have undertaken offshore personal survival training covering a specified range of topics within 5 years of the start of a race run under ISAF OSR Category 0, 1 or 2.

The range of topics includes:

<u>'Training topics for Theoretical Sessions</u>

1. *Care and maintenance of safety equipment*
2. *Storm sails*
3. *Damage control and repair*
4. *Heavy weather – crew routines, boat handling, drogues*
5. *Man overboard prevention and recovery*
6. *Giving assistance to other craft*
7. *Hypothermia*
8. *SAR organisation and methods*
9. *Weather forecasting*

<u>Training topics for Practical, Hands-On Sessions</u>

1. *Liferafts and lifejackets*
2. *Fire precautions and use of fire extinguishers*
3. *Communciations equipment (VHF, GMDSS. Satcomms, etc.)*
4. *Pyrotechnics and EPIRBs'*

The OSR also include in their appendices a detailed syllabus for the ISAF Model Training Course Offshore Personal Survival. The model course covers a wide spectrum of training areas, including a section on damage control and repair, and specifically lists 'loss of keel and/or capsize'. It is not mandatory for training centres to follow the model course syllabus when delivering this course.

During its investigation the MAIB obtained examples of two ISAF Offshore Safety Courses being delivered in the UK, neither of which followed the model course format.

1.19.5 International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual

The IAMSAR Manual consists of three volumes and is jointly published by the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). It provides guidelines for a common aviation and maritime approach to organizing and providing SAR services.

Volume I, *'Organization and Management'*, discusses the global SAR system concept. Volume II, *'Mission Co-ordination'*, assists personnel who plan and co-ordinate SAR operations and exercises. Volume III, *'Mobile Facilities'*, is intended to be carried aboard rescue units to help with performance of a search, rescue or on-scene co-ordinator function.

Volume II includes the following information and guidance (inter alia):

With regard to survival and recommended search times:

> *'Thus in water at 5ºC (41ºF), the 50% survival time for a normally-clothed individual is estimated to be about one hour, with a recommended search time of six hours. The corresponding times for 10ºC (50ºF) are two hours and 12 h(ours). While in water at 15ºC (59ºF) the 50% survival time is about six hours, with the recommended search time of 18 h(ours)…'*

and

> *'For offshore incidents, it is reasonable to expect that individuals may be better equipped to survive and have access to appropriate protective clothing, such as lifejackets and possibly liferafts. Consequently, search times for them should be at the upper limits of those expected (10 times predicted 50% survival time), unless obviously adverse conditions prevail, and should exceed them if it is possible that survivors may have been able to get out of the water.'*

With regard to supplies and survival equipment:

> *'Supplies and survival equipment are carried by air and maritime SAR facilities to aid survivors, and facilitate their rescue. The type and number to be carried depend on the circumstances on scene. Maritime facilities and helicopters generally can deliver this equipment directly to survivors. Fixed-wing aircraft can deliver supplies to survivors if suitable landing areas exist nearby or if the supplies can be dropped at the scene.'*

and

> *'When deciding whether or not supplies should be dropped, consider whether communications have been established with survivors, and if so, whether:*
>
> - *The needed supplies have been identified;*
> - *Suitable aircraft are available; and*
> - *The crew has adequate training and experience.*

Pilot and crew should understand and be able to account for factors that affect an air drop, such as:

- *Correct release point;*
- *Drift effect of the wind;*
- *Aircraft speed;*
- *Aircraft height;*
- *Relative locations of the distress site and the rescue facility's base;*
- *Time before rescue can be effected; and*
- *Danger of exposure.'*

Volume III provides the following information and guidance (inter alia):

With regard to assistance by SAR aircraft and supply dropping:

'Assistance by aircraft during a SAR mission can include dropping liferafts and equipment to craft in distress…'

'Ships in distress or survivors may be supplied by SAR aircraft with special items of droppable equipment.

Suggested procedure for aerial delivery of rafts, supplies, and equipment to persons in watercraft or in water:

- *Approach slightly upward and perpendicular to the wind direction*
- *Drop item(s) with 200m buoyant trail line attached to a position 100 m ahead of survivors*
- *Let trail line fall so that it will float downwind to survivors.'*

With regard to conclusion of search where a search is unsuccessful:

'The following diagram **(Figure 15)** *provides realistic survival times for people believed to be in water at various temperatures. If there is a possibility that survivors may have survival equipment or have been able to get out of the water, search times should be extended.*

Remember that the graph can only be indicative. Predicting survival times in immersion victims is not a precise science; there is no formula to determine exactly how long someone will survive or how long a search should continue. In water temperatures above 20ºC (68ºF) search times exceeding 24 h(ours) should be considered.'

Image courtesy of IMSAR

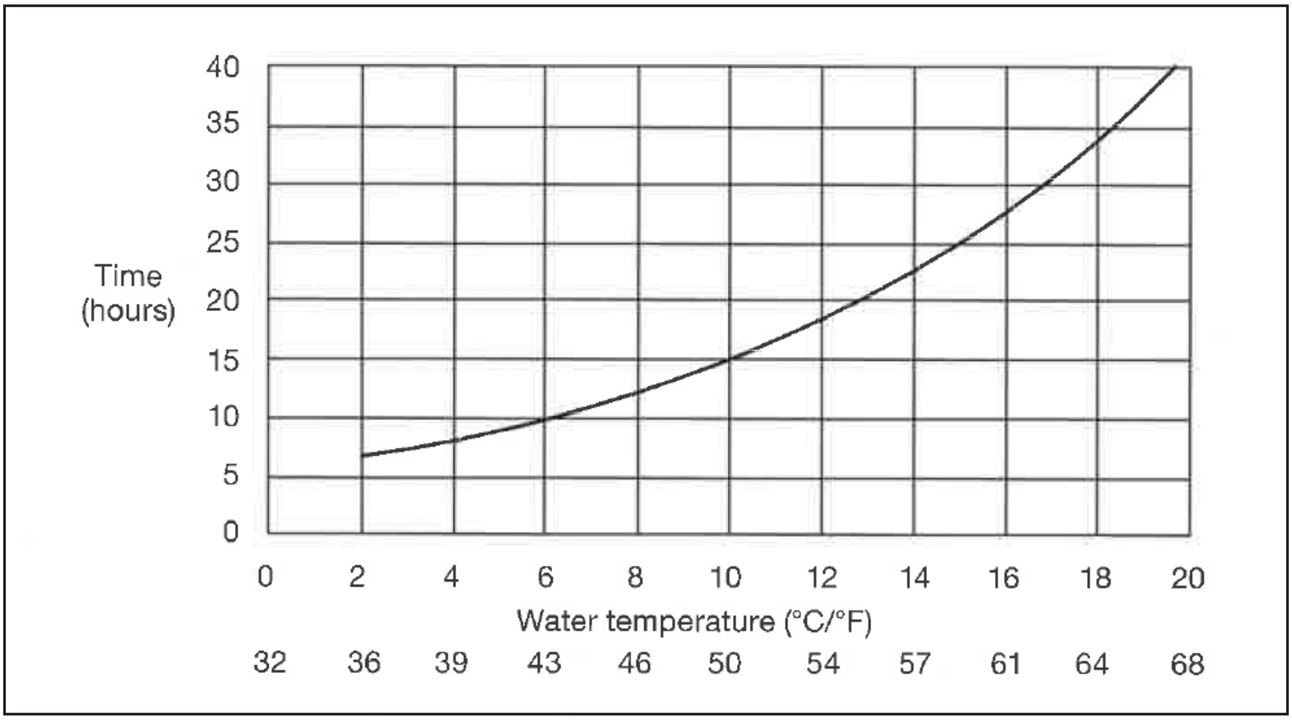

Figure 15: *'Graph on realistic upper limit of survival time for people in the water wearing normal clothing, from time of entry into the water'*

1.20 OTHER KEEL FAILURES

In October 2013, ISAF compiled a list of yacht keel failures that had occurred since 1984, which are summarised in Table 4 below.

