



**The Bahamas  
Maritime Authority**

## **THE COMMONWEALTH OF THE BAHAMAS**

### **FOUR C'S ADVENTURES 37ft Aluminium Catamaran 'Unnamed'**



**Report of the marine safety investigation into an explosion resulting in loss of life and multiple serious injuries on board a 37ft charter boat at Exuma, Bahamas on 30 June 2018**

## 37ft Charter Boat – Marine Safety Investigation Report

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

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

*The United States of America (USA) registered their participation as a Substantially Interested State and the following USA agencies provided assistance to The Bahamas Maritime Authority:*

- *United States Coast Guard (USCG),*
- *National Transportation Safety Board (NTSB), and*
- *The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) which is a federal law enforcement organization within the United States Department of Justice.*

*The Bahamas Maritime Authority would like to express its appreciation to the above organisations for their expertise and assistance throughout the course of this investigation. In addition, the BMA would like to express its appreciation to the Royal Bahamas Police Force.*

Date of Issue: 01 October 2018  
Bahamas Maritime Authority  
120 Old Broad Street  
LONDON  
EC2N 1AR  
United Kingdom

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# 1 GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BMA	Bahamas Maritime Authority
BMID	Bahamas Maritime Investigations Department
ft	feet
HP	Horsepower
ISO	International Standards Organization
Kts	Nautical mile per hour
m	meters
mJ	Milli Joule
MJ	Mega Joule
NM	Nautical mile
NTSB	National Transportation Safety Board
Port Department	Port Department of the Bahamas
USCG	United States Coast Guard
UTC	Universal Time Coordinated
SIS	Substantially Interested State
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
“	Inch

All times noted in the report are given in the style of the standard 24-hour clock without additional annotation and as local time in the Bahamas, which was UTC -4.

## 2 SUMMARY

- 2.1 The Bahamas Maritime Authority (BMA) were instructed to conduct an independent marine safety investigation into this very serious marine casualty by the Bahamas Minister of Transport and Local Government on 06 July 2018.
- 2.2 On 30 June 2018, ten passengers and two crew boarded the 37foot (11.3 metre) aluminium catamaran at Barratarre, Great Exuma for a half day boat tour of The Exuma Cays and the surrounding area.
- 2.3 Shortly after setting off, a large explosion took place in the vicinity of the starboard pontoon near the middle of the boat. This led to two passengers being ejected from the boat, two passengers trapped beneath the debris while the remaining passengers and crew managed to evacuate the boat before the boat was engulfed in fire.
- 2.4 As a result of the explosion, there was one loss of life and multiple very serious injuries sustained by the passengers on board. There was no severe damage to the marine environment.
- 2.5 The BMA investigation identified that a large explosion had occurred in vicinity of the starboard permanently installed fuel tank located towards the middle of the starboard pontoon and beneath the deck plate on which the passenger seating was arranged. The investigation also identified that:
  - i The 37ft aluminium boat was not registered with Port Department of the Bahamas and had never undertaken a Port Department inspection required under national legislation.
  - ii The fuel fill and vent hose did not meet the required specification for its intended purpose.
  - iii The boat was not constructed in accordance with any standard or to any naval architectural or technical drawings.
  - iv The construction materials used could not be verified for suitability of use in the marine environment.
- 2.6 All recommendations have been made to the Owner of Four C's Adventures and the Port Department of the Bahamas with the aim of improving safety and reducing the recurrence of very serious marine casualties.

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### 3 DETAILS OF INVOLVED VESSEL(S) AND OTHER MATTERS

#### 3.1 Details of vessel

3.1.1 The unnamed boat of 37ft in length, referred from now on in the report as ‘37ft Boat’ was owned and operated by the Owner of Four C’s Adventures, a charter boat service company operating from Barratarre, Great Exuma, The Exuma Cays.

3.1.2 Four C’s Adventures operates several boats for the purpose of providing local tours of Exuma and the surrounding islands predominantly to tourists visiting the island(s) of Exuma. The exact number of boats owned and operated could not be confirmed by the Owner. The marine safety investigator sighted one catamaran of approximately 45ft docked in Barratarre, one mono-hull speed boat of fibreglass construction and a smaller (approximately 30ft) catamaran of aluminium construction at the Owner’s registered business address in Stuart Manor, Exuma and a fourth boat of approximately 60ft in length under construction at the same address. The Owner informed the marine safety investigator that a fifth boat was being painted locally on the island, constructed out of fibreglass and is of 36ft in length identified as a Palmetto design speed boat.

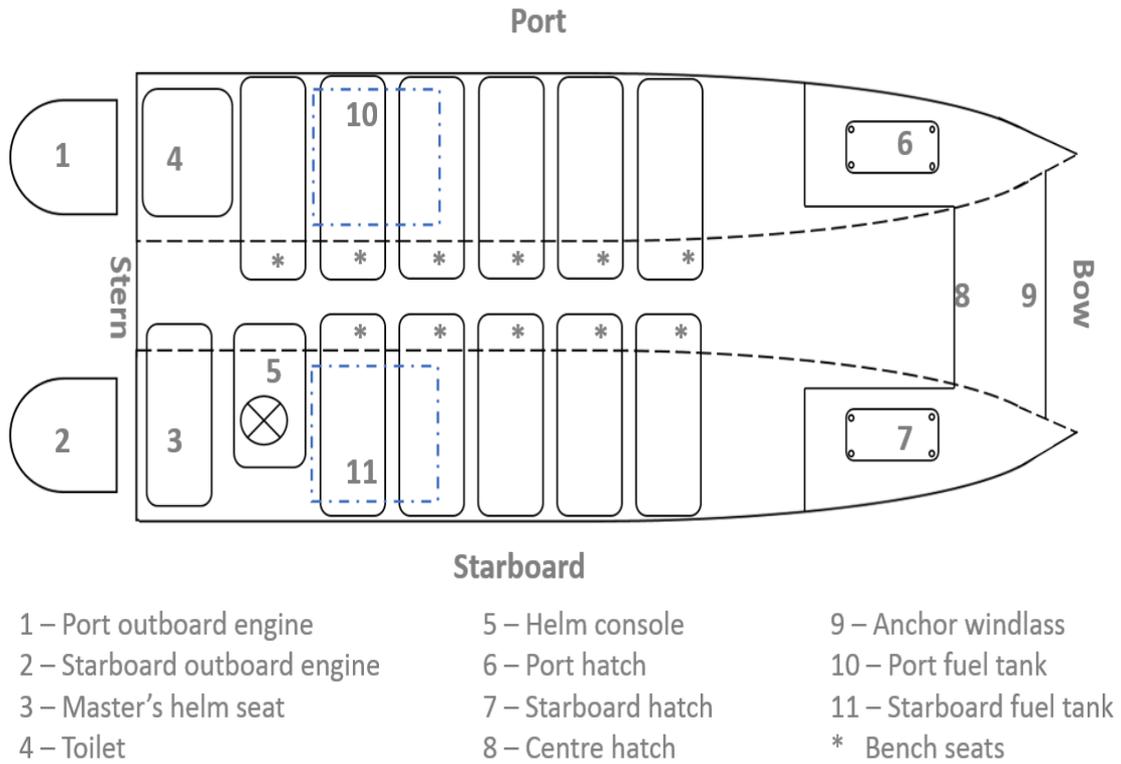
3.1.3 The 37ft Boat had the following principal particulars:

Built	2016, Stuart Manor, Exuma
Builder	Four C’s Adventures
Owner	Four C’s Adventures
Design	Aluminium catamaran (no design specification)
Length overall	11.3 metres (37 feet)
Breadth	3.81 metres (12.5 feet)
Depth moulded	1.4 metres (4.6 feet)
Propulsion	2 x Yamaha outboard engines Serial No Port: 1043991 Serial No. Starboard: 1003326 Manufactured 2012
Propulsion power	600hp (2x 300hp)

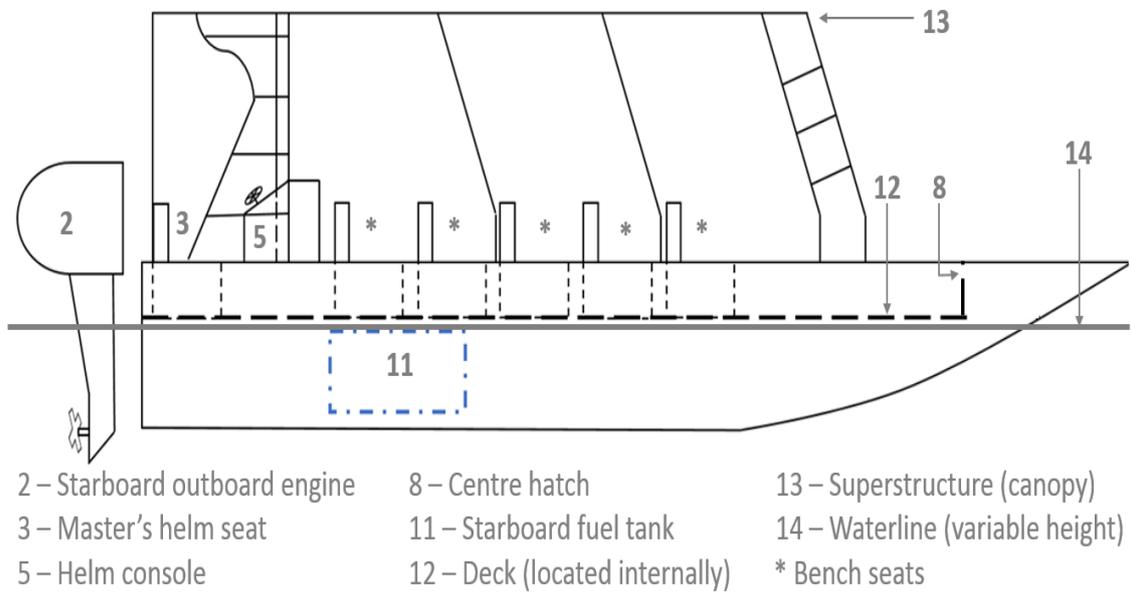
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Gross tonnage	3.4 tonnes
Fuel tank capacity	2 x 120-gallon fuel tanks (240 gallons)
Fresh water tank	1 x 40-gallon tank
Batteries	2 x 12 DC volt (in parallel)

