

Interim Report on the capsizing of “The Big Hairy”

This interim report is produced in accordance with World Sailing [Regulation 38](#) and Australian Sailing [Special Regulations Part 1, 2.02.5](#) for Safety Reporting.

Australian Sailing is committed to learning from safety incidents and sharing these learnings with other clubs throughout Australia. The primary objective of this report is investigation of the factors that led to the keel failure, and the secondary objective is to use the information and learnings gathered during the investigation to help inform future guidelines for the safety of sailors.

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Summary

A fatal incident occurred about 0730 Hrs. on Sunday 16 June 2024 approximately 4 nautical miles SW of Lady Elliot Island whilst the racing yacht *The Big Hairy* was enroute from Rosslyn Bay Queensland to the Royal Queensland Yacht Squadron, Manly Queensland, to participate in the Brisbane to Keppel Yacht Race. The yacht departed Rosslyn Bay on the afternoon of 15 June 2024. The Skipper/owner Tim McCall later stated about 0730 Hrs. on the 16 June 2024 “the keel snapped off the vessel, causing the vessel to capsize.” Whilst two of the crew Tim McCall and Bronson McCall were subsequently rescued, it appears the deceased Roger Searl was entrapped and subsequently drowned. The drowning of Roger Searl is subject to the findings of the Queensland Coroner.

Information and Sources

- 1) Previous owners of The Big Hairy (previously known as Runaway) provided information about the yacht from their respective period of ownership.
- 2) Clubs that had been the organising authority of races into which The Big Hairy had been entered

provided information about the yacht's compliance with the rules applicable to that event.

- 3) Data available from ORCi and IRC rating certificates were a source of information, particularly the boat's measurements.
- 4) Correspondence from Tim McCall provided context and factual information.
- 5) At the time of this interim report, no detailed information had been received relating to the original design and construction of the yacht, the incident itself or subsequent rescue.

About the race

- 6) The Brisbane to Keppel Yacht Race (Race) was to be conducted on the waters between Brisbane and Great Keppel Island on Thursday 20 June 2024.
- 7) The organising authority was the Royal Queensland Yacht Squadron (RQYS).
- 8) The Race was governed by the Racing Rules of Sailing and Australian Sailing's Special Regulations Part 1.
- 9) The yacht *The Big Hairy* had officially entered the Race and had submitted all information required by RQYS to participate.
- 10) All yachts entered in the Race were required to have a Special Regulations Equipment Audit Certificate. The race documents including the Notice of Race and Sailing Instructions were publicly available on the Regatta Website. The Incident Management Plan was included in the Sailing Instructions and provided details and procedures in case of emergency.
- 11) At the time of the incident *The Big Hairy* was on a delivery voyage from Rosslyn Bay Queensland to Manly Queensland to participate in the race.

Conditions and context

- 12) The Australian Bureau of Meteorology's Daily Weather Observations for Sunday 16 June 2024 at Lady Elliot Island record a maximum wind gust SSW of 50 km/h (27 Knots) at 0529 Hrs and a wind speed of 26 km/h (14 knots) SSW at 0900 Hrs. The temperature was 20 degrees Celsius and the Barometric pressure of 1015.5 hPa.

The incident

- 13) The yacht *The Big Hairy*, owned by Tim McCall departed Rosslyn Bay on the afternoon of 15 June 2024 bound for the RQYS Marina, Manly Queensland.
- 14) There were 3 Persons on board *The Big Hairy* at the time of the incident: Timothy McCall (owner/skipper), Bronson McCall, and Roger Searl (now deceased).
- 15) The owner/skipper Timothy McCall was an experienced yachtsman who possessed the following certifications: First Aid Certificate, Keelboat Instructor, National Equipment Auditor, Safety and Sea Survival Certificate.
- 16) Crew member Bronson McCall was an experienced yachtsman who possessed the following certifications: First Aid Certificate and Safety and Sea Survival Course.
- 17) Roger Searl was an experienced yachtsman who possessed the following certifications: First Aid Certificate, Safety and Sea Survival Course, National Equipment Auditor, and past Keel Boat Instructor (expired).
- 18) *The Big Hairy* was on a direct marine route from its home port Rosslyn Bay to the RQYS marina (Manly, Qld) when the keel snapped off the vessel causing the vessel to capsize. The journey began in the afternoon of 15th June 2024, and the accident occurred at approximately 07.30 a.m. on 16 June 2024, 4nm SW of Lady Elliot Island.

Keel Design and Regulation

- 19) Yachts with an age or series date from approximately 1987 to 2010 and competing in category 1 or 2 races shall have been designed, built and modified in accordance with the requirements of either:
 - a. the EC Recreational Craft Directive
 - b. the ABS Guide for Building and Classing Offshore Yachts
 - c. ISO 12215 Category A
- 20) Special Regulation 3.03 applies.
- 21) From 2010, all yachts competing in category 1 or 2 races shall have been designed, built and modified in accordance with ISO 12215 Category A. Special Regulation 3.03 applies.
- 22) From 2022, boats competing in category 1, 2 and 3 races shall have completed structural inspections of the keel and rudder fin within 24 months of the race. Special Regulation 3.02.4 applies.
- 23) *The Big Hair* has an age date of 2003 and is certified by John Sayer as being designed and built in accordance with the ABS Guide for Building and Classing Offshore Yachts.
- 24) On 19/1/2023 a keel and Rudder inspection was conducted by Thomas Ferrier-Gorman, Marine Surveyor, of the yacht. In an Australian Sailing 2021-24 Keel and Rudder Inspection Form signed by Mr Thomas Ferrier-Gorman and provided to Australian Sailing the following was noted: "Keel Bolts-Visually in good condition. Torque test to builder's specs all ok. Internal Hull Structure-No signs of delamination. Hull in sound condition. External Hull Condition-No stress points found. Testing complete with no issues."
- 25) Upon arrival in Rosslyn Bay, a significant pull to port whilst steering was noted. Upon inspection on the Keppel Bay Marina travel lift, the rudder was observed as asymmetric. After removal and investigation, it was decided the rudder was unrepairable and needed to be replaced.
- 26) The new rudder was manufactured from carbon fibre and epoxy by Southern Light Marine in Adelaide and fitted in on 7/6/2023.
- 27) After the new rudder was fitted, a second Keel and Rudder Inspection was conducted by Greg Christie, of CQ Riggers and Shipwrights Mulambin Qld of the yacht. In an Australian Sailing 2021-24 Keel and Rudder Inspection Form signed by Mr Christie and provided to Australian Sailing the following was noted: "Keel Bolts-Sound and Fit for purpose, Internal Hull Structure-Sound and Fit for purpose, External Hull Structure-No stress cracks found, Sound and Fit for Purpose."