Cause of failure	Number
Undefined	40
Welded fin failures	11
Grounding or collision	8
Hull/internal structure	8
Keel bolts	3
Keel cant system	2
Total	**72**

Table 4: Summary of ISAF data on keel failures

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 OVERVIEW

Due to the circumstances of this accident, and the consequent absence of survivors and material evidence, its causes remain a matter of some speculation. However it is concluded that *Cheeki Rafiki* capsized and inverted following a detachment of its keel. In the absence of any apparent damage to *Cheeki Rafiki*'s hull or rudder other than that likely to have been directly associated with keel detachment, it is concluded unlikely that the vessel had struck a submerged object. Instead, a combined effect of previous groundings and subsequent repairs to its keel and matrix had possibly weakened the vessel's structure where the keel was attached to the hull. It is also possible that one or more keel bolts had deteriorated. A consequent loss of strength may have allowed movement of the keel, which would have been exacerbated by increased transverse loading through sailing in worsening sea conditions.

2.3 DESIGN AND CONSTRUCTION

The Beneteau First 40.7 yacht was designed to comply with RCD Design Category A, which requires a vessel to be able to withstand a wind speed of greater than force 8 and a significant wave height of greater than 4 metres, excluding abnormal conditions. ISO 12215-9 provides 'hurricanes' as an example of 'abnormal conditions'. With reference to the hindcast weather data for 0300 on 16 May 2014, it is concluded that *Cheeki Rafiki* was operating within its design category criteria at the time of its loss.

At the time the Beneteau First 40.7 was designed there was no harmonised ISO standard for keel design and attachment. The Wolfson Unit's assessment of whether or not the Beneteau First 40.7 design would have complied with today's ISO 12215-9, concluded that the majority of the design met the standard but the keel bolt washer plates would have needed to be 3mm thicker and 3mm wider to fully meet the standard. The assessment was based on a design incorporating only the aft 14mm keel bolt. Not intended to be a major load-bearing item, the absence of a second 14mm bolt in the manufactured product would have made little difference to the keel attachment's overall strength.

Beneteau's system of testing new materials prior to their entering the manufacturing process, and quality control measures that were in place at the time of *Cheeki Rafiki*'s construction, provide some assurance that existing First 40.7 yachts were constructed in accordance with the approved design. Further, despite not being a requirement of the RCD, Beneteau had engaged BV to approve the structural design and to inspect its first manufactured hulls to confirm they were constructed in accordance with the approved design.

MAIB inspectors visited four Beneteau First 40.7 yachts that had suffered matrix detachment due to grounding, two of which had also suffered matrix detachment in the forward section, and one further Beneteau First 40.7 yacht with matrix detachment in the forward and aft sections. They also received much anecdotal evidence and a further specific example of matrix detachment. While Beneteau's quality assurance systems provide some assurance that existing Beneteau First 40.7 yachts were constructed in accordance with the approved design, and were compliant with the RCD, there also is evidence that the two bonded parts (i.e. matrix and hull) can separate in service resulting in loss of structural strength. The probability of this occurring will increase with more frequent and harder yacht usage.

Owing to the continuous nature of the matrix where solid floors are in place, particularly in the area of keel attachment, it is not possible to see the bonded areas. It is therefore difficult to readily identify areas where a detachment has occurred, meaning that it is possible for a detachment to remain undetected.

2.4 GROUNDINGS

Cheeki Rafiki grounded twice in 2007. After each grounding, it was inspected and repaired. The yacht had at least four further groundings; all were described as 'light'.

The risk of grounding is an everyday hazard to those who use the water for trade or leisure. Anecdotal evidence collected throughout the investigation suggests that the frequency of grounding, particularly when racing, may be higher than reported.

A decision on whether or not a grounding triggers a subsequent inspection for damage, and possible repair, is often based on the skipper's assessment of whether or not it was a 'light' or 'heavy' grounding. This methodology is highly subjective and, throughout the investigation, considerable variation of opinion existed as to what constituted a 'light' or 'heavy' grounding.

In reality, the effect that a grounding will have on a vessel depends on a number of factors, including the particular part of its hull or keel that came into contact with the ground, and the speed and direction of impact. Therefore, a skipper's perception that the force of a particular grounding is insufficient to raise concern does not necessarily mean that significant damage has not occurred to the keel and/or the vessel's structure.

Considering the potential for the hull and matrix to become detached from each other as a result of grounding, and the difficulty with detecting such detachments on vessels constructed in this way, it is possible that some of *Cheeki Rafiki*'s reported 'light' groundings could have significantly affected the integrity of the matrix attachment in way of the keel. Furthermore, it is possible that additional unreported 'light' groundings occurred, further increasing the likelihood that the keel attachment structure had been weakened.

A focus of RYA training for yacht skippers is to avoid grounding. However, anecdotal evidence collected during the investigation suggests that it is not unusual for students to be allowed to ground a vessel, particularly on the more basic courses and at times during an examination, if in the opinion of the instructor or examiner it is safe to do so. This practice is of particular concern on vessels manufactured with a matrix bonded to the hull.

It is appropriate that the importance of preventing a yacht from grounding is covered in current RYA yachting qualification syllabi. However, the potential effect of grounding on a vessel's structure is not covered. When yachts are grounded for training purposes, the focus is on how to remain safe while aground and to refloat at the earliest opportunity. It is unlikely that the potential for a vessel's structure to be damaged during any grounding, with the consequential need for expensive inspection and repair, is routinely discussed during RYA training courses. Therefore, the practice of allowing a yacht to ground during training courses and examinations may lead candidates to underestimate the likely consequences.

2.5 INSPECTION AND REPAIR

Following the grounding in August 2007, *Cheeki Rafiki* was temporarily rested on its keel to enable inspection for signs of hull deflection. This method of inspection was supported by two repairers who were visited by MAIB inspectors. While it is possible that this practice could provide some indication of matrix detachment, it is unlikely to be sufficient to identify areas where full detachment has not occurred and some bonding exists.

There is no industry-wide guidance available which sets out a method for detecting matrix detachment. However, among those repairers who were questioned during this investigation, the most common method used is hammer testing. The success of this method relies, to a large extent, on the experience and ability of the person carrying out the test and the conditions at the time. False indications may be obtained, particularly in the area around the keel washer plates owing to the clamping effect of the keel bolts, and also where the rig has been so highly tensioned that some compression of the matrix/hull attachment has occurred.

The repair invoice following *Cheeki Rafiki*'s grounding in August 2007 indicates that the resulting damage was in way of six bays. Photographs taken of the keel bilge area prior to the vessel's departure on the ARC trans-Atlantic Ocean race 2013 show areas of renewed gel coating, indicating the result of a previous repair. At least two of these areas are in bays immediately either side of bays where the keel was bolted to the hull **(Figures 16** and **17)**. Given that detachment had probably occurred in the two repaired bays, it is possible that detachment had also occurred in way of the keel but had not been detected because of the clamping effect of the keel bolts, the keel not having been removed.

All of the repairers visited by MAIB inspectors agreed with Beneteau's advice to its after sales and dealer network that the keel should be removed when necessary. However, there is currently no industry-wide guidance on the circumstances that would necessitate keel removal.

The repair invoice also indicates that the repair was not carried out in accordance with Beneteau's recommended method contained in the advice to its after sales and dealer network. Of the repairers visited by MAIB inspectors, there was divided opinion as to the appropriate repair method and, again, there is currently no industry-wide guidance on this matter.