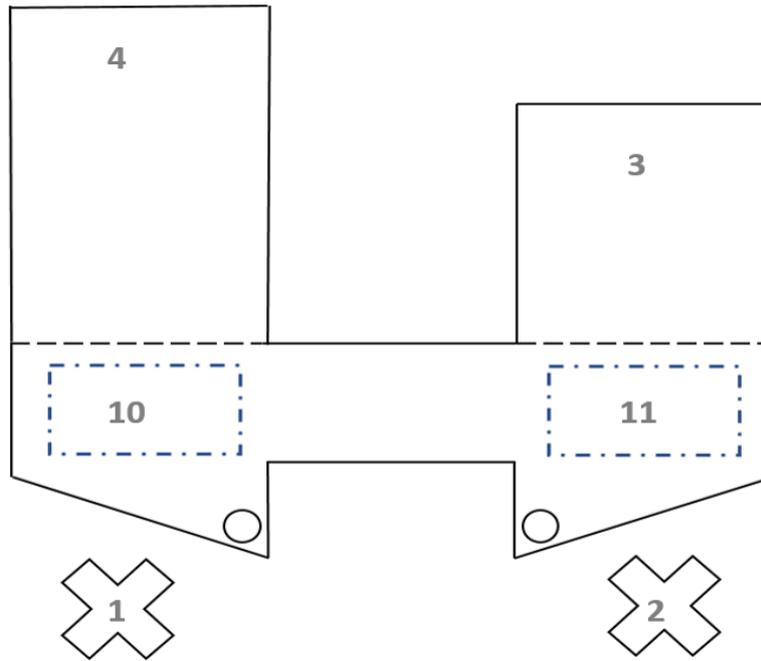
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**Figure 1: BMID illustrated structure – view from above**



**Figure 2: BMID illustrated structure – view from starboard side**



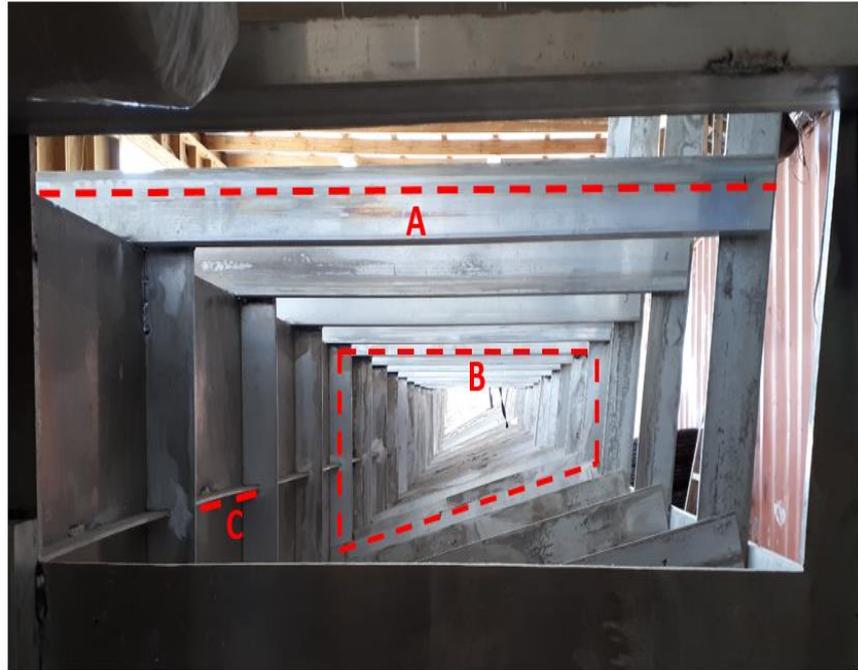
- |                          |                               |
|--------------------------|-------------------------------|
| 1 – Port outboard engine | 2 – Starboard outboard engine |
| 3 – Master’s helm seat   | 4 – Toilet                    |
| 10- Port fuel tank       | 11 – Starboard fuel tank      |

**Figure 3: BMID illustrated structure – view from the rear (transom)**

### 3.2 Construction Method

- 3.2.1 The photograph within figure 4 was taken by the marine safety investigator of the 60ft catamaran under construction at the Owners registered business address. It was confirmed by the Owner that this boat and the subject boat of this investigation are constructed using identical techniques.
- 3.2.2 The hull is constructed entirely of aluminium. The aluminium plates used in the construction process are of three thicknesses, namely; 3/16” plates for the side plating and cockpit deck, 1/4” bottom plating and 1/2” plates for the transom. The plates are Tungsten Inert Gas (TIG) welded to a transverse frame (B) constructed out of 2” and 1” angle bars. Each pontoon was framed using a ‘D’ frame configuration with each transverse frame spaced approximately two feet apart. A longitudinal stiffener (C) is used to provide longitudinal strength. Multiple transverse beams (A) of 4”x2” are used across the entire width of the boat joining the port and starboard transverse frames in which the cockpit deck is welded to. The centre hull section of the boat is constructed out of 1/4” aluminium plates and welded to the inner most transverse frame and the underside of the transverse beam.

A - Transverse beam  
B - Transverse frame ('D' frame)  
C - Longitudinal stiffener



**Figure 4: Internal starboard pontoon structure of 60ft catamaran under construction, looking forward from the transom**



**Figure 5: Photograph of the actual starboard pontoon of the 37ft Boat after the explosion and fire – transverse beam (A), partial transverse frame (B) and longitudinal stiffener (C)**

3.2.3 The superstructure (commonly referred to as a canopy) providing sun shade for the seating area is constructed from 3/8” aluminium plates screwed onto 2”x1” and 3”x1” aluminium tube frames, the under side of which can be seen

in figure 6. This is held in position by 12 anodized aluminium 1” tubes welded to the top of the boat’s freeboard (topside), as seen in figure 8.

D – 3”x1”  
External and  
centre support  
tube frame

E – 2”x1”  
Internal tube  
frame

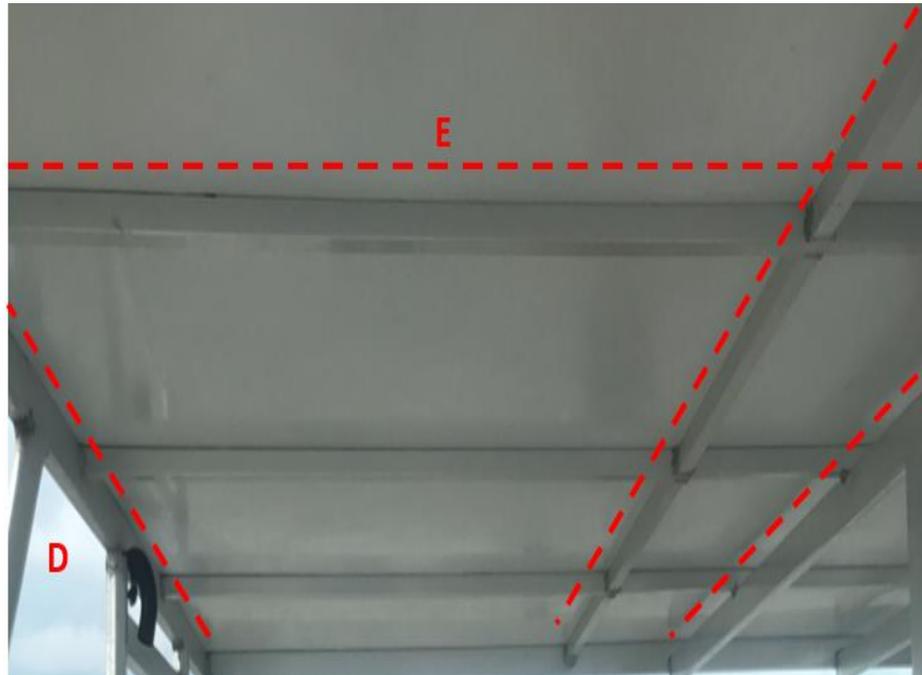


Figure 6: Underside of superstructure (canopy)

G – 3”x1”  
Vertical support  
(centreline)

F – 1” External  
support

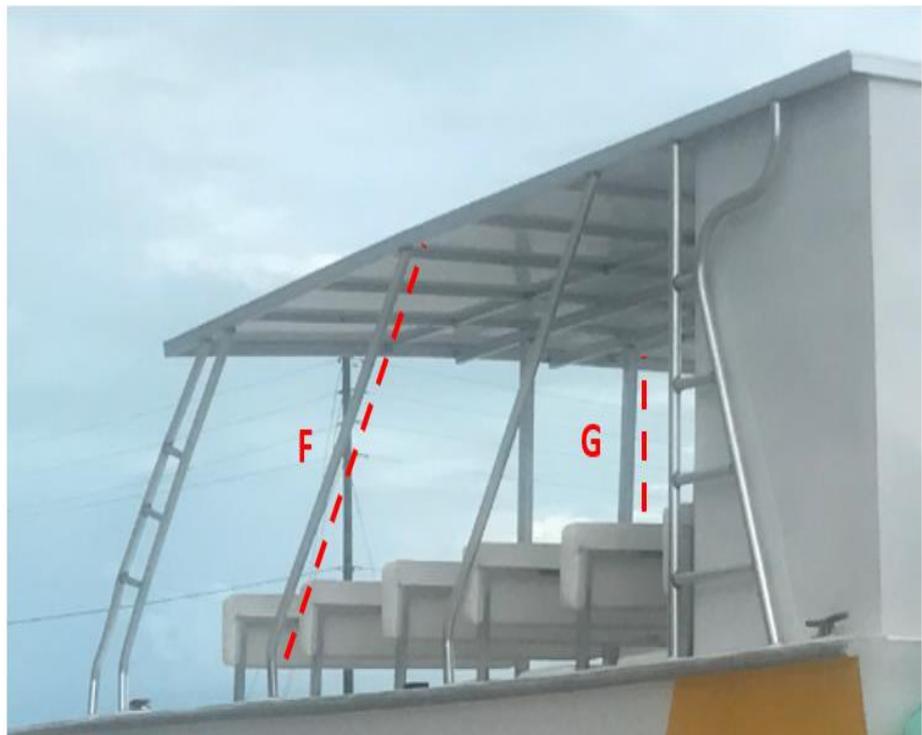


Figure 7: Port side view of superstructure and supporting frame



**Figure 8: Vertical tubes supporting superstructure and secured to topside**

- 3.2.4 The 37ft Boat was constructed in 2016 by the Owner with the assistance of an apprentice<sup>1</sup> welder. The marine safety investigator was informed that the boat was not designed or constructed to any international standard. The boat was constructed using templates designed and manufactured by the Owner and no technical drawings were used in the construction process.
- 3.2.5 The boat had the seating capacity for 33 passengers, displaced on 11 bench seats with 3 persons to each seat. Two crew would operate the boat, one crew assigned as the Master and the second crew member referred to as the Mate. The boat was also fitted with a hand-pump toilet located on the port quarter (left corner) of the boat within an aluminium panelled structure.