Safety Equipment

- 28) Maritime Safety Queensland requires that for vessels 3 types of safety equipment for Boats registered in Queensland:
 - a) Compulsory Equipment for all registered boats: www.qld.gov.au/transport/boating/registration/recreational.
 - b) Compulsory Equipment for all boats in certain areas.
 - c) Other equipment that's recommended you carry to meet your general safety obligation www.msq.qld.gov.au/safety.
- 29) Beyond partially smooth waters is defined within the Queensland Maritime Safety Requirements.
- 30) Equipment required to operate in these waters includes: EPIRB Flares, Fire Fighting Equipment, Signaling Device, V Distress Sheet and Life Jackets for each person board.
- 31) Australian Sailing's Special Regulations require for Category 3 races that each crew shall have a lifejacket complying with AS4758-2015 (minimum Level 150N) or AS1512-1996 Type 1 or Type 2, or equivalent or more stringent overseas standard.
- 32) The Special Regulations recommend that a lifejacket be worn by crew at times when true wind speed is 25 knots or more.

- 33) *The Big Hairy* passed a Category 3 Equipment Audit on 14/3/2024 for the QCYC Special Regulations Equipment Audit marked “for the Brisbane to Gladstone Yacht Race (Only).” The audit was conducted by Roger Searl. This audit noted *The Big Hairy* had life raft for 6 persons and lifejackets in date for a crew of 6 and was valid for 12 months from the date of audit.
- 34) In a document titled “2024 Brisbane to Keppel Tropical Yacht Race” signed and dated by Tim McCall on 15 May 2024 and witnessed by Deborah Walker, acknowledged amongst other items that: The boat complies with the special regulations part 1 for Category 3 races.

Incident management planning

- 35) Incident Reporting advice and the Incident Management Plan for the Race were included in the Sailing Instructions.
- 36) The Sailing Instructions were made available to all competitors on both the website and in hard copy at the Regatta’s Official Notice Board.

The Yacht

- 37) *The Big Hairy* is described as a Sayer 11, designed by Jon Sayer, built by Jon Sayer, of Carbon Construction with a length over all of 11.0 meters, Beam 3.932 meters and draft of 2.561 meters, and displacement of 2751 kg.
- 38) *The Big Hairy* was designed and built for the 2003 Melbourne to Osaka Double Handed Yacht Race competing as *Team FGI*, entered by Jon Sayer.
- 39) The yacht was purchased by James Ryssenbeek and Andrew McCole and competed without incident in the Melbourne to Hobart and Melbourne to Vanuatu Yacht Races.
- 40) Whilst competing in the 2007 Melbourne to Osaka Yacht race, the yacht reportedly sustained keel damage off the East Australian Coast, around 150nm off Fraser Island, believed to have lost its keel. Ryssenbeek and McCole were able to bring the boat to safety without outside assistance.
- 41) The yacht, then named *Runaway*, received a new keel and rudder with a view to complete in the 2013 Melbourne to Osaka yacht race.
- 42) Drew Carruthers then purchased the yacht and competed in the 2015 Brisbane to Keppel Tropical yacht race, the 2016 Brisbane to Gladstone yacht Race, the 2016 Pittwater to Coffs Harbour yacht race and the 2016 Coffs Harbour to Paradise yacht race. No modifications, repairs or groundings happened during Drew Carruthers’ ownership.
- 43) In 2016 Daniel Turner purchased the yacht from Drew Carruthers specifically to compete in the 2018 Melbourne to Osaka Race. In 2017 the yacht underwent an extensive refit in preparation for the 2018 Race. The keel was not modified, removed or touched in any way during Daniel Turner’s ownership other than antifouling. The keel touched mud at slow speed (2-3 knots) in Yamba NSW during the 2016 delivery to South Australia.
- 44) Mr Turner had a pre-purchase survey in 2016 and an insurance inspection prior to the Osaka Race in 2018.
- 45) Upon successful completion of the 2018 Melbourne to Osaka race the yacht was hoisted onto a ship on a custom made cradle, returned to South Australia where it was dry stored until being sold in 2019.
- 46) In 2019 Joanna Been and David Aplin purchased the yacht from Daniel Turner. In August 2019 the yacht was hauled out. It was noted the vessel had ablative antifoul with significant build up and rough finish. This was sanded this off back to the fairing on the hull and bare steel/lead on the keel. The keel and hull were then epoxy primed and vivid hard racing antifoul sprayed on. The rudder was removed, inspected, and bearings serviced. One of the crew was a shipwright

who assisted with these processes. No issues were found with the hull or keel.

- 47) A Nautilus Marine Boat Insurance Inspection Form dated 20/11/2019 was also provided by Joanna Been to Australian Sailing. Within this form noted at the section labelled keel was a tick at the item accept and the notation "No visual movement between hull/keel interface." In the section labelled "keel bolts", there was again a tick for the item accept, and the notation "10 X 3/4 S/S appear good." In the remarks section of the form, the item marked open waters was ticked, and the following remarks made: "This vessel was constructed to well proven robust specifications using correct modern composite boat building practice and has a proven record of both short and long distance offshore racing. There was no stress evident in high load areas of the structure. It was noted that "Team Runaway is currently in very good and seaworthy condition." This form was signed by Doug Watson of Doug Watson Shipwright Services P/L Registered Class 1A Accredited Surveyor number 295.
- 48) In December 2019 the yacht competed successfully in the Sydney to Hobart Yacht Race.
- 49) In November 2020 the yacht was sold to Simon Pearce and delivered by Jo Been to Royal Geelong Yacht Club.
- 50) Jo Been confirmed in her correspondence to Australian Sailing that during her ownership the vessel was never grounded or suffered any damage.
- 51) In response to correspondence from Mr Glen Stanaway of Australian Sailing, Mr Simon Pearce stated on 9/7/2024 that: "No hull or keel modifications were performed, Local shipwrights worked on rudder delamination issue, we did touch some mud in Corio Bay on one occasion. There was a light breeze and we tacked/gybed (can't remember) and heeled her over with body weight and over sheeting the main and sailed her off, I did not commission any surveys, hauled twice for maintenance."
- 52) During June 2023, Tim McCall inserted a new depth triducer (temperature, speed, depth) to ensure the best results were available to them. Vertical measures were taken out of the water from bottom of the keel to triducer to ensure they had the correct offset. The offset entered was increased so they still had 0.1m under the keel when the depth sounder read zero.
- 53) In February 2024, the preparation and new antifoul was applied by Keppel Marine marina boatyard personnel. The instruction was to wet sand and prepare the boat for a race finish. The Micron AP was to be sprayed, then allowed to properly harden, then wet sanded with 400 grit to ensure a full race finish, as per advice from the International Paints representative.
- 54) Tim McCall stated on 19/9/2024 that "We are exceptionally careful not to ground the boat, and it has never grounded whilst in my ownership."
- 55) On 23/7/2024 Australian Sailing engaged Mr David Lyons, Chartered Engineer of Coolum Beach as it's representative to conduct a visual inspection of *The Big Hairy* remaining keel materials, and the internal and external adjacent hub area and provide a report to Australian Sailing.
- 56) On the 2 August 2024 Mr Lyons inspected *The Big Hairy*, at Bundaberg Port Marina.
- 57) On 23 August 2024 Mr Lyons issued a comprehensive Expert Naval Architect's Interim Report titled: Inspection of failed ballast keel on the yacht "The Big Hairy" HIN AU-WWA187638/TIM01Q/ON 857223. Attached at Annex A.
- 58) In the Executive Summary of this Interim report Mr Lyons stated the following: "The vessel reportedly lost its keel in Queensland coastal waters on 16 June 2024 (the incident). The same vessel also reportedly lost most or all of its previously installed keel in 2007. From my visual inspection, it was possible to identify metal fatigue as the most likely cause of the failure of the vessel's fabricated mild steel plate keel. I explain the mechanism of metal fatigue in the body of this report. Fatigue crack initiation and growth occurred at the connection of the keel to the yacht's hull, creating the catastrophic separation of the keel from the vessel's hull, resulting in its capsize and inversion due to grossly inadequate remaining stability after the keel was lost." These findings are to be regarded as interim while further testing of the surviving part of the keel

connection is undertaken, whereafter this report can be finalised.