Figure 16: *Cheeki Rafiki*'s keel bilge area prior to departure on the ARC 2013, with table temporarily removed

Figure 17: *Cheeki Rafiki*'s keel bilge area prior to departure on the ARC 2013, with table temporarily removed

2.6 CODING

2.6.1 SCV Code compliance

In order for *Cheeki Rafiki*'s small commercial vessel certificate to remain valid for operations in *Area Category 2 – Up to 60 miles from a safe haven*, the vessel needed to be inspected by an authorised person on behalf of the certifying authority on or before 18 March 2014. As the vessel was in the Caribbean Sea at that time, Stormforce Coaching asked YDSA if the certificate could be extended until the vessel returned to the UK. The request was forwarded to the MCA, who rejected it on the grounds that the SCV Code did not allow for certification to be extended.

The request for an extension of *Cheeki Rafiki*'s Category 2 certification led to an exchange of emails between Stormforce Coaching, YDSA and the MCA (see section 1.14) that concluded with the MCA stating '…*If the voyage is a relocation voyage for commercial purposes, the vessel is almost certainly not being used as a pleasure vessel*'. However, subsequent to the email exchange, a telephone conversation was held between Stormforce Coaching and an MCA official, which was not documented, that resulted in the principal/director believing that it was permissible for *Cheeki Rafiki* to relocate to the UK as a 'pleasure vessel' **(Annex F)**.

Following the accident, the MCA has stated to the MAIB that '…the ongoing charter between the owner and *Stormforce meant that it [Cheeki Rafiki] was a commercial vessel*'. It has also stated that '…*the expression "passage to or from a race" means literally that, from the berth to the start line, not crossing the Atlantic'* and *'…the return crossing was nothing to do with any race…so the vessel should have been appropriately coded or complied fully with the relevant merchant shipping legislation that would otherwise have applied'*. In such circumstances, Stormforce Coaching would have needed to obtain *Area Category 0 – Unrestricted Service* commercial certification for *Cheeki Rafiki* in order for the vessel to make the return crossing of the Atlantic Ocean.

Regulation 2(1) of The Merchant Shipping (Vessels in Commercial Use for Sport or Pleasure) Regulations 1998 states that, in the case of a vessel owned by a body corporate, a 'pleasure vessel' is any vessel which, '*at the time it is being used*', is '*used only for sport or pleasure and on which the persons on board are employees or officers of the body corporate, or their immediate family or friends'*. Without formal guidance, it is not clear whether or not an 'employee' of a body corporate extends, for example, to a managing agent or a yacht delivery company employed by the body corporate, or to employees of that managing agent or yacht delivery company. It is also not clear whether or not there are circumstances in which a charterer could be interpreted to be an 'owner', particularly in the case of a bareboat charterer. Furthermore, although the term 'immediate family' is qualified by definition in that Regulation, the same is not true of the term 'friend'.

Regulation 2(1) goes on to state that the vessel must be '*on a voyage or excursion which is one for which the owner does not receive money for or in connection with operating the vessel or carrying any person, other than as a contribution to the direct expenses of the operation of the vessel incurred during the voyage or excursion*'. While noting the MCA's statement to the MAIB following the accident, without formal guidance, it is not clear whether or not the owner of a chartered vessel is to be considered as receiving money, and that the vessel is consequently in commercial use, for the period that the vessel remains on charter.

Given the wide scope for interpreting when a vessel is or is not a commercial vessel, there is a need for the MCA to provide more explicit guidance about circumstances under which commercial certification for small vessels is required, and when it is not.

MGN 280 Section 28 – Vessels Operating under Race Rules, has text that is, similarly, open to a wide range of interpretation. Specifically, Section 28.1 differentiates between a '*chartered'* vessel and a vessel '*operated commercially*', and allows for a commercially operated vessel to '*not comply with the provisions of the Code whilst racing, or whilst in passage directly to or from a race*', provided certain conditions are met. While noting the MCA's statement to the MAIB following the accident, without formal guidance, the issue is whether the phrase '*directly to or from a race'* should be interpreted as meaning from the last port of departure to the start line, or any passage undertaken for the purposes of attending a race. In the latter case, an Atlantic Ocean crossing out of Code would be permissible, potentially representing a significant saving to the vessel operator.

2.6.2 Vessel examination

A detachment of *Cheeki Rafiki*'s matrix was detected by a YDSA surveyor during the vessel's initial coding survey on 18 March 2011 (see 1.12.2). The vessel's SCV2 form had been annotated to show that the first and second annual examinations had been completed by the owner/managing agent, as permitted by the SCV Code for Category 2 vessels carrying fewer than 16 persons. However, the absence of a formal verifiable inspection procedure for the conduct of annual examinations to be undertaken by a nominated competent person at Stormforce Coaching gives rise to some uncertainty as to the thoroughness of those examinations.

A vessel operating under the SCV Code would require Category 0 coding for any trans-Atlantic Ocean crossing, and with some modification it would have been possible for *Cheeki Rafiki* to have achieved Category 0 coding.

For Category 0 vessels the SCV Code requires annual examinations to be conducted by an authorised person on behalf of the certifying authority. However, it not being a requirement for Category 2 vessels, and following Stormforce Coaching's decision to allow *Cheeki Rafiki*'s certification to lapse at the third anniversary, no authorised person had examined the vessel since its coding survey in 2011. It is possible that any indications of a potential structural problem might have been identified had the annual examinations required by the SCV Code been conducted by an authorised person.

The SCV Code permits coded vessels chartered or operated commercially while racing not to comply with the provisions of the SCV Code provided that they follow, inter alia, ISAF OSR provisions. *Cheeki Rafiki* had been entered for the ARC in 2011 and 2013 westbound trans-Atlantic Ocean crossings that would otherwise require Category 0 coding. The ISAF OSR contain a recommendation that the keel area should be regularly inspected. However, there is no formal structural inspection requirement within the ISAF OSR. This allows the potential for chartered or commercially operated vessels to operate without any structural inspection by an authorised person ever being carried out.

2.6.3 Qualifications

The SCV Code requires the skippers of Category 0 vessels to hold an RYA/MCA Yachtmaster Ocean certificate of competence and, in addition, another crew member to hold either an RYA/MCA Yachtmaster Ocean or Yachtmaster Offshore certificate of competence.

Cheeki Rafiki's skipper held an RYA/MCA Yachtmaster Ocean certificate of competence and had experienced crew on board to assist him. However, while not required for Category 2 coding, had another crew member held an RYA/MCA Yachtmaster Ocean or Yachtmaster Offshore certificate of competence, the skipper would have been assured of a suitably qualified and experienced person being immediately available with whom he could have consulted on matters relating to the passage, weather and subsequent events.

2.7 THE VOYAGE

2.7.1 Route

Following discussions between the principal/director and the skipper, *Cheeki Rafiki* departed Antigua to undertake a non-stop passage to Southampton. From the evidence available, this decision was made because the route was considered to be the fastest back to the UK and would avoid any delays caused through port calls, thereby ensuring the vessel arrived back in the UK ready for its summer programme.

There are no records of the skipper's intended route. As this was to be the skipper's first eastbound trans-Atlantic Ocean crossing, he would probably have taken account of any advice provided by the principal/director. However, the extent to which this might have influenced his choice of route is uncertain. Although appropriately qualified, the skipper had held his RYA/MCA Yachtmaster Ocean certificate of competence for only 6 months (see section 1.6) and had limited ocean experience other than when racing in an organised event.