### **3.3 Boat Registration**

- 3.3.1 The boat was not registered with Port Department. There are no records of the 37ft boat held with the Port Department locally in Exuma or in Nassau, nor could any record of registration or an application for registration be provided by the Owner during the course of the investigation.
- 3.3.2 Boats subject to the Commercial Recreational Watercraft Act, 2006 are required to undergo an inspection by the Port Department as part of the boat registration process and an annual inspection every year thereafter. There was no record held by the Port Department of a registration inspection or annual inspection for this boat.

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<sup>1</sup> Apprentice welder was referred to within the condition of hull and machinery survey conducted on 02 February 2017 by CBA Engineering Ltd.

### 3.4 Crew Qualifications

- 3.4.1 The Master (42 years of age) of the boat held a valid Form IV Class B<sup>2</sup> Boat Master's Licence for the Commonwealth of the Bahamas under the Boat Registration Act 1961, valid from 31 March 2018. The boat license allows the Master to operate only in the waters of Exuma and The Exuma Cays.
- 3.4.2 The Master held an Elementary First Aid, Personal Survival Techniques, Fire Prevention and Fire Fighting, and Personal Safety and Social Responsibilities certificate meeting the requirements of STCW 95 Code section A- VI/I paragraphs 2.1.1.1, 2.1.1.2, 2.1.1.3 and 2.1.1.4. and valid at the time of the incident. In addition, he held a valid certificate in Basic Navigation meeting the requirements laid down in STCW 95 Regulations A-II/4.
- 3.4.3 The Mate (12 years of age) was the son of the Owner and held no qualifications or endorsements.
- 3.4.4 The Boat Registration Act 1961 stipulates the provisions required of a Master of a boat for hire, which states:
- i. the applicant is conversant with the International Rules and Regulations for Prevention of Collisions at Sea;
  - ii. the applicant is capable of handling his boat in a safe and seamanlike manner;
  - iii. in the event of no engineer being carried on the boat, the applicant is capable of carrying out running maintenance and minor repairs;
  - iv. the applicant has a basic knowledge of first aid; and
  - v. in the case of an applicant who is desirous of acting as a master of a boat registered to operate in all the harbours and waters of The Bahamas, and in any other case where the Authority shall deem it necessary, the applicant has an adequate knowledge of pilotage and navigation.
- 3.4.5 No provision exists within the Boat Registration Act 1961 stipulating the requirements for a Mate to be on board any boat for hire.

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<sup>2 2</sup> Form IV is a Bahamas Boat Master's Licence issued under The Boat Registration Act 1961. Categorisation Class 'B' is only valid for use in a particular harbour.

## 4 NARRATIVE OF EVENTS

- 4.1 On Friday 29 June, the day before the incident, the 37ft Boat had undertaken a day charter from 0930 to 1730. On arrival at the dock on completion of the charter, the passengers disembarked and the boat was loaded onto a trailer and taken out of the water. The drain plugs located on the lowest point of the transom were removed to allow any water accumulated throughout the day to be drained out of each pontoon.
- 4.2 The 37ft Boat was then cleaned by the crew in preparation for the next day's charter. No defects or faults were reported to the Owner on completion of the day's charter.
- 4.3 On the morning of 30 June, the boat was scheduled to undertake a charter with 10 passengers and 2 crew. The crew, consisting of the Master and Mate commenced loading the boat with provisions for the half day<sup>3</sup> charter.
- 4.4 Prior to entering the water, the boat was re-fuelled from the fuel pump facility located adjacent to the dock with gasoline<sup>4</sup>. Approximately 15 gallons of fuel was witnessed being added to the starboard fuel tank via the fuel filler cap located on the topside of the boat.



**Figure 9: Dock and pontoon at Barratarre, Great Exuma**

<sup>3</sup> A half day charter is from 0900 -1230 sailing approximately 20nm.

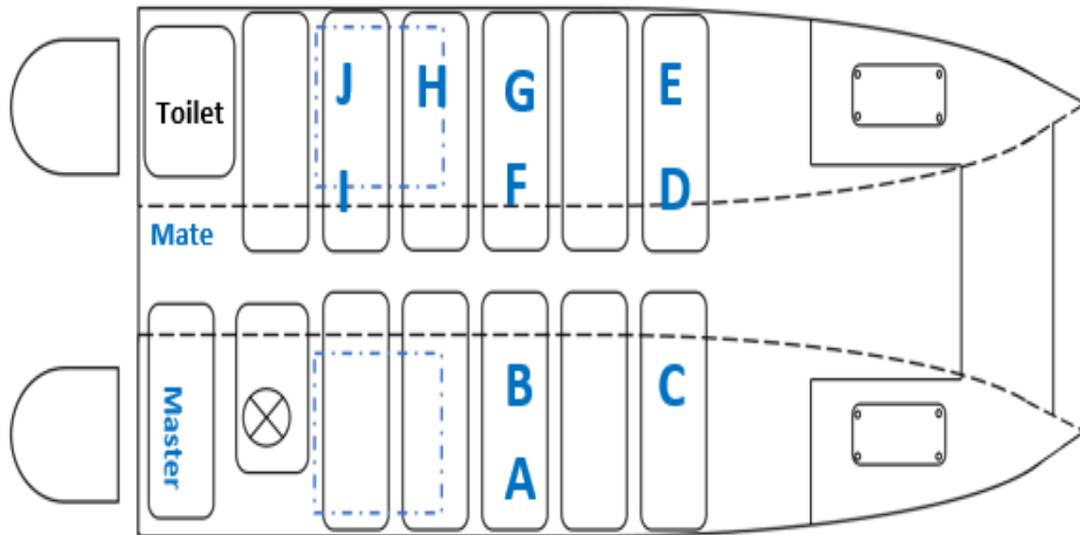
<sup>4</sup> Gasoline (US), or petrol (UK) is a transparent petroleum-derived liquid that was used as the fuel in the spark-ignited internal combustion engine onboard. It consists mostly of organic compounds obtained by the fractional distillation of petroleum, enhanced with a variety of additives.

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- 4.5 From approximately 0830, the 10 passengers (all United States citizens) arrived at Barratarre dock to commence the half day charter. The 10 passengers and 2 crew embarked on the boat and departed the dock at approximately 0900. The Master sailed the boat off the dock, no more than 20-30 yards before commencing a safety brief and discussion concerning the intentions for the morning's charter.
- 4.6 During this time the Master put the throttles into neutral allowing the boat to drift, underway but not making way.
- 4.7 On completion of the briefing to the passengers, the Master took the helm behind the helm console and the Mate stood next to the helm on the port side of the boat.
- 4.8 At approximately 0910, the Master increased speed using the throttles in order to get the boat on the plane<sup>5</sup>, this took approximately 15-30 seconds to achieve a speed in the region of 25kts. As the boat increased in speed, the bow lifted approximately 3-4ft as the boat passed over successive waves. It was recalled by one passenger that this occurred three or four times and was described as "*the natural movement of a boat whilst underway*".
- 4.9 Less than one minute later, a large explosion occurred in vicinity of the middle of the starboard pontoon. The force of the explosion resulted in the starboard pontoon lifting clear of the water before coming back down and resting in the water. The explosion was followed instantaneously by flames and an immediate deceleration of speed.
- 4.10 The testimony provided by those who witnessed the explosion from onboard, recalled the explosion was followed by flames across the deck of the boat and large quantities of debris consisting of aluminium deck plates, bench seats and the canopy structure either displaced or missing.

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<sup>5</sup> Planing is the mode of operation for a waterborne craft in which its weight is predominantly supported by hydrodynamic lift, rather than hydrostatic lift (buoyancy).