Findings drawn from the incident

- 59) The findings are interim until further information about the design and construction of the yacht, incident and rescue can be provided. Australian Sailing awaits further advice from the designer and builder, the surviving crew, expert witnesses and the findings of the Queensland Coroner.
- 60) The race documents met the requirements and guidelines from Australian Sailing as set out in the Racing Rules of Sailing and the RQYS disseminated all appropriate documentation regarding the Race in accordance with Australian Sailing recommendations.
- 61) The incident happened on a delivery trip and was outside the scope of an organising authority's safety management system and risk management plan.
- 62) *The Big Hairy* was designed and built in accordance with the applicable regulations of the time.
- 63) From the evidence received to date, the previous and current owners of the yacht conducted all reasonable ongoing maintenance and inspection of the yacht including its keel.
- 64) The owner of *The Big Hairy* Tim McCall had submitted all documentation and conducted all vessel and safety inspections as required to enter the race and met all reasonable expectations regarding safety equipment and vessel maintenance and inspection, including the integrity of its keel.
- 65) There has been no evidence received indicating that there were visible signs of fatigue in the keel prior to the yacht's departure from Rosslyn Bay.
- 66) More extensive tests than those currently required in the Special Regulations, such as complete removal of the keel, or non-destructive testing methods, as appropriate for the keel construction and attachment method, would likely have identified the weaknesses in the keel.
- 67) From the evidence received to date, it would appear that *The Big Hairy* capsized in the vicinity of Lady Elliot Island Queensland due to the catastrophic failure of the keel, most likely as a result of metal fatigue.
- 68) None of the regulated and promoted inspection methods reasonably expected of a recreational boat owner would have identified this risk of metal fatigue.
- 69) The crew of *The Big Hairy* were appropriately experienced and skilled to undertake the delivery trip.
- 70) It appears that the crew member Roger Searl drowned whilst entrapped.

Recommendations

- 71) Australian Sailing make recommendations to World Sailing that a working party be formed to develop and propose the regulation of more extensive keel inspections, such as complete removal of the keel, or non-destructive testing methods, as appropriate for the keel construction and attachment method, or use of the yacht, on a longer time period than those structural inspections done on a 24 month period in accordance with Offshore Special Regulations 3.02.2 and 3.02.3.
- 72) Australian Sailing communicate with boat owners of the value of more extensive keel inspections, such as complete removal of the keel, or non-destructive testing methods, as appropriate for the keel construction and attachment method, or use of the yacht. This may be done on a longer time period than the minimum inspection requirements set out in the Special Regulations.
- 73) Australian Sailing communicate with clubs on:
 - a) The continued importance of Keel and Rudder Inspection on older yachts and vessels subject

to or suspected of grounding.

- b) The imperative to have appropriate levels of support in place for crews personally affected by an emergency.

This report has been produced by Australian Sailing on an interim basis pending further information.

Australian Sailing passes on its sincere sympathy to the wife and family of the deceased Roger William Searl and its support to the surviving crew of *The Big Hairy*, Tim and Bronson McCall. The previous owners of *The Big Hairy* (formerly *Runaway*) and interested clubs are thanked for their assistance and the information they provided regarding the history of the yacht, particularly its keel, and the expert advice of Mr David Lyons is also acknowledged.

**INSPECTION OF FAILED BALLAST KEEL
ON THE YACHT
THE BIG HAIRY
HIN AU-WWA187638 / TIM01Q / ON 857223**

**EXPERT NAVAL ARCHITECT'S
INTERIM REPORT**

Instructed by:

Australian Sailing

Reference: Letter dated 23 July 2024

by:

Mr David Lyons

CEng FRINA FIEAust RPEQ

Date of Issue: 23 August 2024

Our Reference: Report_Lyons_TBH_20240823

Commercial in confidence

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<https://forums.sailinganarchy.com/threads/yacht-loses-its-keel.246914/>



<https://www.seabreeze.com.au/forums/Sailing/General/Yacht-upside-down-near-Lady-Elliot?page=>



<https://www.abc.net.au/news/2024-06-16/man-dies-after-yacht-capsizes-off-lady-elliott-island/103984858>

EXECUTIVE SUMMARY

- 1 I inspected the sailing yacht *The Big Hairy* (formerly named *Runaway*—the **vessel**) on 2 August 2024 at Bundaberg Port Marina.
- 2 The vessel reportedly lost its keel in Queensland coastal waters on 16 June 2024 (the **incident**). The same vessel also reportedly lost most or all of its previously installed keel in 2007.
- 3 From my visual inspection, it was possible to identify metal fatigue as the most likely cause of the failure of the vessel's fabricated mild steel plate keel. I explain the mechanism of metal fatigue in the body of this report.
- 4 Fatigue crack initiation and growth occurred at the connection of the keel to the yacht's hull, creating the catastrophic separation of the keel from the vessel's hull, resulting in its capsize and inversion due to grossly inadequate remaining stability after the keel was lost.
- 5 These findings are to be regarded as interim while further testing of the surviving part of the keel connection is undertaken, whereafter this report can be finalised.

INTRODUCTION

- 6 I received instructions from Australian Sailing, requesting that I conduct a visual inspection of the failed ballast keel on the sailing yacht *The Big Hairy* in a letter dated 23 July 2024 (attached at Appendix A).
- 7 The letter sought my opinion in my capacity as an expert naval architect and chartered engineer with experience in sailing yacht design and associated regulatory developments in sailing yacht design and construction standards and regulations.
- 8 I inspected the yacht at Bundaberg Port Marina on 2 August 2024.
- 9 This report makes interim findings as to the root cause of the keel failure.
- 10 Destructive testing of the welds at the keel junction with the vessel's hull is recommended, whereafter this report can be finalised. The design of the testing regime is yet to be finalised but I would be prepared to participate in the detailed design of recommended test procedures.