While yacht routing guidance published by respected author Jimmy Cornell does not specifically advise against non-stop routing from the Caribbean Sea to Europe, his comments regarding the Lesser Antilles to Azores route nevertheless imply that a non-stop route is not common. Although slightly further north than the suggested limiting latitude of 30ºN for vessels following the Lesser Antilles to Azores route, Bermuda provides the option of an additional port call, the use of which is referred to in the guidance as 'accepted wisdom'. Although not recommending against heading north up to latitude 40ºN to pick up favourable westerly winds, comments relating to the Bermuda to Azores route point out that, in doing so, a higher frequency of gales can be expected than by following a rhumbline route to the Azores. The principal/director and the skipper had agreed that *Cheeki Rafiki* could divert to the Azores for additional spares or supplies if required. However, the inclusion of Bermuda and/or the Azores in the intended route would have readily allowed for particular contingencies (e.g. reduction in fuel reserves) and scheduling flexibility (e.g. to avoid forecast adverse weather). Had the above published guidance been fully heeded, an alternative route might have been planned that avoided higher latitudes and their associated weather phenomena while still being able to effect a timely passage.

Of the three yachts that were being returned to Europe by a yacht delivery company at the time of *Cheeki Rafiki*'s loss, two were routed via Bermuda and the Azores, and one was routed via the Azores only. The two that were routed via Bermuda each had a small fuel tank capacity, and it was considered that the amount of fuel likely to be used when transiting lower latitudes could leave insufficient fuel reserves in the case of a direct passage to the Azores. The company advised that all three yachts should proceed no further north than 32ºN. The routes taken, while conservative, reflected the above published routing guidance and information on routing and planning charts for May, and took account of the forecast weather conditions.

On 7 May, Stormforce's principal/director suggested that *Cheeki Rafiki* divert to Bermuda to refuel, after the skipper reported having to run the engine owing to light winds, and his intention to continue to do so for the next day or so. However, a diversion to Bermuda had not been planned prior to the vessel's departure from Antigua; the skipper indicated that he was unable to find a chart for Bermuda on board and was therefore reluctant to go there. Ensuring charts for possible ports of refuge are available on board should be an essential element of planning for ocean passages.

2.7.2 Weather

On board *Cheeki Rafiki* it was possible to download grib files containing weather data, and the Ugrib software installed on board would have enabled the skipper to display wind speed and direction, barometric pressure and expected rainfall. Records show that *Cheeki Rafiki*'s satellite telephone was connecting to the internet at least once per day for most days of the passage, but it has not been possible to determine which internet sites were accessed or how much data from each was downloaded.

In his emails to the principal/director on 5 and 6 May the skipper asked, firstly, for 'any weather routing info …as you can see the bigger picture' and, secondly, for weather information. While the skipper's latter email on 6 May indicated that he was making use of grib file data, it is possible that the skipper was also using the internet connection to access other sources of weather information. Further, while the Ugrib pictures in this report at **Figures 2** and **4** show most of the North Atlantic Ocean for the relevant period, it cannot be known whether or not the skipper was downloading the same amount of data or restricting his access to a smaller part of it.

In his email of Saturday 10 May the skipper reported having to use the engine the previous night due to light winds, and when the principal/director replied to that email on Monday 12 May he advised the skipper to '*perhaps steer NE*'. The principal/director's email mentioned that there would be lightish winds until Wednesday, but did not warn of the worsening conditions thereafter (see **Figures 4** and **5**) that were predicted in the Ugrib 12 May 0600 forecast.

It is unclear how much reliance *Cheeki Rafiki*'s skipper was placing on the advice from Stormforce Coaching's principal/director, though the latter was of the opinion that the skipper would be seeking his own weather information and he would only provide assistance if asked.

Although the conditions prevailing at the time of *Cheeki Rafiki*'s loss were theoretically within the design parameters of the yacht, it would have been prudent to have taken action to avoid the forecast high winds and rough seas.

2.8 KEEL DETACHMENT AND INVERSION

2.8.1 Failure mode

Cheeki Rafiki started taking water at some point following the skipper's emailed reference on 14 May to the vessel having '*just hit a big wave hard*'. The skipper's subsequent telephone call to the principal/director on 15 May indicated that the water ingress was worsening, that the water had been identified as sea water, and that the source of ingress could not be located. The weather had also worsened, with a wind speed of force 7 and a significant wave height of 4.7m, conditions that *Cheeki Rafiki* was designed to encounter. Whether or not the '*big wave*' on 14 May weakened the vessel's structure sufficiently to initiate the water ingress is uncertain. However, without evidence to indicate otherwise, it is concluded that the cause of the water ingress was related to the worsening weather conditions.

Figures 18 and **19** show a photograph taken from USS *Oscar Austin* on 23 May. **Figure 19** indicates the bays probably repaired in 2007 following the vessel's grounding, together with those possibly repaired given their location around the aft end of the keel. It is difficult to conclude with certainty what caused the damage shown in the photograph and whether the material evidence had changed between the accident occurring and the photograph being taken. However, a number of observations can be made.

- The two forward 24mm keel bolts have sheared.

- The aft 24mm keel bolt has sheared, and has apparent rust staining around it, indicating that the keel bolt might have corroded.

- The washer plates of the three pairs of 24mm keel bolts appear to have pulled away with the missing section of the hull and are no longer present, leaving the partial remains of the aft pair of 24mm keel bolt holes in the remaining hull.

In the absence of any apparent damage to *Cheeki Rafiki*'s hull or rudder, other than that likely to have been directly associated with keel detachment, it is concluded unlikely that the vessel had struck a submerged object. Instead, had the vessel's structure where the keel was attached to the hull been weakened as a consequence of previous groundings, this might have allowed movement of the keel due to transverse loading in the prevailing sea state. It is also possible that one or more keel bolts had deteriorated. Keel movement would have then increased, through sailing in the worsening sea conditions, until the structure catastrophically failed, resulting in the keel becoming detached from the hull, and the vessel rapidly capsizing and then inverting.

2.8.2 Response to the flooding

Having discovered that *Cheeki Rafiki* was taking on water, it was essential that the source of ingress be quickly identified and, if possible, addressed. The skipper's email to the principal/director at 2022 on 15 May indicated that he had checked the hull and sea cocks, and had found no damage. He also asked the principal/director for advice and indicated that he would check for emails 2 hours later. The fact that the skipper had not made a voice call at that time and was prepared to wait for 2 hours for advice suggests that he did not interpret the situation as one of immediate