**Figure 10: The seating location of the 10 passengers and two crew at the point of the explosion**

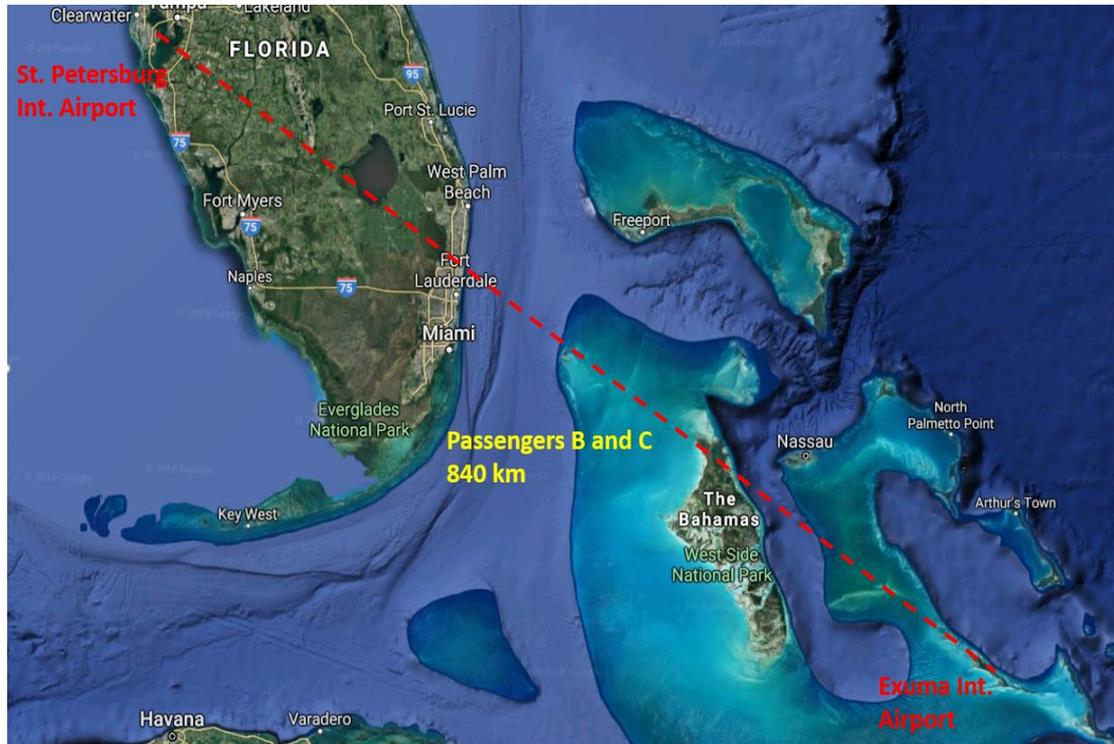
- 4.11 The Mate was stood next to the helm at the time of the explosion. Shortly thereafter he recalled having a bench seat being lifted off from on top of him by the Master and then being assisted off the boat on the port side.
- 4.12 The Master was heard by one witness shouting “*get off the boat*” before leaving the boat himself. According to one witness recollection, both engines were still running and in neutral whilst passengers were evacuating the boat but does not recall when the engines shut down.
- 4.13 As the Mate entered the water, he witnessed two female passengers in the water, approximately 100m astern of the boat. It was confirmed that one female passenger ‘A’, sat in the 3<sup>rd</sup> row of seats from the bow on the starboard side (outboard) and was ejected out of the boat to starboard by the force of the explosion. The second female passenger ‘D’ sat in the 1<sup>st</sup> row of seats from the bow on the port side (inboard) and was ejected out of the boat to port. The Mate witnessed passenger ‘D’ helping passenger ‘A’ in the water.
- 4.14 The remaining passengers who were able, jumped into the water which was approximately 4 feet in depth.
- 4.15 A number of charter boats were in the vicinity and witnessed the aftermath of the accident. One charter boat operated by Four C’s Adventures called ‘Big Cat’ and a small day fishing boat came to the aid of those passengers who had evacuated and were in the water. First aid was provided by passengers and boat crew from boats in the vicinity. A qualified medical Doctor was on board another boat as a passenger and provided additional first aid however was limited in the level of care that could be provided with the equipment available.

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- 4.16 Passenger 'B' was identified as being in the centre of the boat and unconscious with severe lower limb injuries. Passenger 'B' was then heard screaming by passenger 'I' who carried passenger 'B' to the small day fishing boat.
- 4.17 Passenger 'E' had received a serious injury above the neck and managed to get off the boat and onto the charter boat 'Big Cat'.
- 4.18 Passenger 'C' was identified as still being on the boat amongst the flames and beneath the debris. Two crew from an adjacent boat entered the water and made their way to the boat and pulled passenger 'C' from the wreckage. Passenger 'C' was then handed to passengers 'J' and 'I' who carried passenger 'C' to the charter boat 'Big Cat'. This boat, having recognized the severity and extent of injuries to passenger 'C' immediately proceeded to the dock at Barratarre with passengers 'C', 'J' and 'E' on board.
- 4.19 Subsequently, passengers 'I', 'A', 'G', 'F', 'D', 'B' and 'H' boarded the small day fishing boat and were transported to the dock at Barretarre.
- 4.20 On arrival at the dock at Barratarre, the charter boat 'Big Cat' reversed up to the slipway whereupon local workers and passengers from the boat gathered sheets of ply wood and wooden beams to rig a makeshift stretcher in order to transport passenger 'C' from the boat onto the rear of a pick-up truck which belonged to the company, Four C's Adventures. This vehicle then departed Barratarre and proceeded to the local hospital in the capital city George Town with passengers 'I', 'H', 'G', 'J', 'D', 'F', 'E', a driver and one additional passenger who was local to Exuma. The vehicle arrived at the local hospital approximately 30 minutes later where upon the injured were disembarked and met by two nurses.
- 4.21 Passengers 'A' and 'B' remained at Barratarre until the arrival of an ambulance which transported both passengers to the local hospital at George Town. The ambulance arrived at the dock approximately 40 minutes after the small day fishing boat arrived at the dock.
- 4.22 Passengers 'J' and 'I' requested a back-board in order to transition passenger 'C' from the rear of the vehicle into the hospital. Once a back-board was provided passenger 'J' and 'I' lifted passenger 'C' from the vehicle and onto the back board before helping the two nurses escort passenger 'C' into the trauma room.
- 4.23 Initially only two nurses were present in the hospital providing immediate first aid to the 8 passengers from the boat. A doctor arrived at the hospital approximately 40 minutes after the arrival of passenger 'C' at approximately 1120.
- 4.24 By approximately 1130, passengers 'A' and 'B' arrived at the hospital.
- 4.25 Passenger 'A' was assessed, and immediate medical treatment was provided however due to the extent and severity of injuries sustained, passenger 'A' died in George Town hospital shortly after arriving.

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- 4.26 At approximately 1300, passengers ‘C’ and ‘B’, accompanied by passenger ‘J’ were transitioned from the hospital trauma room into the rear of an ambulance and taken to Exuma airport where a USCG C130 medical transportation plane had arrived in order to medically evacuate passenger ‘C’ and passenger ‘B’ to Bay Front Trauma hospital, St Petersburg, Florida, United States.



**Figure 11: The route taken by the first USCG aircraft from Exuma**

- 4.27 Passengers ‘I’, ‘E’, ‘D’, ‘F’, ‘G’ and ‘H’ remained at the hospital and assessed for injuries where it was determined that passenger ‘D’ had severe internal injuries.
- 4.28 Passenger ‘J’ arrived back at the hospital where upon passengers ‘I’, ‘F’, ‘G’ and ‘H’ had been discharged and left the hospital to return to their accommodation to pack up their belongings and proceed to Exuma airport where a second USCG C130 aircraft would transport passengers ‘E’, ‘D’ and ‘F’ to Nassau for onward transportation to Princess Margaret hospital in Nassau.

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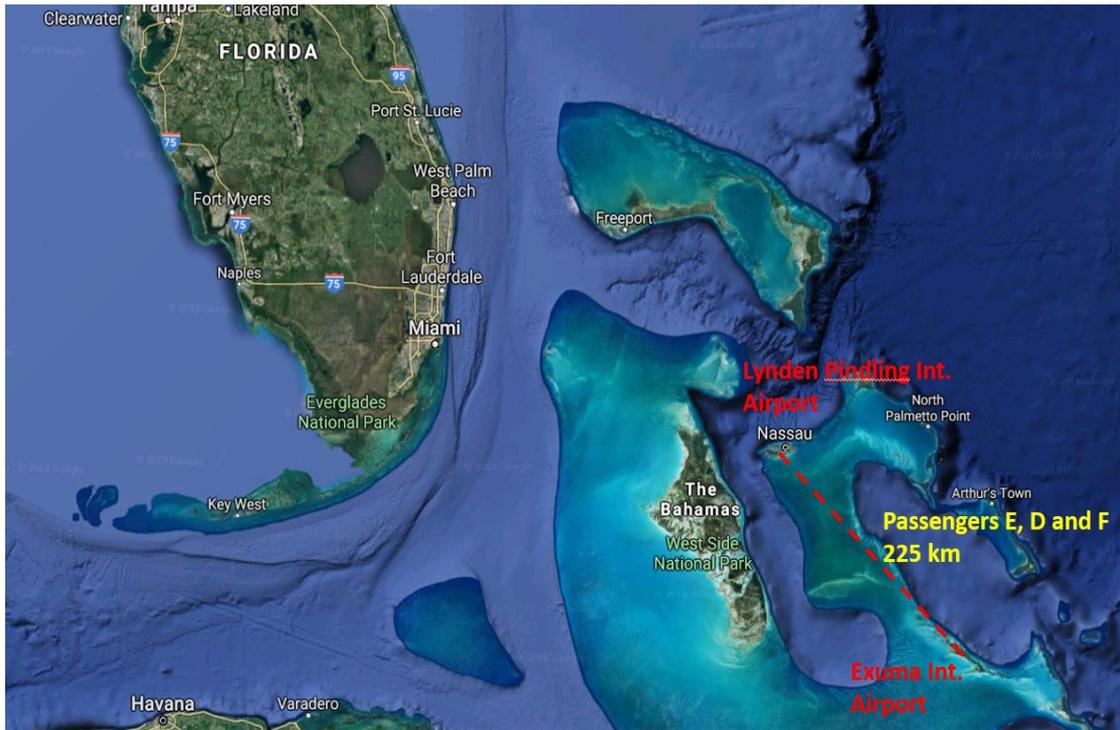


Figure 12: The route taken by the second USCG aircraft from Exuma

4.29 Shortly thereafter, a third USCG C130 aircraft transported passengers ‘G’, ‘H’, ‘J’ and ‘I’ to Bay Front Trauma hospital, St Petersburg, Florida.