QUALIFICATIONS AND EXPERIENCE

- 11 I have been a qualified professional engineer, specialising in naval architecture (designer of boats and ships) for 37 years, working with vessel owners, operators and shipbuilders as my clients. I am a Fellow of the Royal Institution of Naval Architects, a Fellow of Engineers Australia (Structural College), a Chartered Engineer (Engineering Council, UK) and a Registered Professional Engineer Queensland (RPEQ) in Naval Architecture.
- 12 I am presently providing educational programs in naval architecture at the University of NSW Canberra at the Australian Defence Force Academy.
- 13 My career is heavily practice-based in the area of vessel design and construction. I have been responsible for more than fifty sailing yacht designs including an overall winner of the Sydney to Hobart Yacht Race. My design expertise focuses on practical vessel structural design and construction management. I am comfortable to provide expert opinion in the present matter regarding *The Big Hairy*.
- 14 I have participated in numerous merit-based marine safety committee roles (as Convenor or Member) for 27 years, with current roles at the International Organisation for Standardisation (ISO), Standards Australia and the Offshore Racing Congress.
- 15 My work for ISO is focused on sailing yacht ballast keels including their design and attachment to the yacht's hull. As Convenor of ISO Working Group 35 with responsibility to develop the standard known as ISO/DIS12215 Part 9 *Sailing craft appendages*, my contribution from 2022 until today has been the systematic review of the standard, which will be published in updated form in 2025, replacing the 2012 version. To my knowledge, this is the only comprehensive global standard concerned with the attachment of sailing yacht keels. 'Appendage' is the general term applied to sailing yacht keels.
- 16 I have extensive expert witness experience. My written and oral opinions have been provided in the Australian County, District, Supreme, Federal and Coroner's Courts, and the High Court of New Zealand, within which I have provided expert evidence, including under cross-examination.
- 17 My curriculum vitae appears at Appendix B.

INSPECTION AND INTERIM FINDINGS

- 18 I inspected the remnants of the failed keel of the vessel when I visited it at Bundaberg Port Marina on 2 August 2024. I understand that the keel failed at sea while sailing southward in Queensland coastal waters on 16 June 2024.



Fig.1 – The vessel at Bundaberg Port Marina on 2 August 2024.

- 19 **Background and terminology:** The ballast keel on a monohull yacht such as this vessel performs two key functions:
- a) Due to its mass¹ and position underneath the hull, it imparts stability. This ensures that the vessel has power to carry sail at moderate angles of heel (heel means tilting laterally, in response to the wind in the sails) and at larger angles of heel, to resist capsize and inversion to an upside-down attitude. This does not mean that such vessels cannot capsize due to the action of very large waves, but if they do, the keel renders the vessel unstable when inverted, provided another wave impacts the vessel and returns it to an upright position. The keel's role in safety is critical.
 - b) The ballast keel also acts as a “lifting surface”. As the yacht moves forward, the hydrodynamic flow of water over the keel generates a net sideways force which minimises side-slip of the yacht, enabling it to sail “close to the

¹ The keel comprises the fin and bulb. On *The Big Hairy*, the mass of the keel comprises approximately 50% of the total mass (weight) of the empty vessel.

wind”, that is, the angle between the direction of travel and the wind is minimised. This is desirable for the yacht’s performance as it maximises the so-called “velocity made good” which is the effective speed of the yacht.

For hydrodynamic performance reasons, the yacht designer is encouraged to minimise the area of attachment of the vertical section of the keel (the keel **fin**) to the underside of the yacht’s hull, called the **root** as shown in Fig.2:

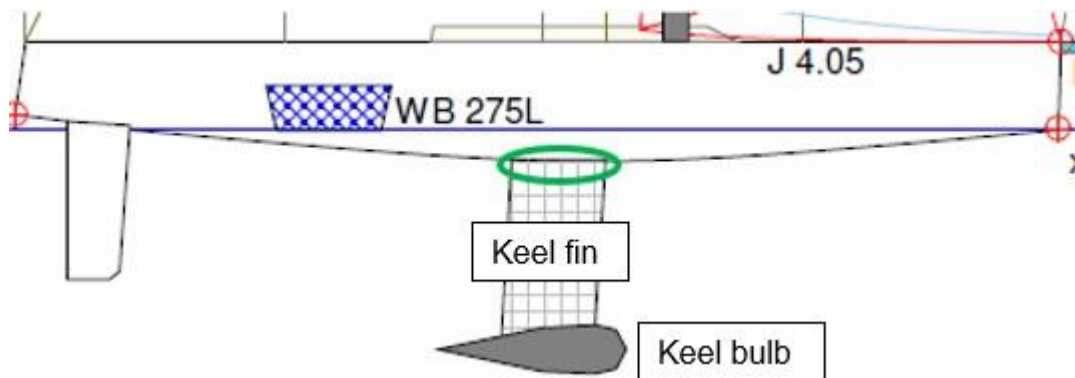


Fig.2 – The keel **root** shown within the green ellipse (marked up image taken from the vessel’s ‘IRC’ handicap rating certificate, obtained from Australian Sailing).

At the same time, the root must be of sufficient minimum size to ensure the strength of the attachment of the keel to the hull. The vessel’s keel fin is fabricated from welded mild steel and bolted to the hull.

The designer is faced with two conflicting objectives: To minimise the keel root for hydrodynamic performance reasons while preserving sufficient material to ensure that it remains attached to the hull. Ensuring adequate strength is the paramount consideration.

- 20 My inspection of 2 August 2024 was of a visual nature. This was sufficient for the present purposes which, based on my expertise and experience was to understand the nature of the failure, provide my interim conclusions and advise what further testing and investigations should be undertaken so that the cause of the incident could be confirmed. Later in this report, I will describe destructive

testing that I recommend in order to shine more light on the cause of the failure of the keel and to allow me to finalise my report.

21 From my inspection and experience, I could identify that the keel fin was manufactured by cutting, rolling and welding pieces of mild steel plate, forming a hollow fin with closed upper end. Around this fin, rolled so as to shape its sides into two half-aerofoils, was welded a flat horizontal rectangular steel **hull plate** through which ten bolts were passed to secure the assembly to the hull in a recess, as illustrated in Fig.s 3 and 4 below:

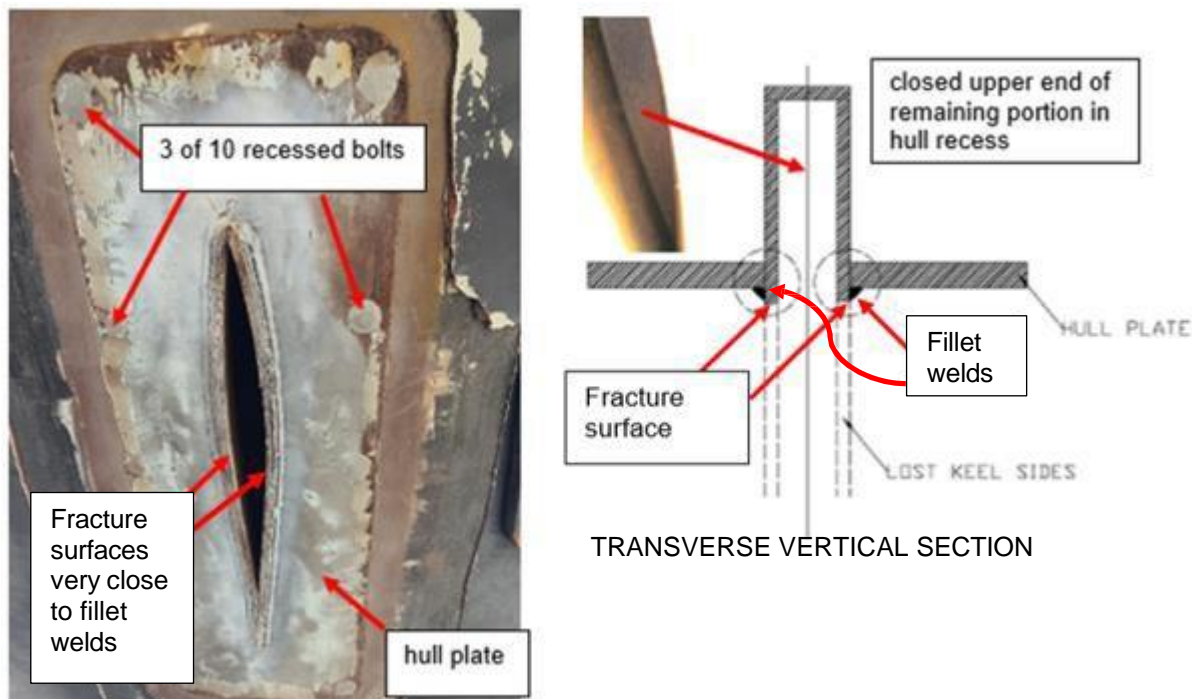


Fig.3 (above, left) – The keel **root** showing the break's **fracture surfaces** very close to the fillet welds at the keel root (the fin below it was lost at the time of the incident). The term 'fillet weld' is given to a line of weld connecting two pieces of metal at an angle to one another, in this case perpendicular (90°) to each other. **Fig.4 (above, right)** – transverse vertical section through the keel, showing the remaining portion of keel fin that inserts into a hull recess, and the horizontal rectangular steel **hull plate**. The photo in **Fig. 5 below** represents the intact arrangement (from the same or similar vessel—the photo's true origins have not been confirmed but are representative of the actual arrangement on the vessel):



(**Fig.5** - Source: <https://forums.sailinganarchy.com/threads/keel-falls-off-yacht-in-sydney-southport-race.124808/page-3>)

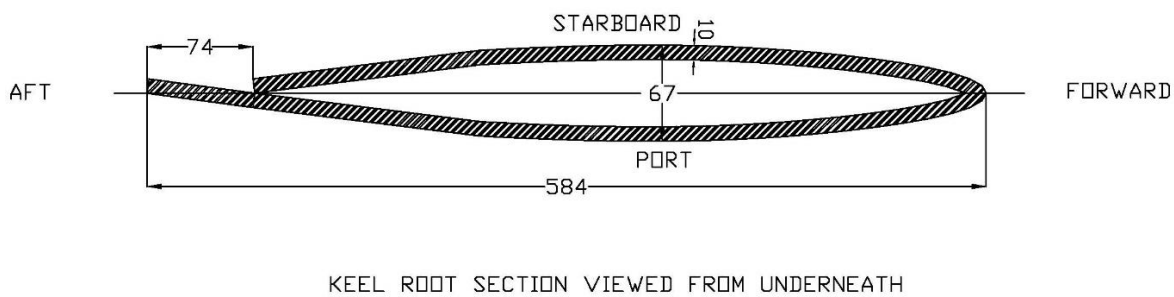
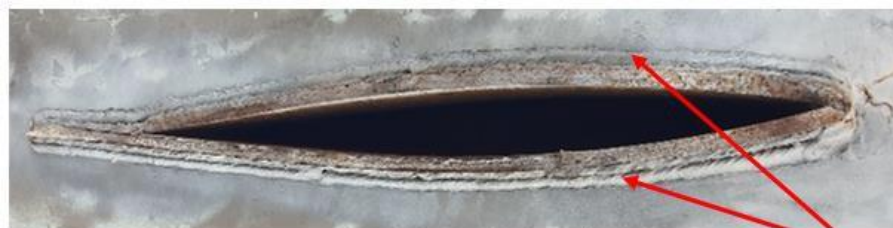


Fig.s 6 & 7 – Drawing (above) with dimensions [mm] and photo (below) of the keel **root** fracture surface.



Perimeter continuous welds

- 22 The fracture surfaces are co-incident with, or in very close proximity to the welds (no more than the keel sides' plate thickness of 10 mm and mostly less).
- 23 Cracking at the boundaries of the fracture surface closest to the welds appears to be co-incident with the **toes** of the welds. The toes are the junction of the weld face and the base metal:

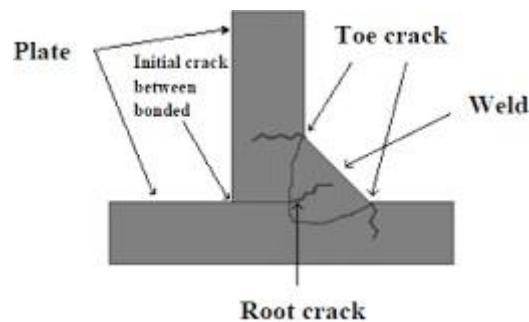


Fig.8– Typical weld geometry shown in cross-section (https://www.researchgate.net/figure/Cracks-initiation-at-weld-toes_fig2_353287193)

- 24 Fracture cracking at weld toes is a well-recognised phenomenon.
- 25 For the purpose of providing background information that assists in understanding what led to the incident, I would like to outline what I believe represents best practice for the welding of critical structures such as a sailing yacht keel. Whenever steel plates are welded together for keel fabrication, there

are several indispensable attributes of the welding procedure that must be ensured. These include:

- a) That the keel connection, particularly at its root and its welding have been designed and documented, accounting for local stress concentrations and fatigue risk. **Fatigue** in metals is the mechanism of progressive failure that occurs due to the repeated cyclical application of loads of magnitude less than the yield breaking load (and the ultimate strength) of the metal. Failure initiates and progresses due to cracking of the metal². Cracking can usually be identified before ultimate failure.
- b) That the parent metal and the weld material are compatible, and plate edges are prepared with notches, chamfers and backing straps as called for in detailed weld design to increase weld penetration and strength.
- c) That the throat and leg dimensions of the weld are appropriate for the thicknesses of the parent metals:

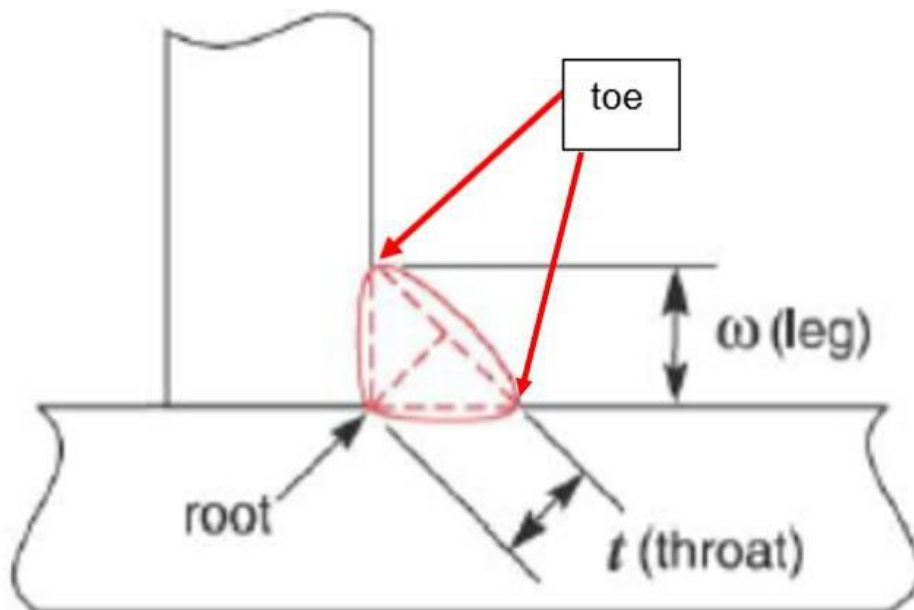


Fig.9 – Weld throat and leg dimensions, with toe indicated (adapted from https://www.researchgate.net/figure/Dimensions-of-the-fillet-weld_fig1_264036794).