Image courtesy of United States Coast Guard

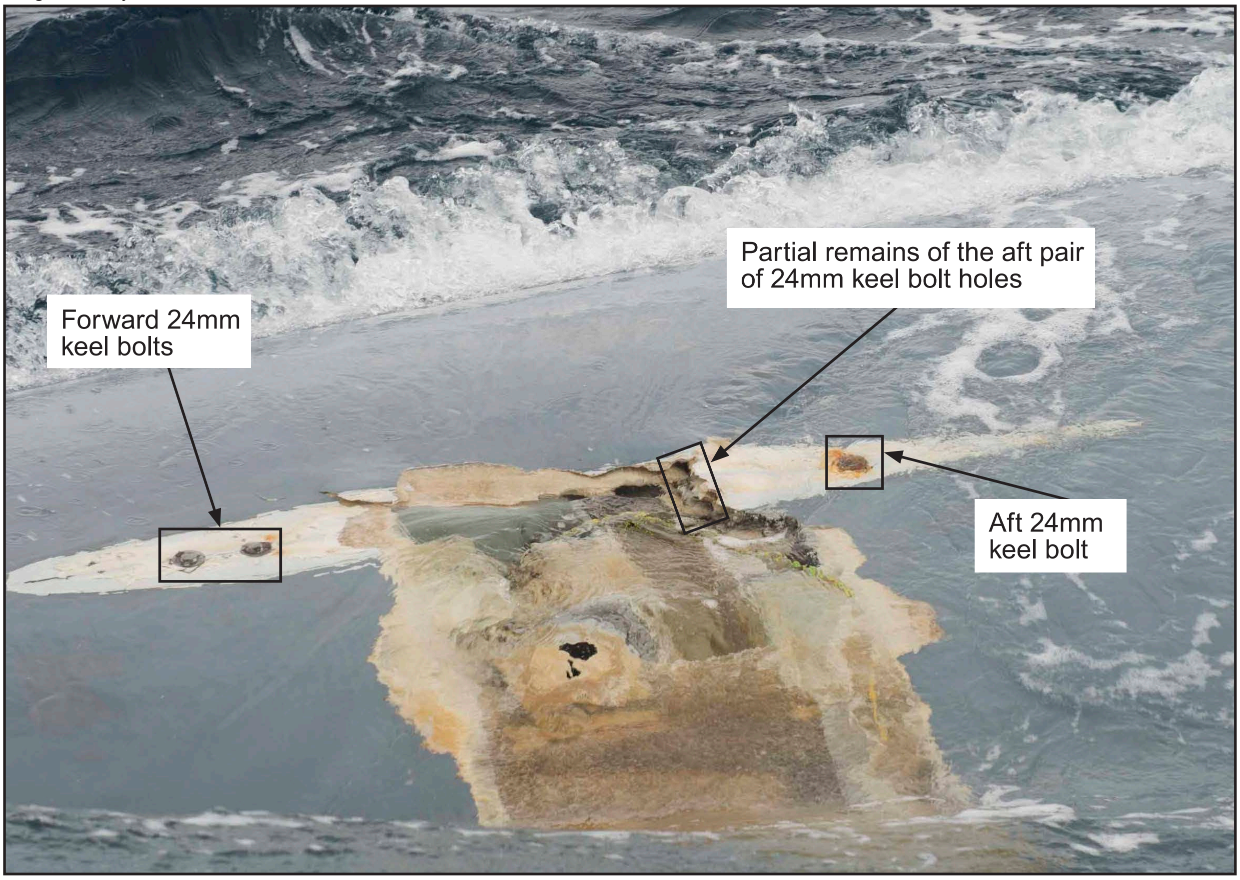

Figure 18: Photograph of *Cheeki Rafiki*'s upturned hull taken by the crew of USS *Oscar Austin* in the afternoon of 23 May 2014

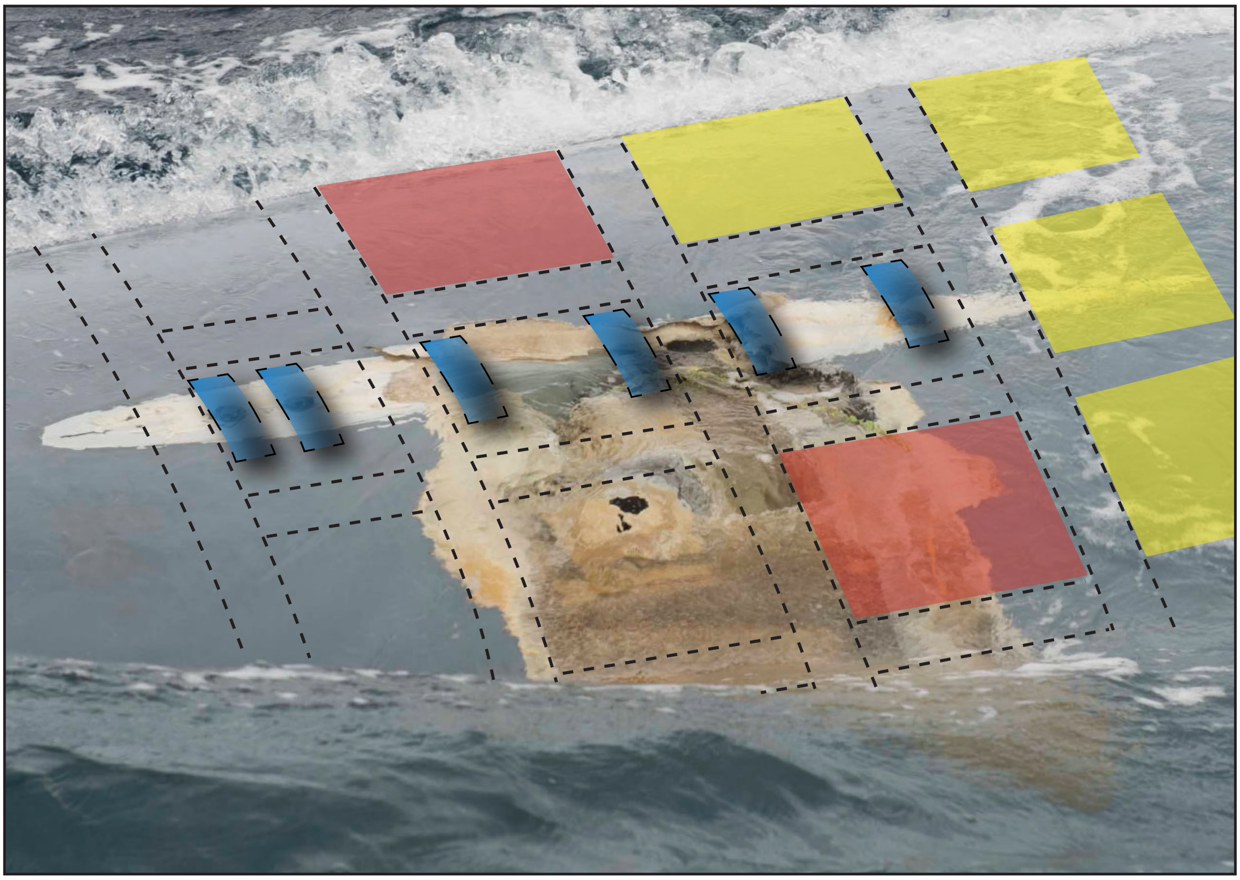

Figure 19: Figure 18 superimposed with the approximate position of the matrix frames and location of the bays probably (red) and possibly (yellow) repaired in 2007

danger. At 2221, instead of checking for emails, the skipper made a satellite telephone voice call to the principal/director to describe the worsening situation and the fact that the source of ingress could not be located. Although this might suggest that the skipper was becoming increasingly concerned about the situation, the vessel's speed appears not to have been reduced, and the skipper made no checks for emails and no further voice calls to the principal/director until 0330 on 16 May. This indicates that, at least until 0330, the skipper remained of the opinion that the vessel was not in immediate danger.

In accordance with ISO 10240, the Owner's Manual provided information on hull openings, location of sea cocks and bilge pumping. However, as it was not specifically required by ISO 10240, the manual did not identify the keel area as a potential source of water ingress or provide advice on how to address such an event. Consequently, the manual would have been of little assistance to the skipper in identifying and addressing the source of water ingress in this case.

The skipper held an RYA/MCA Yachtmaster Ocean certificate of competence and had completed the ISAF Offshore Safety Course. Emergency situations are covered in the syllabus of RYA/MCA Yachtmaster Coastal and Yachtmaster Offshore certificates of competence. The responsibilities and required actions of a skipper in the event of flooding are not specifically included, but are covered in the RYA Sea Survival Handbook. They are also covered in the ISAF Model Training Course Offshore Personal Survival syllabus, which includes a section on damage control and repair, and specifically lists 'loss of keel and/or capsize'. However, this topic was not necessarily included in the ISAF Offshore Safety Course attended by the skipper. Therefore, the skipper's level of knowledge in this area is uncertain and might not have been tested.