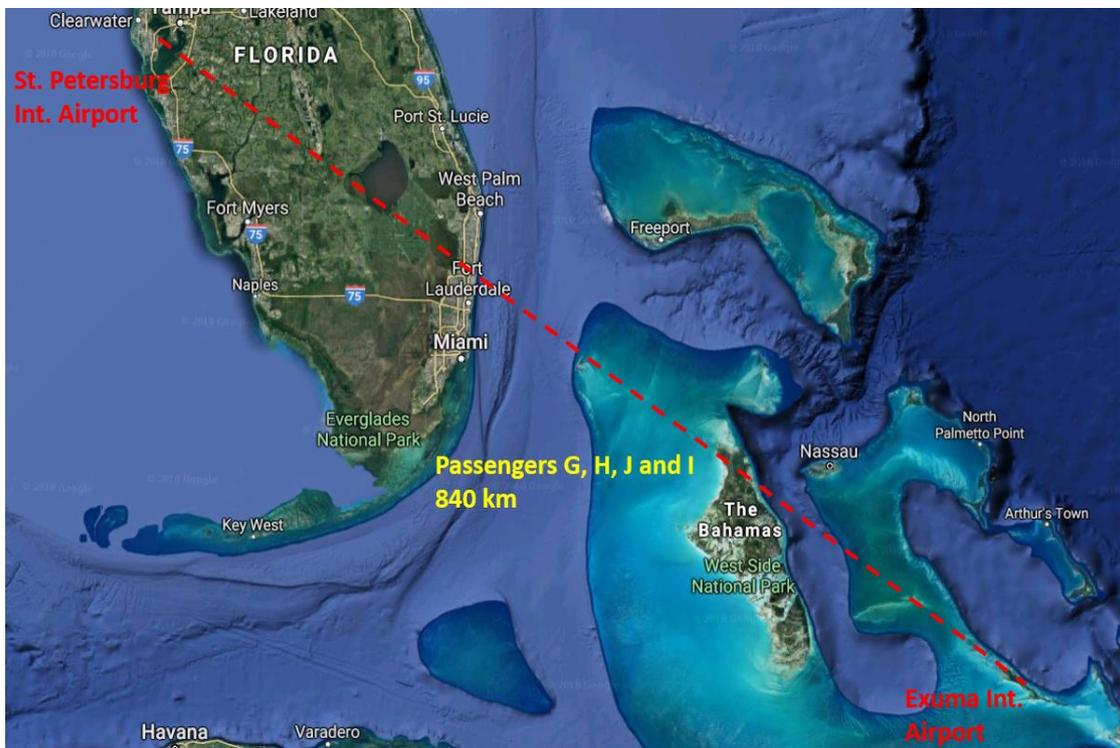


Figure 13: The route taken by the third USCG aircraft from Exuma

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## **5 ANALYSIS AND DISCUSSION**

### **5.1 Aim**

- 5.1.1 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.

### **5.2 Construction method**

- 5.2.1 The Owner of Four C's Adventures built the 37ft Boat in 2016 with the assistance of a welding apprentice. The catamaran design was chosen because of its shallow draught and wide beam allowing for maximum passenger occupancy whilst able to access the shallow waters surrounding Exuma.
- 5.2.2 No technical drawings were available to consult during the course of the investigation as the boat was not built to any standard<sup>6</sup> or specification. The boat was built using self-made templates before cutting and welding the aluminium around a wooden template to create the design. At no point during the build process was a qualified naval architect or certified marine surveyor consulted. Therefore, it cannot be known precisely what grade of aluminium and other materials were used in the construction process.

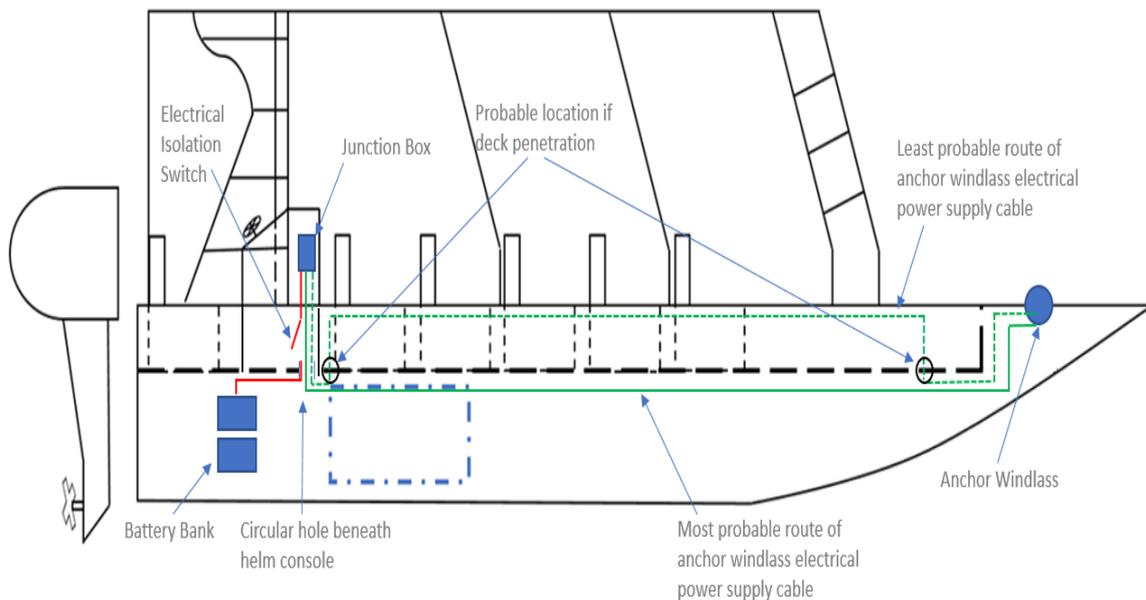
### **5.3 Electrical system**

- 5.3.1 The electrical power on board was provided from two 12-volt DC batteries (battery bank) connected in parallel and earthed to the hull via a metal copper strip from the negative terminal to the hull. The junction box was connected to the battery bank via an electrical isolation switch. All electrical appliances were connected to the junction box which was contained within the helm console, beneath which the batteries were located. The electrical cables and engine control cables ran through a circular hole cut into the base of the helm console. Two bilge pumps were removed from the boat two weeks prior to the accident as they were deemed faulty. They would have been connected directly to the battery bank and not via the junction box. An anchor windlass (electric winch) located on the bow was provided with power from the battery bank via the junction box. The anchor windlass was reported as not working and the Owner informed the marine safety investigator that the fuse for the anchor windlass had been removed. This could not be verified due to the substantial damage to the electrical system after the fire.

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<sup>6</sup> International Organization for Standardization – An independent, non-governmental international organization with a membership of 161 national standards bodies, of which the Bahamas is a Correspondent Member.

5.3.2 The electrical cable to the anchor windlass was reported as being located under the topside of the boat. Although this could not be visually verified after the accident, the location of the electrical cable as it runs between the junction box and the anchor windlass remains a key factor of the investigation. It is known that all electrical cables from the junction box within the helm console and beneath the deck plate. The most probable scenario during construction would be to run the electrical cable forward, beneath the deck plate to the bow and connect to the anchor windlass avoiding any electrical cables on deck or any deck penetrations being required. If, however the electrical cable was run as suggested by the Owner, above the deck, two penetrations would need to be made in the deck to service the electrical cable; above and then beneath the deck plate, as indicated within figure 14 by the green pecked line.



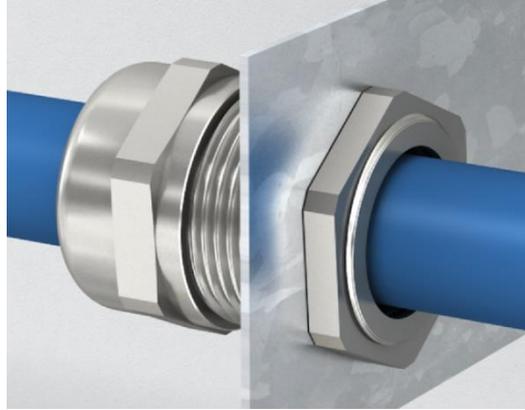
**Figure 14: Electrical system schematic and anchor windlass circuit**

5.3.3 The three pictures shown below within figure 16 indicate that beneath the deck plate, electrical cables did exist. This has been corroborated by witness testimony confirming that no electrical cables were observed above the deck plate. The bottom picture indicates the anchor windlass installed on board and confirms the Owner’s testimony that the electrical supply cable was connected to the underside of the anchor windlass i.e. beneath the deck plate.

5.3.4 As there was no inspection conducted, it cannot be confirmed if the electrical cables that passed through the transverse beam were properly protected to ensure the insulation material surrounding the electrical cable (conductor) was protected. If the electrical cable is not protected by a cable gland<sup>7</sup> or equivalent method (see figure 15), chaffing of the insulation material surrounding the