- d) That the weld seams are intermittent or continuous, as appropriate case-by-case:

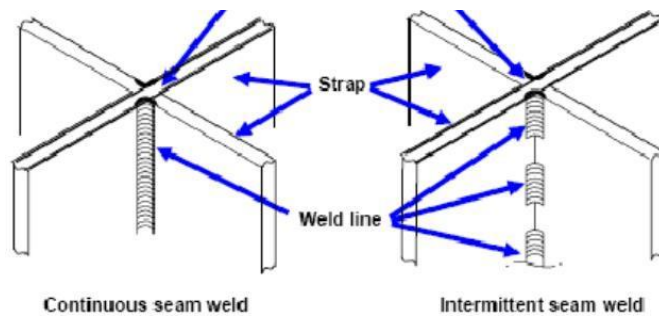


Fig.10– Continuous and intermittent welds (https://www.researchgate.net/figure/Continuous-weld-line-of-the-specimen-welded-by-the-proposed-LASER-welding-method_fig7_298897430).

- e) That the heat put into the weld during the welding process is appropriate and in particular, not excessive. Excess heat results in a Heat Affected Zone (HAZ) which can lead to a hardening of the parent metal and brittle behaviour that reduces the fatigue resistance and fracture toughness of the welded joint. Post-weld heat treatment to control and ensure these properties is usually necessary.
- f) That only a qualified welder performs all welding, who ensures that inclusions, porosity and gaps are avoided. Trial weld samples of critical welds should be produced before commencing the actual job and tested to confirm adequacy. Samples are to be retained so the actual job can be confirmed as matching the trials.
- g) That hold-points are identified during the welding, allowing inspection by a qualified independent third-party inspector.
- h) That completed welds are dressed by grinding or polishing to increase toughness.
- i) That non-destructive examination of the finished welds is undertaken to check quality, such as X-ray (where accessible), ultrasonics, dye-penetrant testing or other methods.
- j) That all of these steps are documented in a welding quality plan.

If steps a) to j) are not followed, premature fatigue failure of the welds or the parent metal in the immediate vicinity will likely be the result, with catastrophic consequences.

- 26 Placement of welds at a critical location such as the keel root creates very high stresses and leads to the risk of fatigue. This is because the keel fin is subjected to its greatest bending load at this location, which is concentrated at the perpendicular welded connection between the vertical keel sides and horizontal hull plate (see Fig.4). The resulting local stress concentration makes consideration of fatigue failure in the design essential. If this is not done, fatigue failure will usually occur. Better still, welds in the most high-stressed keel root region should be avoided completely. If weld failure can result in loss of the keel, an alternative keel attachment design should be chosen.
- 27 My inspection of the fracture surface of the vessel leads me to believe, based on my experience and expertise, that the keel has broken at the welds at the keel root as a result of fatigue, exacerbated by inconsistent weld quality, the contribution of the Heat Affected Zone and the decision to place a weld at such a critical stress location as the keel root. Further physical testing is needed to confirm these findings.
- 28 The following photos that I took assist in illustrating the keel failure:



Fig.11 – Fracture surface—forward direction to top of page, vessel's port side to right of photo.

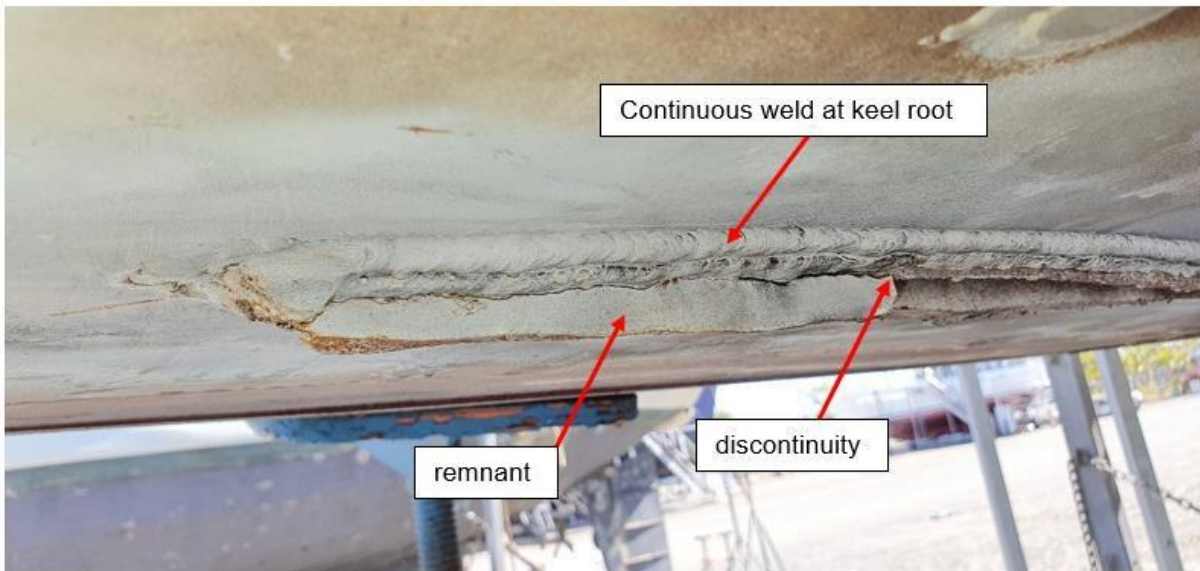


Fig.12 – Fracture surface, vessel's bow to left, taken from perspective of the vessel's port side.

Remnant piece shows where crack changed direction at a discontinuity such as a notch or inclusion. The view is consistent with the starboard (right-hand) side of the keel root failing first on starboard tack (vessel sailing with wind blowing over the right-hand side), then remaining port (left-hand) side of keel root failing thereafter, with total detachment of the keel.