On receiving the skipper's email at 2022 on 15 May, the principal/director sent return emails at 2046, 2048, 2230 and 2332, and prudently alerted MRCC Falmouth of the situation by telephone at 2246. The emails requested information and provided appropriate advice on identifying and stemming the water ingress, including inspection of the keel bolts and signs of any cracking around them, as well as precautionary advice, including the wearing of lifejackets and preparation of the liferaft, in case the situation worsened. In his email at 2332, he requested that the skipper call him every 4 hours. However, none of the above emails were received by the skipper. With the satellite telephone on board *Cheeki Rafiki* switched off, the principal/director was unable to communicate directly with the skipper to confirm receipt of his emails.

Without the benefit of the principal/director's advice, it is possible that the skipper had neither identified nor considered that the source of water ingress was in the keel area. Consequently, it is probable that he had neither recognised the increasing risk of the keel becoming detached nor the danger of continuing on the same approximate course without reducing speed **(Figure 20)**, producing high lateral keel load; a point not included in the principal/director's advice.

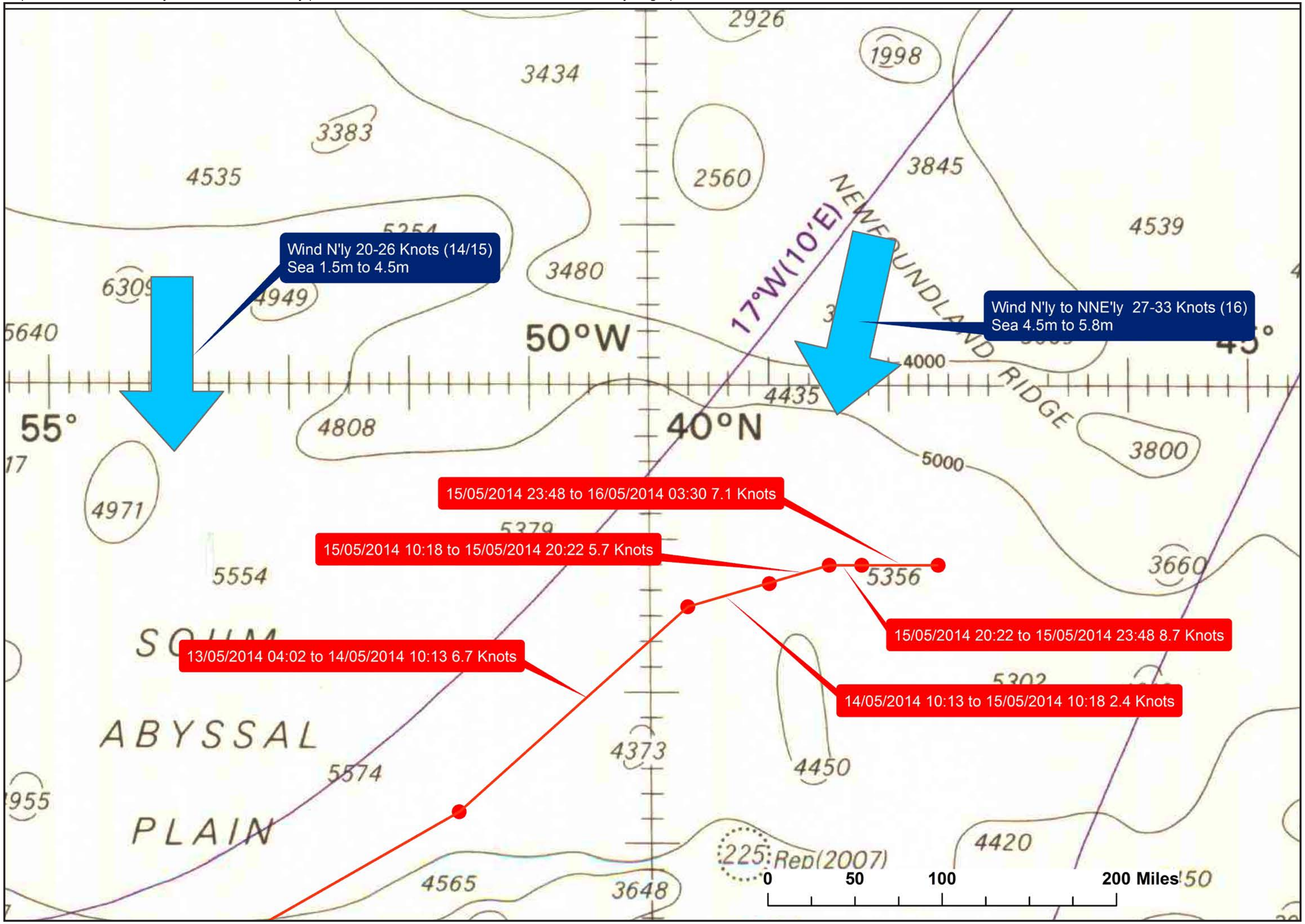

Figure 20: *Cheeki Rafiki*'s indicative courses and speeds made good obtained from its Iridium satellite telephone recorded positional data between 14 May and 16 May 2014

2.9 SEARCH AND RESCUE

2.9.1 Alerting

No alert was received from *Cheeki Rafiki*'s EPIRB, possibly because it could not be retrieved from inside the vessel following the rapid capsize and consequent inversion after the keel detached from the hull. Under the SCV Code, Category 0 vessels are required to have EPIRBs installed in an easily accessible location from which they can float free should the vessel sink. However, if not practicable, the SCV Code permits stowage in a position where it cannot float free. The float-free requirement might not have applied to *Cheeki Rafiki*, if it had been coded as a Category 0 vessel, as there were fewer than 16 persons on board.

Despite there being no requirement for their carriage, the PLBs owned by the skipper and the mate, and registered with the MCA, provided the only means of alerting the emergency services to the accident.

A benefit of a PLB is that it is small enough to be carried on a person and be immediately available at all times. It is therefore a very useful additional means of raising the alarm in an emergency. However, unlike an EPIRB, many types of which are designed to float and automatically transmit once in contact with water, a PLB must be manually operated and held clear of the water with its antenna vertical for it to be able to transmit effectively.

The skipper's PLB was operated first and transmitted for 2 hours and 36 minutes. The mate's PLB was activated 12 minutes before the last alert was received from the skipper's PLB, and continued to transmit for 20 hours and 7 minutes. It is unknown why neither PLB transmitted for its design minimum of 24 hours. However, in the wind and sea conditions following *Cheeki Rafiki*'s loss, manually operating a PLB and then holding it in the required position for a substantial period of time would have been difficult. Furthermore, although provided with a buoyancy pouch and lanyard, the PLB would have sunk if it had been removed from its pouch and inadvertently dropped without being attached.

2.9.2 Termination of initial search and rescue effort

As part of its investigation, the MAIB examined the circumstances in which the initial SAR effort was terminated. The remote location of *Cheeki Rafiki*, approximately 720 miles east-south-east of Nova Scotia in the Atlantic Ocean, rendered it necessary for the search to be conducted using fixed-wing aircraft. It is now known that *Cheeki Rafiki*'s liferaft was not deployed when the vessel capsized. Consequently, the aircraft crews needed to sight survivors in the water to confirm their location prior to dropping survival equipment from the aircraft. To have dropped survival equipment without first having sighted a person in the water ran the risk of the equipment being out of reach of any survivors, and then unavailable for dropping from the aircraft should a survivor be subsequently located.

The IAMSAR Manual suggests a 50% survival time for a normally-clothed person in water temperature of 15ºC is 6 hours, and recommends a search time of 18 hours. This can be extended to 60 hours if the person has access to a PFD and/or liferaft, unless adverse conditions prevail, or longer if the person had been able to climb out of the water. The IAMSAR Manual also indicates that a realistic upper limit of survival time for a person wearing normal clothing in water temperature of 15ºC is 25 hours.