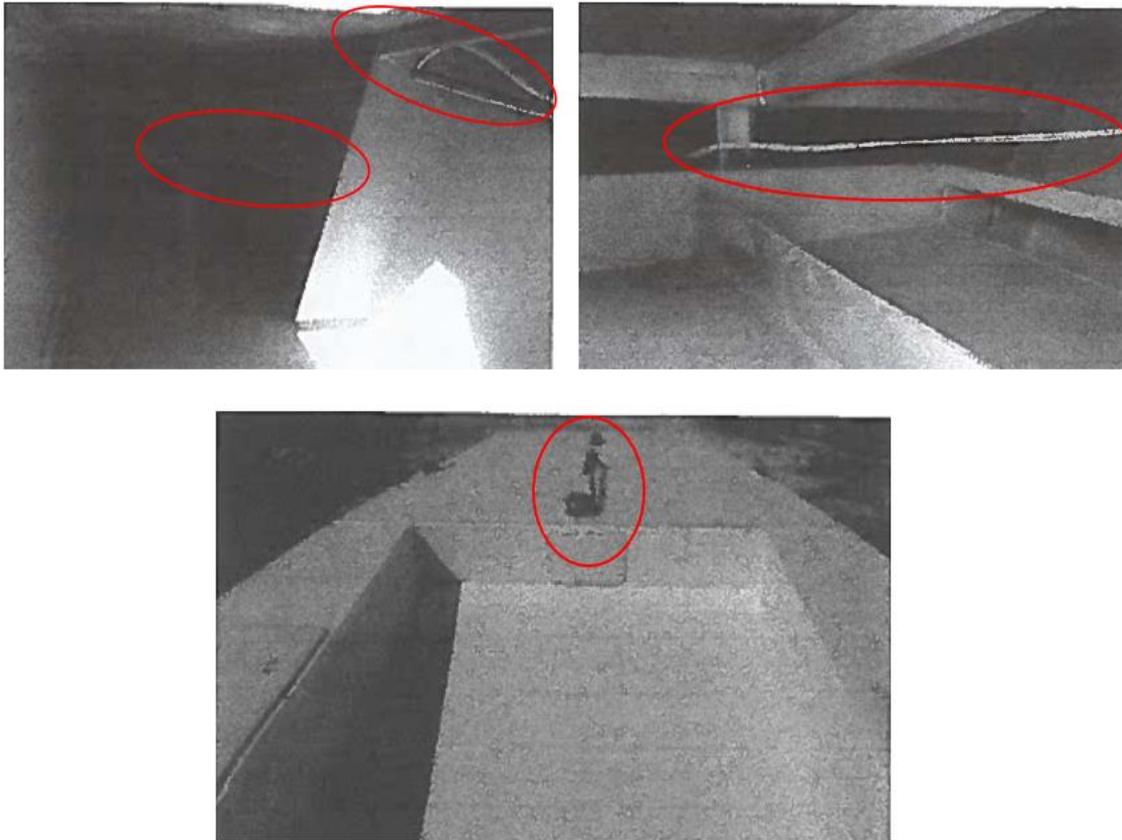
<sup>7</sup> A typical method used to provide protection without compromising the integrity of electrical cables passing between transverse beams is known as a cable gland.

conductor can occur, this will compromise the integrity of the insulation and expose the conductor within.



**Figure 15: An example of electrical cable gland fitted in an aluminium bulkhead**

- 5.3.5 As can be seen within figure 16, the electrical cables were not secured in a fixed position. Instead, the electrical cables were able to move freely with the motion and vibration of the boat, potentially increasing the susceptibility of damage to the insulation material surrounding the conductor as contact is made with the aluminium frame.



**Figure 16: Pictures provided from the 37ft Boat show (left to right) the cable run through a transverse frame, cable not secured running beneath the deck plating and anchor windlass in position on the bow**

5.3.6 If the conductor is exposed, a charge sufficient enough in energy could be released by either coming into contact with a conductive material or through contact with a liquid, resulting in a short circuit and possible immediate release of energy in the form of a spark to be generated.

#### **5.4 Fuel system**

5.4.1 The fuel system on board consisted of an aluminium tank located within each pontoon approximately 2m in front of the transom. The tank was welded and suspended from the underside of the transverse beam and supported on each side within the transverse frame. Each tank had a fuel fill hose, a fuel vent hose and a fuel supply pipe. The filling and vent hoses were located on top of the tank in the forward, outboard corner and secured in place by two hose clips.

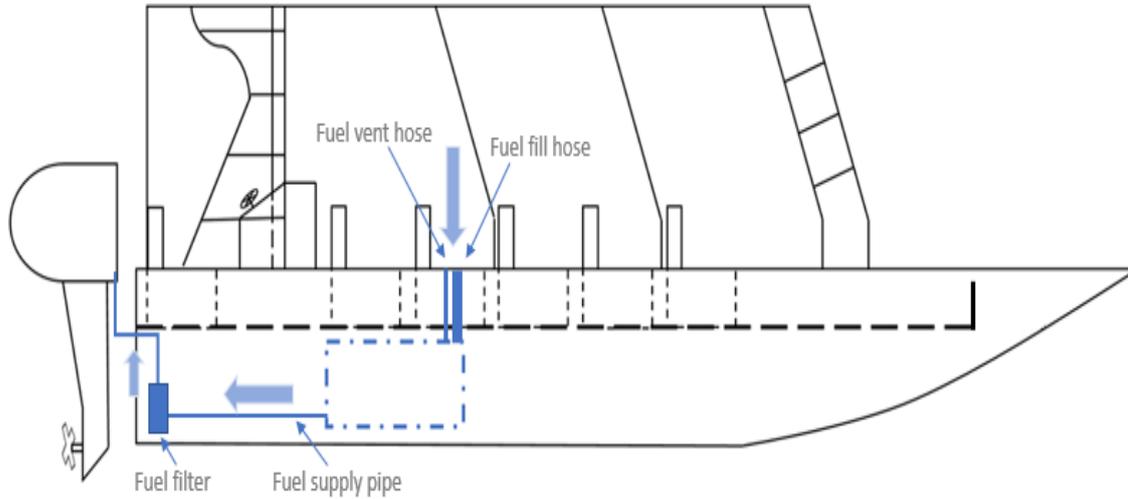
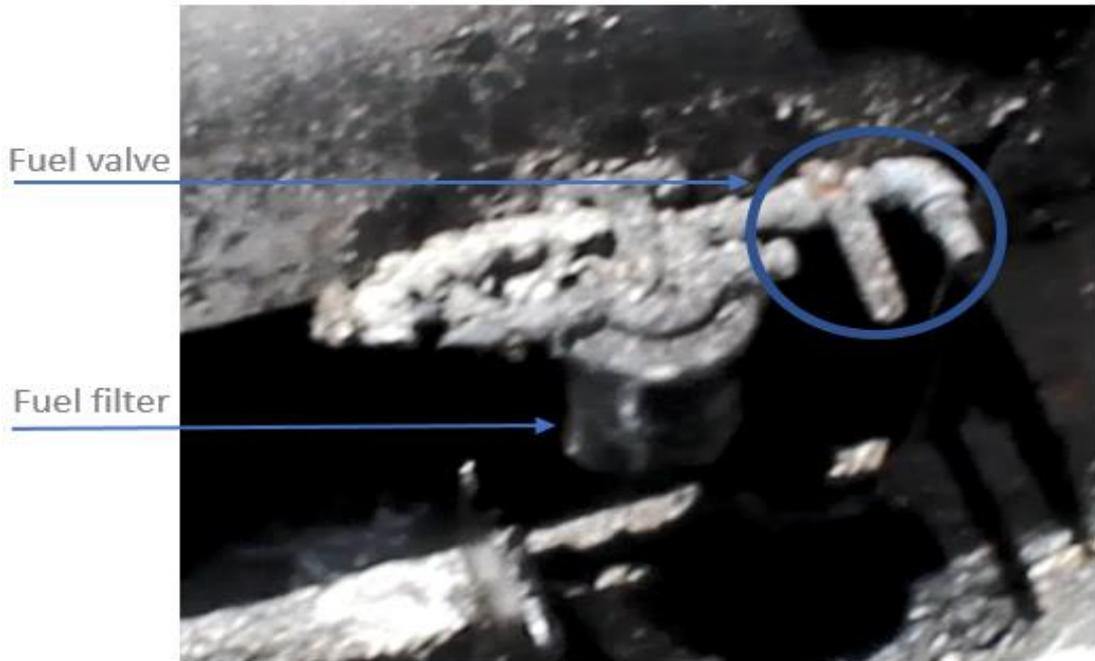


Figure 17: Schematic of fuel system on board



Figure 18: Fuel inlet and vent holes on top of the starboard fuel tank

5.4.2 The fuel supply pipe, located at the rear bottom inner most corner of the fuel tank, supplied fuel to the fuel filter via a one-way valve and then directly into each engine via a rubber hose.



**Figure 19: Remnants of port fuel filter and fuel valve**

- 5.4.3 The fuel supply system on each tank supplied fuel to a separate fuel filter for each tank prior to delivering the fuel to each Yamaha 300hp engine via a rubber hose. Gasoline could be supplied by both tanks simultaneously or each tank independently by use of a fuel supply valve located on each fuel supply pipe.
- 5.4.4 The fuel fill hose used during the construction process of the boat could not be identified after the fire due to the extensive damage. However, the fuel hoses identified in figure 20 were taken from another Four C's Adventures boat and it was confirmed by the Owner that the same make and model of fuel fill hose was used on all boats constructed by the Owner. The fuel fill hose is manufactured by Shields, a marine hose manufacturer. According to the manufacturer, model XHD (Extra Heavy Duty) series 148 is designed for use in bilge water discharge, specifically in the application of submersible, remote and hand bilge pump applications. It is not designed and not recommended for use with any gasoline/alcohol blends or liquids. Further, the Series 148 Extra Heavy Duty hose is resistant to mild chemicals, permeation and saltwater and should not be used with gasoline or alcohol blends as it does not meet the required SAE J1527 Type A2 and ISO 7840<sup>8</sup> Type A2 NMMA/CE Type accepted standards.

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<sup>8</sup> ISO 7840:2013 specifies general requirements and physical tests for fire-resistant hoses for conveying petrol or petrol blended with ethanol and diesel fuel. It applies to hose for small craft with permanently installed fuel systems.



**Figure 20: Example of the exact fuel fill and vent hoses installed on board the 37ft Boat**

5.4.5 There are two consequences when gasoline and alcohol blends come into contact with this type of hose and both have the same outcome. The first will result in the hose to harden, eventually the hardened hose will fracture and potentially result in a leak of gasoline. The second consequence is that gasoline and alcohol blends will degrade the structural wall of the hose to such an extent that the hose will no longer contain the gasoline in liquid or gaseous form. In both cases, gasoline will then be able to permeate the surrounding environment. The manufacturer was contacted during the course of the investigation and stated that *“the series 148 hose should under no circumstances be used in the application of a fuel fill hose”*.

## **5.5 Construction and Survey**

5.5.1 The Owner requested a surveyor to conduct a survey during and on completion of the construction process in 2016. The surveyor identified to undertake the survey was approached by the Owner, however the Owner declined to proceed with the survey citing financial reasons. This was the only attempt by the Owner to have a survey conducted which was intended to verify the structural integrity of the boat and installation of fuel and electrical systems.