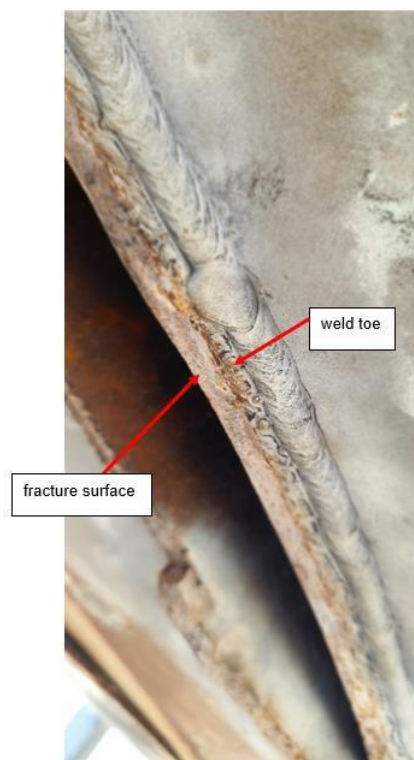
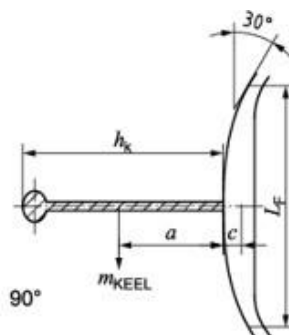


Fig.13 – Fracture surface in the parent metal directly adjacent to the weld toe on the starboard side looking forward. Possibly a double line of weld, to be confirmed by sectioning and polishing in further tests that are required in order to finalise this report



Fig.14 – White-coloured paint overspray within the keel cavity suggests that the keel had gaps in the welded connection of its root that let paint in. If present, gaps are also additional sites of crack initiation and promote further fatigue failure.

- 29 At the time of the keel's construction, there was no requirement for independent inspection of the keel's fabrication and welding nor was there any requirement for the design of the keel's fabrication to be independently reviewed.
- 30 In my opinion, the keel exemplifies a highly-stressed welded keel prone to fatigue failure. Fatigue failure was therefore going to occur before the normal service life of the keel was reached. Normal service life accounts for quasi-static 90° 'knock-down' loads (by "quasi", meaning some movement during the event is envisaged in design). Fig.s 15 and 16 illustrate the knock-down case and the ensuing 'normal' quasi-static load at the keel root:



a) Craft with axial keel heeled at 90°

Fig.15 – taken from ISO/DIS12215-9 Fig. 1 a)



Fig.16 – A near-90° ‘knock-down’ of a similar yacht. Although such behaviour may seem ‘spectacular’, sailing yachts and their keels are expected to be designed and built to cater for such a scenario, and account for some movement during the event, that designers treat as “quasi-static”. This is not an instance of fatigue loading, which must be accounted for separately (<https://www.alamy.com/stock-photo-jameson-whisky-the-irish-entry-for-the-admirals-cup-broaches-in-breezy-31503836.html>)

- 31 Using dimensions and masses of the vessel’s keel found on its ‘IRC’ and ‘ORC’ rating certificates (used to produce sailing race results—obtained from Australian Sailing), I was able to calculate the quasi-static knock-down factor of safety for the vessel’s keel. The factor of safety that I calculated was 2:1, as shown in red in Table 1 below. This was the minimum value required by the sailing yacht structural ‘scantlings’ guide in use at the time and required by Australian Sailing, the American Bureau of Shipping *Guide for Building and Classing Offshore Racing Yachts* (ABS), now obsolescent:

| Measured/calculated particular: | Value: | Unit: | Source: |
|---------------------------------------|-----------------|-------------------|--|
| Draft | 2561 | mm | IRC/ORC certificates ref. Australian Sailing |
| Canoe draft | 300 | mm | estimated |
| Bulb draft | 300 | mm | estimated |
| Keel fin span | 2111 | mm | deduced |
| Bulb mass | 1100 | kg | IRC |
| Fin mass | 182 | kg | calculated |
| Fin root moment [A] | 1887460 | Nmm | calculated |
| Bulb moment [B] | 24398451 | Nmm | calculated |
| Total moment [A+B] | 26285911 | Nmm | calculated |
| Fin root thickness | 67 | | measured |
| Fin root moment of inertia | 4880000 | mm ⁴ | calculated |
| Root stress | 178 | N/mm ² | 2:1 |
| 350 mild steel nominal yield strength | 350 | N/mm ² | assumed (unwelded) |

Table.1 – 90° quasi-static knock-down factor of safety at keel root with factor of safety of 2:1 shown in **red** (Note: IRC and ORC are the names of two international measurement yacht handicap systems administered by Australian Sailing that are a reliable source of vessel measurement data to facilitate these calculations). Australian Sailing is the national governing body for the sport of sailing: www.sailing.org.au.

The use of estimates shown in the table does not indicate a deficiency in the calculations. I am confident that estimated dimensions do not pose a threat to the integrity of the calculations. In any event, the cause of the failure lies elsewhere (that is, fatigue cracking) not in the quasi-static 90° knock-down load case.

- 32 The calculated factor of safety of 2:1 is subject to the assumptions stated in the right-hand column of Table 1 and is not intended to account for local stress concentrations present at the keel root, material variability, or fatigue. Note that a factor of safety of 2:1 suggests that the item is theoretically twice as strong as its yield strength. **However, once stress concentrations, material variability and fatigue have been accounted for, premature fatigue failure of the vessel's keel is predicted. The ABS did not provide guidance on fatigue.**

33 There was surface corrosion of the welds and parent metal, and I suspect, porosity, inclusions and gaps all of which are deleterious to the keel's strength of attachment at the root.

34 My findings as to cause are interim in nature:

I recommend that sectioning, polishing and examination of the root welds be undertaken in accordance with a specimen extraction and testing regime, following which this interim report can be finalised.

INTERIM CONCLUSIONS

- 35 The vessel's keel fell off due to metal fatigue at its connection to the hull,
leading to capsize and inversion of the vessel.
- 36 This report remains interim, pending the outcome of a test regime that
includes sectioning, polishing and examination of the keel root welds.

A handwritten signature in black ink on a yellow background. The signature is stylized, starting with a large 'D' and ending with a long horizontal stroke.

Mr David Lyons

CEng FRINA FIEAust RPEQ

Director, Lyons CENA Pty Ltd ABN 98 633 251 779

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Coolum Beach
Queensland 4573
Australia
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E David@LyonsConsult.net
www.linkedin.com/in/davidhlyons

23 July 2024

David Lyons
Chartered Engineer
PO Box 155
Coolum Beach QLD

Dear David,

Ref: 2024/2925 Big Hairy

Australian Sailing has a responsibility to contribute to the global oversight is in relation to offshore yachting and offshore racing in particular. In this area World Sailing oversees a plan review process where offshore yacht designs are reviewed for compliance with the applicable international standards being ISO12215 for hull construction and scantlings, including keels and rudders. World Sailing also oversees safety regulations concerning keel and rudder inspection procedures as per their Regulations.

One area of significant concern in relation to the safety of offshore racing is keel failures and especially keel failures that have followed keel modifications. In the last 25 years there have been approximately 90 keel failure incidents worldwide that have led to 27 lives being lost.

The incident on 16 June 2024 when the yacht Big Hairy ("the Yacht") lost its keel resulted in the death of Mr Roger Searl is being investigated by the Coroners Court of Queensland. The Yacht was salvaged and is in Bundaberg under the control of the Coroners Court of Queensland and police investigating the incident.

Australian Sailing is an interested party because the Yacht was being delivered to the Royal Queensland Yacht Squadron to participate in the Brisbane to Keppel Tropical Yacht Race. Given that interest, Magistrate O'Connell has approved that a representative of Australian Sailing may conduct a visual inspection of the yacht. A copy of that approval is attached.