Although the mate's PLB continued to provide positional data until 2248 on 16 May, and to alert until 0236 on 17 May, 22 hours and 31 minutes after the skipper's first PLB alert, the search aircraft crews were unable to sight any persons in the water or a liferaft during that period.

The initial SAR effort was terminated at 0940 on 18 May, 53 hours and 35 minutes after receipt of the first PLB alert. Although it was not known when the initial SAR effort ceased that *Cheeki Rafiki*'s liferaft had not been deployed, RCC Boston had calculated the chance of the liferaft being detected during the search period as 'high' (see section 1.3.3). As the liferaft had not been found, any crew who had successfully abandoned the yacht as it capsized would therefore have been in the water. As such, the search time far exceeded RCC Boston's estimated survival time for a person in the water, and was in the order of that recommended in the IAMSAR Manual for the prevailing circumstances.

2.9.3 Liferaft availability

RCC Boston calculated the probability of success of finding a person in the water with a PFD was only 6%. Given the difficulty of a person in the water being sighted from a fixed-wing aircraft, and the potential delay for surface SAR assets to arrive on scene in a remote part of the Atlantic Ocean, the survival of *Cheeki Rafiki*'s crew was largely dependent on being able to deploy a liferaft in addition to activating an alert.

As a Category 2 coded vessel, *Cheeki Rafiki* was not required to have its liferaft stowed on deck and fitted with float-free arrangements so as to be able to float free and inflate automatically. Instead, the liferaft was stowed aft of the helm position, in accordance with the vessel's design, and was not removed from its stowage position prior to or following the vessel's capsize and inversion. However, it seems that some attempt had been made to prepare the liferaft for deployment since its securing straps and associated bench seat section appear to have been removed.

Removal of the liferaft from its stowage position could have resulted in it becoming a significant hazard to the crew as a result of its potential movement within the cockpit area. For the liferaft to have been useful in the event of the vessel capsizing and inverting, it would have first needed to be deployed and inflated, which would have run the risk of it being carried away in the prevailing wind and sea conditions. Accessibility of a liferaft in the event of an inversion is currently required by the SCV Code only in respect of a sailing multihull vessel.

Following *Cheeki Rafiki*'s capsize and inversion, the crew were reliant on either being able to access the liferaft or it floating free from the vessel. Neither was possible due to the liferaft's stowage position.

A Category 0 coded vessel is required to have its liferafts stowed on the weather deck or in an open space, and fitted with float-free arrangements so that the liferafts float free and inflate automatically. While the nature of *Cheeki Rafiki*'s inversion would probably have rendered a hydrostatic release unit (normally used in float-free arrangements) ineffective because of insufficient immersion, stowing the liferaft in an open space might have provided the crew of *Cheeki Rafiki* with a more realistic chance of manually deploying the liferaft following the accident.

Liferaft stowage on small vessels is particularly challenging as weather decks can be frequently awash, running the risk of liferafts being lost overboard. However, in the event of a yacht capsizing and inverting in circumstances in which survival is dependent on liferaft availability, it is vital that every effort is made to ensure that they remain readily accessible and capable of being deployed for use quickly and easily.

2.10 FATIGUE

In the absence of key witness evidence, the extent to which those on board *Cheeki Rafiki* were fatigued at the time of the accident is uncertain. However, they were almost 12 days into the voyage, had been experiencing progressively worsening weather conditions, and had been attempting to identify and address a source of water ingress for up to 42 hours prior to the first PLB alert. It is therefore probable that they were fatigued and that their performance was impaired accordingly.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES RELATING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. It is difficult to readily identify areas where a matrix detachment has occurred in GRP yachts manufactured with a matrix bonded to the hull. This is especially the case where the keel is not removed prior to inspection and where floors have been layed up between frames. [2.3]

2. It is possible that some of *Cheeki Rafiki*'s reported 'light' groundings could have significantly affected the integrity of the matrix attachment in way of the keel. [2.4]

3. A skipper's perception that the force of a particular grounding is insufficient to raise concern does not necessarily mean that significant damage has not occurred to the keel and/or the vessel's structure. [2.4]

4. False indications may be obtained when hammer testing to identify matrix detachment, particularly in the area around the keel washer plates, owing to the clamping effect of the keel bolts and where the rig has been tensioned to cause compression of the matrix/hull attachment. [2.5]

5. There is currently no industry-wide guidance on appropriate methods for identifying matrix detachment and conducting repairs, or on the circumstances that would necessitate keel removal. [2.5]

6. Matrix detachment had previously occurred in *Cheeki Rafiki*, probably in bays immediately either side of the bays where the keel was bolted to the hull. It is therefore possible that detachment had also occurred in way of the keel but had not been detected because of the clamping effect of the keel bolts. [2.5]

7. Had *Cheeki Rafiki*'s structure where the keel was attached to the hull been weakened as a consequence of previous groundings, this might have allowed movement of the keel due to transverse loading in the prevailing sea state, resulting in its becoming detached from the hull. It is also possible that the keel bolts had deteriorated. [2.8.1]

8. It is probable that the increasing risk of *Cheeki Rafiki*'s keel becoming detached and the danger of continuing on the same approximate course without reducing speed had not been recognised. [2.8.2]

9. Given the remote location of *Cheeki Rafiki* at the time of its loss, the crew's survival was largely dependent on being able to deploy to a liferaft in addition to activating an alert. [2.9.3]

10. In the event of a yacht capsizing and then inverting in circumstances in which survival is dependent on liferaft availability, it is vital that every effort is made to ensure that a liferaft remains readily accessible and capable of being deployed for use quickly and easily. [2.9.3]

3.2 OTHER SAFETY ISSUES RELATING TO THE ACCIDENT[8]

1. It is possible for matrix detachment to occur in GRP yachts manufactured with a matrix bonded to the hull, resulting in loss of structural strength. The probability of this occurring will increase with more frequent and harder yacht usage. [2.3]

3.3 OTHER SAFETY ISSUES THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. The practice of allowing a vessel to ground during training and examinations has the potential for candidates to underestimate the likely consequences of grounding. [2.4]

2. Given the wide scope for interpreting when a vessel is or is not a commercial vessel, there is a need for the MCA to provide more explicit guidance about circumstances under which commercial certification for small vessels is required, and when it is not. [2.6.1]

3. The absence of a formal verifiable inspection procedure for the conduct of annual examinations to be undertaken by a nominated competent person at Stormforce Coaching gives rise to some uncertainty as to the thoroughness of those examinations. [2.6.2]

4. Had published routing guidance been fully heeded, an alternative route might have been planned for *Cheeki Rafiki*'s trans-Atlantic Ocean crossing that avoided higher latitudes and their associated weather phenomena, while still being able to effect a timely passage. [2.7.1]

5. Although the conditions prevailing at the time of *Cheeki Rafiki*'s loss were theoretically within the design parameters of the yacht, it would have been prudent to have taken action to avoid the forecast high winds and rough seas. [2.7.2]

6. Not specifically required by ISO 10240, *Cheeki Rafiki*'s Owner's Manual did not identify the keel area as a potential source of water ingress or provide advice on how to address such an event. [2.8.2]

7. Although the ISAF Model Training Course Offshore Personal Survival syllabus covers the responsibilities and required actions of a skipper with regard to damage control and repair, it is not mandatory for training centres to follow the model course syllabus. Therefore, an ISAF Offshore Safety Course attendee may not necessarily acquire the relevant knowledge. [2.8.2]

3.4 OTHER SAFETY ISSUES[8]

1. The Beneteau First 40.7 keel washer plates would have needed to be 3mm thicker and 3mm wider for the design, incorporating only one 14mm bolt, to fully meet ISO 12215-9, today's harmonised ISO standard for keel design and attachment. [2.3]

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[8] These safety issues identify lessons to be learned. They do not merit a safety recommendation based on this investigation alone. However, they may be used for analysing trends in marine accidents or in support of a future safety recommendation

2. A vessel complying with the SCV Code would have required Category 0 coding for the eastbound trans-Atlantic Ocean crossing. With modification, it would have been possible for *Cheeki Rafiki* to have achieved Category 0 coding. Category 0 coding requirements would have included:

   - Annual examinations to be conducted by an authorised person on behalf of the certifying authority.