5.5.2 A condition of hull and machinery survey was arranged by the Owner and conducted on 02 February 2017 by CBA Engineering Ltd. located in Nassau. The scope of that survey was to carry out a condition of hull and machinery and a valuation of the boat for insurance purposes. The survey was conducted approximately one year after the boat was constructed. The boat had been

operating as a charter boat in the intervening period. A caveat on the survey report which was provided to the marine safety investigator, states: *‘This survey did not resort to dismantling of machinery or spaces or structures, normally considered closed, nor to the instrument assisted inspection of any of the above, nor their related structures, piping or circuits’*. It is known that access to the hull is limited. Access can be gained to each pontoon, aft of the port and starboard fuel tanks. Access in front of each fuel tank leading forward within each pontoon is restricted. Access to each pontoon in the forward area of the boat can be gained for visual inspection through the hatch covers only. Therefore, a full survey to assess the internal condition of the hull could not be conducted as the majority of the internal compartments were enclosed or inaccessible.

- 5.5.3 The Surveyor provided one recommendation to the Owner within the report, which states: *“While interior seams and joints were extremely well welded, the exterior welds were poorly done and would need continuous monitoring.”* CBA Engineering Ltd. was approached during the course of this investigation in order to validate this statement, which, based on the facts outlined in paragraph 5.5.2, the Surveyor’s recommendation must be based on an assumption rather than fact. Unfortunately, CBA Engineering Ltd. declined to provide any assistance or provide an explanation as to how this recommendation was ascertained.
- 5.5.4 Two pictures were taken of internal welds used in the construction of the 60ft boat located at the Owner’s premises (as seen in figure 21). It is known that the 60ft boat is being constructed using the same techniques as the 37ft Boat. The pictures taken were provided to two independent marine welding specialists associated with two independent Classification Societies<sup>9</sup>. The following opinions<sup>10</sup> were provided: *“the welds shown in the pictures are not of sufficient quality. The welds show large amounts of lack of fusion and I would doubt that they have sufficient penetration in order to give the joints enough strength”* and *“the example does not look adequate”*.

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<sup>9</sup> A Classification Society is a non-governmental organization that establishes and maintains technical standards for the construction and operation of ships and offshore structures.

<sup>10</sup> The opinions provided were solely based on the pictures provided and no physical examination was undertaken.



**Figure 21: Internal TIG welds used in the construction of the 60ft aluminium catamaran**

## 5.6 Source of Ignition

- 5.6.1 In order for the explosion to have occurred on board, an explosive atmosphere must be present. The formation of an explosive atmosphere requires the release of combustible gas and/or liquid to be generated at an optimal concentration and in sufficient quantity. Once the atmospheric conditions are achieved, any ignition source of sufficient energy will result in an explosion<sup>11</sup>.
- 5.6.2 The quantity of energy required to ignite the assumed explosive atmosphere cannot be precisely known. The minimum ignition energy required for gasoline is in the region of 0.8mJ<sup>12</sup>. The electrical circuit on board is capable of producing 0.6-7.3MJ which is well in excess of the energy required to ignite an explosive atmosphere.
- 5.6.3 Although the exact source of ignition has not been determined, a spark generated from the electrical circuit is considered the most probable cause. Either a short circuit, electrical arc, contact resistance resulting from inadequate or failed insulation material surrounding a conductor or an electrostatic charge (i.e. release of accumulated energy) are all considered probable and realistic sources of ignition.

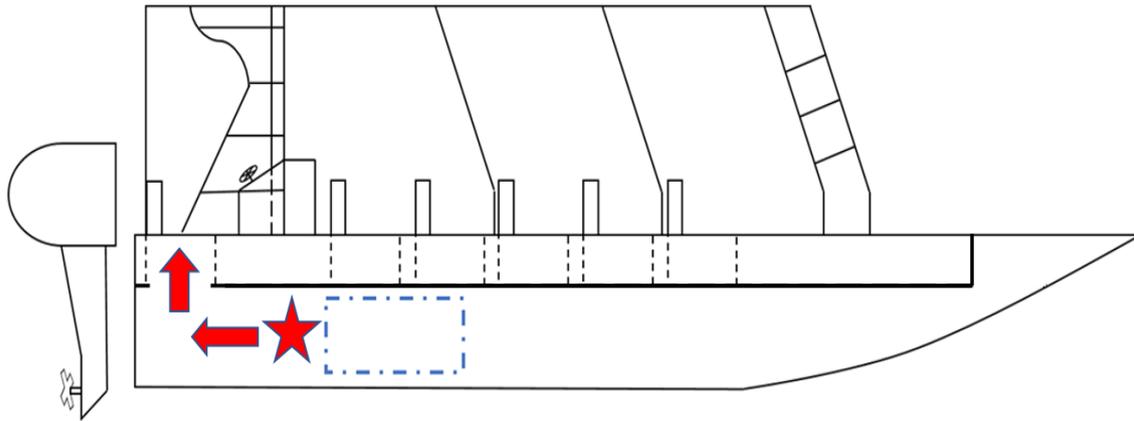
<sup>11</sup> Assuming the combustible gas and vapour mixture is within the explosive limit and subject to aerobic conditions.

<sup>12</sup> Research by Babravskak, V. (2003) Ignition Handbook, Fire Science Publishers, Issaquah WA.

- 5.6.4 At the point of ignition of the explosive atmosphere, a pressure increase (explosive pressure) would have occurred within the starboard pontoon resulting in a blast wave. This blast wave may have been sufficient to cause fuel lines to part resulting in additional fuel to leak or spread into the damaged area of the vessel.

## **5.7 Explosion**

- 5.7.1 The testimony provided by those who witnessed the explosion from on board the 37ft boat recalled first hearing the explosion before observing anything visually, indicating that the explosion occurred beneath the deck.
- 5.7.2 The extent of damage sustained, in particular on the starboard side of the boat prevented the marine safety investigation team from determining the exact location of the ignition for the explosion.
- 5.7.3 The starboard pontoon is not a sealed airtight compartment. Access to the pontoon can be gained underneath the helm seat and at the forward end of the boat via the deck hatches. The deck is constructed of 3/16" aluminium in sheet form and welded together. The location of the welds joining one sheet to another is not known as there is no structural or technical drawings of the boat. If the location of the welds were known, it may be possible to further assess any areas of weakness in the deck.
- 5.7.4 It was confirmed by the Owner that space surrounding the starboard fuel tank was limited by the surrounding hull plates located approximately four inches from the fuel tank on all sides. Access aft of the starboard fuel tank, beneath the Master's helm seat, where the majority of the electrical cables were located including the two batteries could be gained. This part of the starboard pontoon was not sealed with the exception of the base of the seat cushion on which the Master was sitting at the time of the explosion. If the explosion of gas and vapours of combustible liquids occurred behind the starboard fuel tank, it could be considered with a high degree of probability that the initial increase in pressure generated by the explosion, expanded whilst proceeding along the path of least resistance. This path of least resistance would have almost certainly been through the open deck beneath the helm seat in an upwards direction, pushing the helm seat up as it disperses into the rear section of the boat (see figure 22).



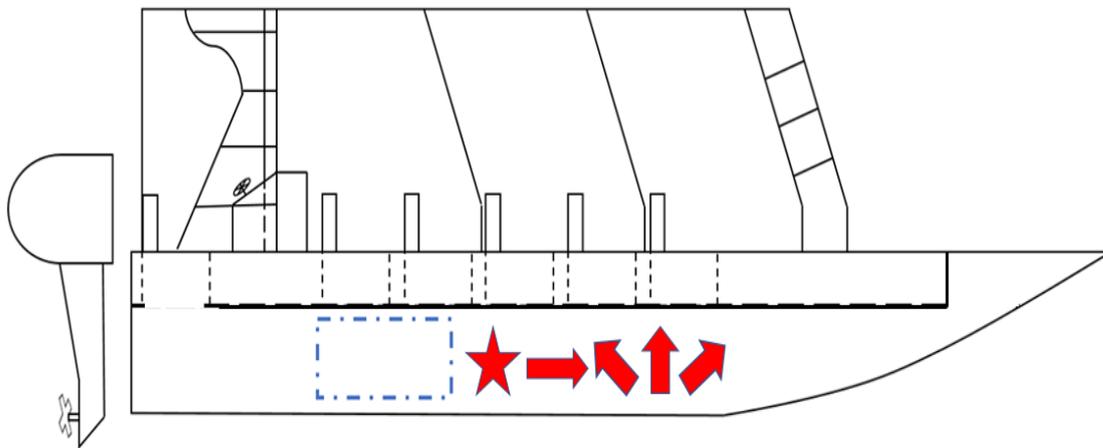
**Figure 22: Diagram of explosion aft of the starboard fuel tank and resultant direction of travel of the blast wave**

5.7.5 Figure 23 (below) provides a good indication, in the moments after the explosion and in the early stages of the fire the damage sustained to the helm seat, console and superstructure before the fire destroyed the available physical evidence. If the explosion had occurred behind the starboard fuel tank, the probability that these fixtures would have been identifiable immediately before the fire engulfed the boat is considered extremely low.