As previously discussed with you, Australian Sailing appoints you to be its representative to conduct a visual inspection of the Yacht's remaining keel materials, and the internal and external adjacent hull area and provide a report to Australian Sailing.

The Yacht is under the control of the Gladstone Water Police at the Bundaberg Port Marina and you should make arrangements with them at your soonest convenience. The contact I have been provided is Senior Constable Joe Moran, and he can be reached at waterpolicegladstone@police.qld.gov.au and 0437 200 056.

I also advise you that Australian Sailing recognises the importance of maintaining the integrity of evidence before the Court and has agreed to provide a copy of your report to the Central Coroner to assist their investigation.

Yours faithfully,



Glen Stanaway
Head of Governance, Rules and Safety
glen.stanaway@sailing.org.au



QUEENSLAND COURTS

CORONERS COURT OF QUEENSLAND - CENTRAL REGION

Our Reference: 2024/2925
Contact: Cathy Head
Telephone: (07) 4889 8409

Mackay Magistrates Court
12 Brisbane Street
Mackay QLD 4740

PO Box 377
Mackay QLD 4740

07 4889 8410

-

Coroner.Central@justice.qld.gov.au

www.courts.qld.gov.au

10 July 2024

Mr Glen Stanaway
Head of Governance, Rules & Safety
Australian Sailing
1A Brooke St
HOBART TAS 7000

Dear Mr Stanaway

I acknowledge receipt of your letter dated 09 July 2024.

Permission is given to Australian Sailing Limited representatives to inspect the retrieved yacht "*The Big Hairy*". Queensland Police Service (QPS) will be notified and appropriate arrangements should be made direct by Australian Sailing with QPS.

Please supply a copy of the Australian Sailing Inspection Report/Assessment of why the keel likely failed once completed.

Yours sincerely

Magistrate O'Connell
Central Coroner

Professional Resume & Capability Statement:

David Lyons CEng FRINA FIEAust RPEQ GCULT — Director of LyonsCENA Pty Ltd:

- **Chartered Engineer and Naval Architect with 36 years experience.** Specialised in ship design, construction and materials (aluminium, steel, composites, timber)—more than 50 vessels designed and in operation today.
- Continuing appointment, UNSW Canberra at the Australian Defence Force Academy, course convenor in naval architecture, sponsored by Navy Engineering.

Qualifications:

- Bachelor of Engineering (Honours) – The University of New South Wales, Australia - 1987.
- Graduate Certificate in University Learning and Teaching – The University of New South Wales (UNSW), Australia - 2017: Experienced university educator with acknowledged skills in tertiary-level technical communication.

Professional associations:

Chartered Engineer (Engineering Council UK) No. 623551

- The Engineering Council (UK) sets and maintains internationally recognised standards of professional competence and commitment: “*Chartered Engineers (CEng) develop solutions to engineering problems using new or existing technologies, through innovation, creativity and change and/or they may have technical accountability for complex systems with significant levels of risk*”. [<https://www.engc.org.uk/professional-registration/the-professional-titles/chartered-engineer/>].

Fellow—The Royal Institution of Naval Architects (RINA) No. 00232335

- The highest attainable merit-based grade of Corporate Membership of the Institution: “*Having achieved professional standing in the maritime community, and having held positions of superior responsibility for a period of at least five years*”. [<https://www.rina.org.uk/requirements.html>].

Fellow—Engineers Australia (Structural College) No. 4116262

- The highest attainable merit-based grade of membership: “*As a Fellow of Engineers Australia you will be recognised as being amongst the true leaders of the industry and profession*”. [<https://www.engineersaustralia.org.au/Membership/Membership-Benefits/Fellow-Membership-Benefits>].

Registered Professional Engineer, Queensland RPEQ (Naval Architecture) No. 16332

UNSW Canberra/Sydney summary:

2021—Course convenor, the new Naval Architecture Program at UNSW Canberra at ADFA.

2014 to 2020—Head of Naval Architecture, UNSW Sydney School of Mechanical and Manufacturing Engineering.

Other current and previous employment history:

2019 – Director, LyonsCENA Pty Ltd – engineering consultancy

Independent third party design verifier and provider of expert consultancy and opinion services (marine/naval architecture).

2011 – 2014: Technical Director, Seaflyer Pty Ltd – naval architecture consultancy

Designer of surface ships and small craft.

2004 – 2011: General Manager, Nuplex Industries Australia t/as EMP Composites

Business manager for six-member consultancy specialising in composite materials engineering.

1996 – 2004: Technical Manager, DIAB Australia Pty Ltd

Manager of engineering services with regional responsibility for Australasia and south-east Asia. Core materials for sandwich construction.

1992 – 1996: Technical Director, Seaflyer Pty Ltd – naval architecture consultancy

Designer of multiple surface ships and small craft; more than fifty vessel built.

1989 – 1992: Technical Manager, Divinycell international

Manager of engineering services with regional responsibility for Australasia and south-east Asia. Core materials for sandwich construction.

Expert opinion:

- (1) Matters taken directly.
- (2) Unisearch Expert Opinion Services – retained since 2018.
- (3) Envista Forensics External Expert.

Online presences:

LinkedIn – www.linkedin.com/in/davidhlyons

UNSW Research Gateway - <https://research.unsw.edu.au/people/mr-david-lyons>

Publications (select) - <https://research.unsw.edu.au/people/mr-david-lyons/publications>

Researchgate.net - https://www.researchgate.net/profile/David_Lyons3

Other professional associations/memberships:

- International Standards Organisation TC188 WG 35 Convenor *Small Craft* (2022 - current)
- International Technical Committee - *Offshore Racing Congress* (1997 - current)
- Special Regulations sub-Committee - *World Sailing* (2009 - 2016)
- National Safety Committee - *Yachting Australia* (2010 - 2016)

Editorial and consultancy appointments:

- Member, Editorial Board – *International Journal of Maritime Engineering*, The Royal Institution of Naval Architects (2017-current).
- World Sailing – Convener: Critical structures In-build Validation Scheme (2016 - 2018)
- Australian Sailing honorary consultant – technical/offshore (2011 - current)
- Advisory Committee member, Sailing Yacht Research Foundation (USA, 2013 - current)

Legal/Technical:

- My expert naval architecture/engineering reports have been tendered in the NSW Coroners Court, Federal Court, Supreme Court of NSW, NSW District Court, Supreme Court of Queensland and the High Court of New Zealand. Experienced in court testimony and cross-examination as an expert witness.

Other competencies and achievements, including sport:

Italian language – conversational level and written proficiency.

Overall winner, 1993 Sydney to Hobart Yacht Race—aboard own design *Micropay Cuckoo's Nest*.

International sailor – competed at the Admiral's Cup (UK)—extensive blue water experience.

Australian Champion *Melges 24* class, 2009. Sailed since the age of four.

Recipient, Australian Sports Medal, 2000 (Sailing) by His Excellency's Command, Sir William Deane, Governor-General of Australia.

David Lyons CEng FRINA FIEAust RPEQ GCULT

Director - For and on behalf of Lyons CENA Pty Ltd ABN 98 633 251 779T +61 (0)418 208 370 E David@LyonsConsult.net
www.linkedin.com/in/davidhlyons