   - One additional person on board to hold at least an RYA/MCA Yachtmaster Ocean or Yachtmaster Offshore certificate of competence.

   - If practicable, an EPIRB to be installed in an easily accessible location and capable of floating free and activating automatically if the vessel sinks.

   - Liferafts to be stowed on the weather deck or in an open space, and installed so they can float free and inflate automatically. [2.6.2, 2.6.3, 2.9.1, 2.9.3]

3. *Cheeki Rafiki*'s Category 2 certification was allowed to lapse, and so no authorised person had examined the vessel since its coding survey in 2011. It is possible that any indications of a potential structural problem might have been identified had the annual examinations required by the SCV Code been conducted by an authorised person. [2.6.2]

4. The absence of a formal structural inspection requirement within the ISAF OSR allows the potential for chartered or commercially operated vessels to operate without any structural inspection by an authorised person ever being carried out. [2.6.2]

5. Had an additional person on board *Cheeki Rafiki* held an RYA/MCA Yachtmaster Ocean or Yachtmaster Offshore certificate of competence, the skipper would have had a suitably qualified and experienced person immediately available with whom he could have consulted on matters relating to the passage, weather and subsequent events. [2.6.3]

6. It is unknown why neither the skipper's nor the mate's PLB transmitted for its design minimum of 24 hours. However, in the wind and sea conditions following *Cheeki Rafiki*'s loss, manually operating a PLB and then holding it in the required position for a substantial period of time would have been difficult. [2.9.1]

SECTION 4 - ACTION TAKEN

The **Marine Accident Investigation Branch** has:

- During the investigation, made the following recommendation to the RYA, which the RYA has accepted:

  2014/159 *Bring to the attention of its instructors, examiners and other members, the risk posed to yachts of keel failure as a consequence of structural weakening that can occur as a result of repeated minor groundings.*

- Issued a Flyer to the Leisure Industry **(Annex L)**.

The **Maritime and Coastguard Agency** has:

- Undertaken to work with the Royal Yachting Association to clarify the requirements for the stowage of inflatable liferafts on coded vessels for inclusion in new workboat and non-workboat codes.

The **Royal Yachting Association** has:

- Drafted enhancements to its Sea Survival Handbook at the next reprint. These advise that in the event of a keel failure a yacht's rapid capsize and inversion is possible, outline the potential cause of keel failure and how it can be avoided, and suggest actions that can be taken when there is concern over the security of a keel.

Stormforce Coaching has:

- Made the following changes to its internal policies/taken the following action:
  - All staff and crew on races or motor/sail training courses who travel more than 60 miles from a safe haven are required to carry a PLB.
  - An external professional weather forecaster and router is to be engaged for ocean passages.
  - In addition to regular visual inspections and inspection following a grounding, all ocean-going yachts are to undergo an annual third-party external survey.
  - Unless participating in a race, yachts on ocean passages are to endeavour to sail in close company with another yacht, with skippers establishing a formal reporting schedule prior to departure.
  - Liferaft stowage locations on all newly acquired yachts that will spend extended periods more than 60 miles from a safe haven are to be reviewed to ensure that the liferaft can be launched in the event of an inversion.
  - Where appropriate stowage is available, existing 12-person capacity liferafts on yachts capable of venturing offshore are to be replaced with two 6-person capacity liferafts.

- ◦ Rudders on sailing yachts capable of venturing offshore are to be painted day-glow orange to assist with their location in the event of an inversion.

- ◦ Lifejackets with retrofitted spray hoods carried on yachts that are likely to venture more than 60 miles from a safe haven have been replaced with new 190N lifejackets fitted with an integral spray hood.

- ◦ A second EPIRB in a float-free location has been fitted on yachts that are likely to venture more than 60 miles from a safe haven.

- ◦ All fleet maintenance reporting, recording and planning are now managed using online cloud-based software.

- ◦ An ‘out of the water hull inspection’ policy is now documented in the company’s operations manual.

The **British Marine Federation** has:

- Submitted a suggestion for discussion at the next systematic review of ISO 10240 (Small Craft-Owner’s manual) to the effect that the Owner’s Manual should state that, in the case of a grounding, a full assessment/survey needs to be completed.

SECTION 5 - RECOMMENDATIONS

The **British Marine Federation** is recommended to:

2015/117 Co-operate with certifying authorities, manufacturers and repairers with the aim of developing best practice industry-wide guidance on the inspection and repair of yachts where a GRP matrix and hull have been bonded together.

The **British Marine Federation** and **Chantiers Beneteau SA** are recommended in collaboration to:

2015/118 Propose to the International Organization for Standardization that the requirements for '*information connected with the risk of flooding*' and '*other information*' detailed in ISO 10240 (Small craft - Owner's manual) be enhanced to include:

- The keel area as a potential source of water ingress on vessels where the keel has been attached to the hull.
- Guidance on the action to be taken in responding to flooding events.
- Warning of the potential consequences of running aground, and the need to carry out an inspection following any grounding incident, taking into account the danger of potential unseen damage, particularly where a GRP matrix and hull are bonded together.

The **Maritime and Coastguard Agency** is recommended to:

2015/119 Issue operational guidance to owners, operators and managers of small commercial sailing vessels, including:

- The circumstances in which a small vessel is required to comply with the provisions of the SCV Code and those in which it is exempt from compliance.
- Management responsibilities and best practice with regard to:
    - vessel structural inspection and planned maintenance by competent personnel, particularly prior to long ocean passages,
    - passage planning and execution, including weather routing,
    - the provision of appropriate lifesaving equipment, including liferafts, EPIRBs and PLBs, and the extent to which they should be float-free and/or readily available, and
    - the provision of onboard procedures, including the action to be taken on discovering water ingress.
- The need for an inspection following any grounding, taking into account the danger of potential unseen damage, particularly where a GRP matrix and hull have been bonded together.

2015/120 Include in the SCV Code a requirement that vessels operating commercially under ISAF OSR should undergo a full inspection to the extent otherwise required for vessels complying with the SCV Code.

The **Royal Yachting Association** is recommended to:

2015/121 Issue advice to owners and skippers of pleasure yachts, and to the yachting community in general, that:

- Raises awareness of the potential consequences of running aground, and the need to carry out an inspection following any grounding incident, taking into account the danger of potential unseen damage, particularly where a GRP matrix and hull have been bonded together.

- Highlights the benefits of regular inspections of a vessel's structure, the carriage of qualified persons on board, float-free lifesaving equipment, and the carriage of PLBs.

2015/122 Require its approved training centres providing the ISAF Offshore Safety Course to follow the ISAF Model Training Course Offshore Personal Survival syllabus.

The **International Sailing Federation** is recommended to:

2015/123 Issue advice to owners and skippers of pleasure yachts, and to the yachting community in general, that:

- Raises awareness of the potential consequences of running aground, and the need to carry out an inspection following any grounding incident, taking into account the danger of potential unseen damage, particularly where a GRP matrix and hull have been bonded together.

- Highlights the benefits of regular inspections of a vessel's structure, the carriage of qualified persons on board, float-free lifesaving equipment, and the carriage of PLBs.

Marine Accident Investigation Branch
April 2015

Safety recommendations shall in no case create a presumption of blame or liability

Marine Accident Report

INVESTORS IN PEOPLE