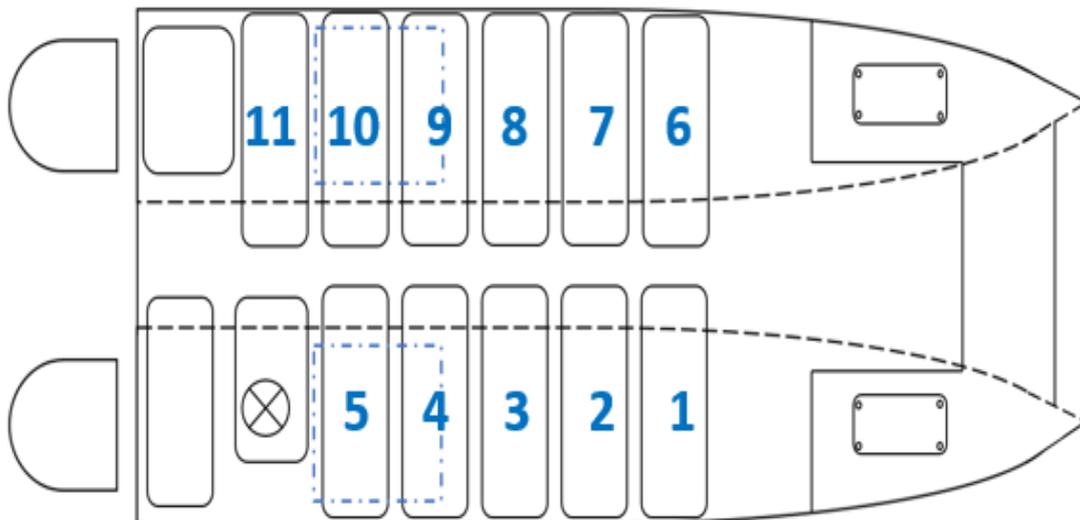


**Figure 23: Moments after the explosion and prior to the fire taking hold of the entire boat. The helm console, helm seat and superstructure pictured remains relatively undamaged**

5.7.6 Based on the significant structural damage in the forward section of the starboard pontoon, the most likely scenario is that the explosion of gas and vapours of combustible liquid occurred in front of the starboard fuel tank. The explosion of a combustible atmosphere generated by gas and vapours in this section of the boat would result in the initial over pressure resulting in a blast wave dispersing forward, filling the void within the pontoon to a point where the structural integrity of the hull could no longer contain the over-pressurisation. The explosive pressure contained within the starboard pontoon, sought to find the path of least resistance. As indicated by the witness testimony, the analysis of the concentration of injuries and based on analysis of the debris found at the scene, it is determined that the explosive path was beneath the deck in the proximity of seats 1, 2 and 3 (see figures 24 and 25).



**Figure 24: Diagram of explosion forward of the starboard fuel tank and resultant direction of travel of the blast wave beneath seats 1, 2 and 3**



**Figure 25: Seating arrangement as numbered 1 - 11**

5.7.7 The deck plating shown within figure 26 below was placed back on the boat after the explosion once the boat was salvaged at Barratarre. The deck plates were matched to their probable starboard side location. As indicated by the red arrows, the 3/16” aluminium deck had been distorted in an upwards direction, indicating that the explosion occurred beneath the deck plate and the force of the explosion forced the deck plates up and away from the structural transverse frame.



**Figure 26: Distorted and damaged deck plate in proximity of starboard side pontoon**

5.7.8 Likewise, as seen below within figure 27 the superstructure (canopy) was forced up and towards the rear of the boat by the force of the explosion separating from the forward stations normally holding the superstructure in place.



**Figure 27: Damage sustained to superstructure immediately after the explosion**

5.7.9 Figure 28 focuses on the starboard fuel tank, specifically the top side which was positioned approximately 4” beneath the underside of the deck plate. This hole was a result of the aluminium material of the tank melting due to the heat of the fire and confirms that the explosion did not occur within the starboard fuel tank. The tank was still able to retain fluid indicating no further structural damage beneath the water level.



**Figure 28: Damage sustained to the top of the starboard fuel tank by the heat of the fire**

## 5.8 Registration Process and Inspection

- 5.8.1 Section 8 of the Commercial Recreational Watercraft Act Chapter 278A, which outlines the requirement for boat registration, states: *‘no craft shall ply, be offered or let for hire for use in the waters as prescribed in regulations unless and until it is registered by the Authority in the port area in which it is to operate’*. The Authority’s<sup>13</sup> function, in accordance with Section 3(2)(a), (b) and (c) of the Commercial Recreational Watercraft Act is: *‘(a) to regulate, control and administer all matters related to commercial recreational water sports in The Bahamas; (b) to collect all licensing fees and other moneys payable under this Act except in the Family Islands<sup>14</sup> where the Administrator shall collect fees and other moneys that are payable; and (c) to advise the Government on any matters relating to its function’*.
- 5.8.2 Section 13 of the Commercial Recreational Watercraft Act Chapter 278A describes the process of registering a boat under the Act and states: *‘An owner of a craft who applies for registration under this Act shall submit in writing plans, specifications and inventories of the craft and produce for inspection the machinery, gear, fixtures, and equipments used in connection with the craft’*.
- 5.8.3 The Commercial Recreational Watercraft Regulations Chapter 278A further dictates the requirement for craft registration and under section 4(1) states: *‘Every craft before being registered under these Regulations shall, together with the machinery, gear fixtures or equipment used therewith, be submitted for inspection by the authority, and the authority shall decide whether the craft is fit and proper to be registered and after registration an inspection shall take place annually’*. 4(3) *Subject to the satisfactory inspection and registration of the craft, the owner shall affix or paint the registration number assigned by the Authority on the craft’*.
- 5.8.4 The Port Department in Nassau and the local Port Department in Exuma were visited as part of this investigation in order to obtain the written plans, specifications and inventories, valid inspection reports and registration documents for the 37ft Boat. Neither Port Department were able to provide any such documentation regarding the 37ft Boat and confirmed that no application had been received for the registration of any such boat.
- 5.8.5 The Port Department had received applications for registration for 2018 for three boats owned and operated by Four C’s Adventures, namely; one 45ft catamaran, one fibreglass mono-hull and one small 30ft catamaran. The annual registration applications were submitted on 27 February 2018 for all three boats along with the required forms and receipt of fees paid. As of 01 July 2018, all three applications remained pending due to the absence of an annual inspection and therefore were not considered registered with the Port

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<sup>13</sup> Part 1 of the Commercial Recreational Watercraft Act, section 3.1 states: The Port Controller or port authority in a port area as defined under the Port Authorities Act is the Authority under this Act.

<sup>14</sup> Exuma is considered a Family Island

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Authority and specifically not in compliance with the Commercial Recreational Watercraft Act, Chapter 278A.

- 5.8.6 One of the limitations preventing an inspection being conducted by the two marine inspectors located on Exuma was due to insufficient resources. Without adequate means of inspecting the boats, the Port Department are unable to fulfil the requirements of the Commercial Recreational Watercraft Act, specifically section 3(2)(a) by adequate means to verify control or regulate craft operating throughout the Island.
- 5.8.7 In 2017, the Port Department conducted an annual inspection on the 45ft, 30ft and mono-hull boats as part of the 2017 annual registration requirements. All three boats passed the annual inspection with no major safety deficiencies identified. In knowing that at least two of the boats constructed by the owner of Four C's Adventures were constructed using the same materials and construction methods as used for the 37ft Boat, there is no guarantee that deficiencies identified during the course of this investigation would have been identified by the Port Department had this boat been subjected to an annual inspection as part of the boat registration requirements
- 5.8.8 It was also determined during the course of this investigation that there are eighteen commercial charter boat companies operating from Exuma. Of the eighteen, six are registered with the Port Department whilst the remaining 12 have registration applications pending but continue to operate on a commercial basis.

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## 6 CONCLUSIONS

- 6.1 The Owner of Four C’s Adventures operates a charter tour business using multiple self-built and purpose-built boats in the north of Exuma. An application for boat registration was not initiated and therefore the Owner did not fulfil the requirements of the Commercial Recreational Watercraft Act Chapter 278A in any respect and should under no circumstances been operating this craft on a commercial basis.
- 6.2 An exact cause of the explosion cannot be determined due to the significant damage sustained during and after the explosion. Unfortunately, without technical drawings, electrical circuit diagram and a schematic of the permanently installed fuel system, an exact model of the 37ft Boat cannot be achieved; preventing any attempt to reconstruct the exact scenario which resulted in this very serious marine casualty.
- 6.3 It can be considered with a high degree of probability, based on the passenger seating positions associated with the severity of injuries sustained, and a detailed assessment of the structural damage, determined that the location of the explosion was in the proximity of the starboard fuel tank resulting in the release of a blast wave on the starboard side, beneath the front three rows of seats. The magnitude of the blast wave had sufficient energy to cause catastrophic damage to the boat and resulting in one loss of life and severe injuries to the remaining passengers on board.
- 6.4 The Port Department lacked sufficient resources to properly control and regulate commercial water craft operating in Exuma and in doing so was unable to enforce the requirements of the Commercial Recreational Watercraft Act.
- 6.5 A significant number of commercial crafts operating within the waters of Exuma are not registered with the Port Department despite having submitted valid applications. The mechanical, structural and safety standards required to be met cannot be verified.
- 6.6 The assistance rendered by passengers and crew from those able, in particular those individuals on board the 37ft Boat and those individuals that came to aid should be recognised for their selfless acts of bravery on the morning of 30 June 2018. The Government of the Commonwealth of The Bahamas is extremely grateful to all those involved in the rescue and repatriation effort.

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## 7 RECOMMENDATIONS

### **Recommendations for the Owner of Four C's Adventures:**

- 7.1 The Owner of Four C's Adventures is required to ensure that any boat owned by Four C's Adventures and intended for use on a commercial basis has a valid boat registration certificate.
- 7.2 Four C's Adventures is required to ensure that all boats owned and operated by Four C's Adventures, intended for use on a commercial basis, comply in full with the requirements of the Commercial Recreational Watercraft Act, Chapter 278A prior to undertaking commercial operations.

### **Recommendations for the Port Authority:**

- 7.3 The Port Authority should enforce the Commercial Recreational Watercraft Act, Chapter 278A in order to ensure full application by all commercial craft.
- 7.4 The Port Authority should consider amending the Commercial Recreational Watercraft Act, Chapter 278A to require all self-built boats to undergo a survey by a Recognized Organisation<sup>15</sup> in order to verify a boat's seaworthiness.
- 7.5 The Port Authority should consider amending the Commercial Recreational Watercraft Act, Chapter 278A to require the Owner of a self-built boat to submit construction plans for approval by a Recognized Organisation for compliance with all current applicable safety standards prior to construction.
- 7.6 The Port Authority should ensure that necessary resources are available to all Port Departments in order to regulate, control and administer all matters related to commercial recreational water sports in The Bahamas.

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<sup>15</sup> An organisation to which The Bahamas has entrusted survey, audit and certification under the provisions of the relevant regulations of the Conventions to which The Commonwealth of The Bahamas is a party.