MARITIME NEW ZEALAND

Accident Report

Capsize

Time to Burn

31 August 2008

Maritime New Zealand

Maritime New Zealand (MNZ) is a Crown Entity appointed under section 429 of the Maritime Transport Act 1994, with the responsibility to promote maritime safety, security and the protection of the marine environment.

Section 431 of the Maritime Transport Act sets out MNZ's functions. One of those functions is to investigate and review maritime transport accidents and incidents.

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VESSEL DETAILS

Ship name:	*Time to Burn*
Ship type:	Recreational sailing vessel
Built:	1994
Construction material:	GRP
Length overall (m):	12.5
Displacement (kg):	6,800

Photograph 1
Time to Burn

GLOSSARY

TERM	DESCRIPTION
ABS:	American Bureau of Shipping
CBES:	Coastguard Boating Education Service
Distress:	A vessel or person is in grave and imminent danger and requires immediate assistance (Maritime Rules Part 88).
EPIRB:	Emergency Position Indicating Radio Beacon
ETR:	Estimated Time of Return
FCAW:	Flux Core Arc Welding
GMDSS:	Global Maritime Distress and Safety System
GPS:	Global Positioning System
HF:	High Frequency
Inshore waters:	Includes harbour, sounds, fiords, lakes. Defined by NZSM 5823:2005 as “where an early rescue may be anticipated” and previously referred to as “sheltered waters”.
ITC:	International Technical Committee
ISO:	International Organisation for Standardisation
Knot (kn):	One nautical mile per hour
MIG:	Metal Inert Gas
MNZ:	Maritime New Zealand. A Crown Entity appointed under section 429 of the Maritime Transport Act 1994 with the responsibility to promote maritime safety and security and the protection of the marine environment and the function to investigate and review maritime transport accidents and incidents.
MET:	New Zealand Metrological Service
MF:	Medium Frequency
MOC:	Maritime Operations Centre
MHz:	Megahertz
MIG:	Metal Inert Gas
Nautical mile (nm):	Measure equal to 1,830 metres
NDT:	Non Destructive Testing
NPBSF:	National Pleasure Boat Safety Forum
NIWA:	National Institute of Water and Atmospheric Research
NZS:	New Zealand Standard
Offshore:	Open Sea. Defined by NZSM 5823:2005 as “rougher waters, not inshore”.
PFD:	Personal Flotation Device
PLB:	Personal Locator Beacon. A form of distress beacon.

Pleasure craft (boat):	A ship that is used exclusively for the owner's pleasure or as the owner's residence, and is not offered or used for hire or reward; but does not include: • a ship that is provided for transport or sport or recreation by or on behalf of any institution, hotel, motel, place of entertainment, or other establishment or business • a ship that is used on any voyage for pleasure if it is normally used or intended to be normally used as a fishing ship or for the carriage of passengers or cargo for hire or reward • a ship that is operated or provided by any club, incorporated society, trust, or business. (Section 2 Maritime Transport Act 1994)
POB:	Persons on Board
RCCNZ:	Rescue Coordination Centre New Zealand
Recreational craft:	See Pleasure craft (boat)
RHS:	Rectangular Hollow Section
SAR:	Search and Rescue
SSB:	Single Sideband
SOLAS:	International Convention for the Safety of Life at Sea 1974
TECT	Tauranga Energy Consumer Trust
VHF:	Very High Frequency
VP:	Vertical Plate
YTS:	Yield Tensile Strength

1. SUMMARY

1.1 At about 0515 hours on 31 August 2008 *Time to Burn*, with two people on board, was approaching Tauranga after sailing from Gisborne. The purpose of the trip was to slip the vessel in Tauranga to inspect and, if required, repair the keel.

1.2 The vessel was motor sailing in moderate seas approximately 11 nautical miles from the Tauranga harbour entrance when the keel detached from the hull, causing *Time to Burn* to lie on its side for approximately 15–20 minutes before capsizing.

1.3 The crew were able to make an emergency call on a hand-held VHF radio, activate marine distress flares, and activate a 406 MHz Emergency Position Indicating Radio Beacon (EPIRB) before the vessel capsized.

1.4 In response to the emergency call a Coastguard rescue vessel was launched. The rescue vessel was able to rescue one of the crew, however, the skipper drowned before the rescue vessel arrived on the scene.

Photograph 2
Time to Burn in a state of capsize after the keel became detached from the vessel's hull.

2. NARRATIVE

Events

2.1 The following synopsis of events is a summary of information gathered from different sources, including interviews in Auckland and Napier with the survivor, and the vessel's designer, builders and owners.

Preamble

2.2 The owners of the vessel knew of a fault on *Time to Burn's* keel. Prior to the accident the vessel had sailed from Napier to Gisborne for routine maintenance because slipping facilities were inoperable in Napier. At Gisborne the keel was observed to be loose when lifted in a travel lift. After seeking professional advice the owners decided to sail to Tauranga to have the keel inspected and, if required, repaired at a local boatyard.

2.3 Prior to departure the crew considered stowing the eight-man liferaft in the cockpit but decided not to because it would have created an obstruction. They decided to stow the raft below deck in the forward cabin under a table.

The trip

2.4 On 30 August at about 0630 hours *Time to Burn* departed Gisborne for Tauranga with two of the owners on board. (See figure 1 for the approximate track taken by *Time to Burn*.)

2.5 One of the owners had previously sailed on the Napier to Gisborne trip, however, the skipper had not. He had been briefed on the problem with the keel and had discussed safety matters with the previous skipper including the importance of activating the 406 MHz EPIRB on board if the vessel ran into difficulty.

2.6 On departing Gisborne *Time to Burn* encountered rough head seas of about 2–3 m from the south east. The vessel rode the seas without issue and continued on the planned track towards Tauranga. During the voyage, as *Time to Burn* rounded East Cape under main sail, the weather conditions altered from strong winds to calm conditions where motoring was required. The next leg of the passage took *Time to Burn* past Cape Runaway where a squall[1] of 27 knots was encountered. The vessel managed this without issue.

2.7 Approaching Tauranga early in the morning on 31 August, while north west of Motititi Island[2], the vessel was motor sailing under main sail alone in seas of approximately 1 m at a speed of 11–12 knots. Wind direction was reported as being north east at approximately 18 knots. The vessel was on a starboard tack with the wind on the starboard quarter. Everything was running normally as they made their approach to Tauranga.

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1 A sudden violent gust of wind or localised storm, especially one bringing rain, snow, or sleet.
2 See figure 2 showing a chart extract of NZ54.

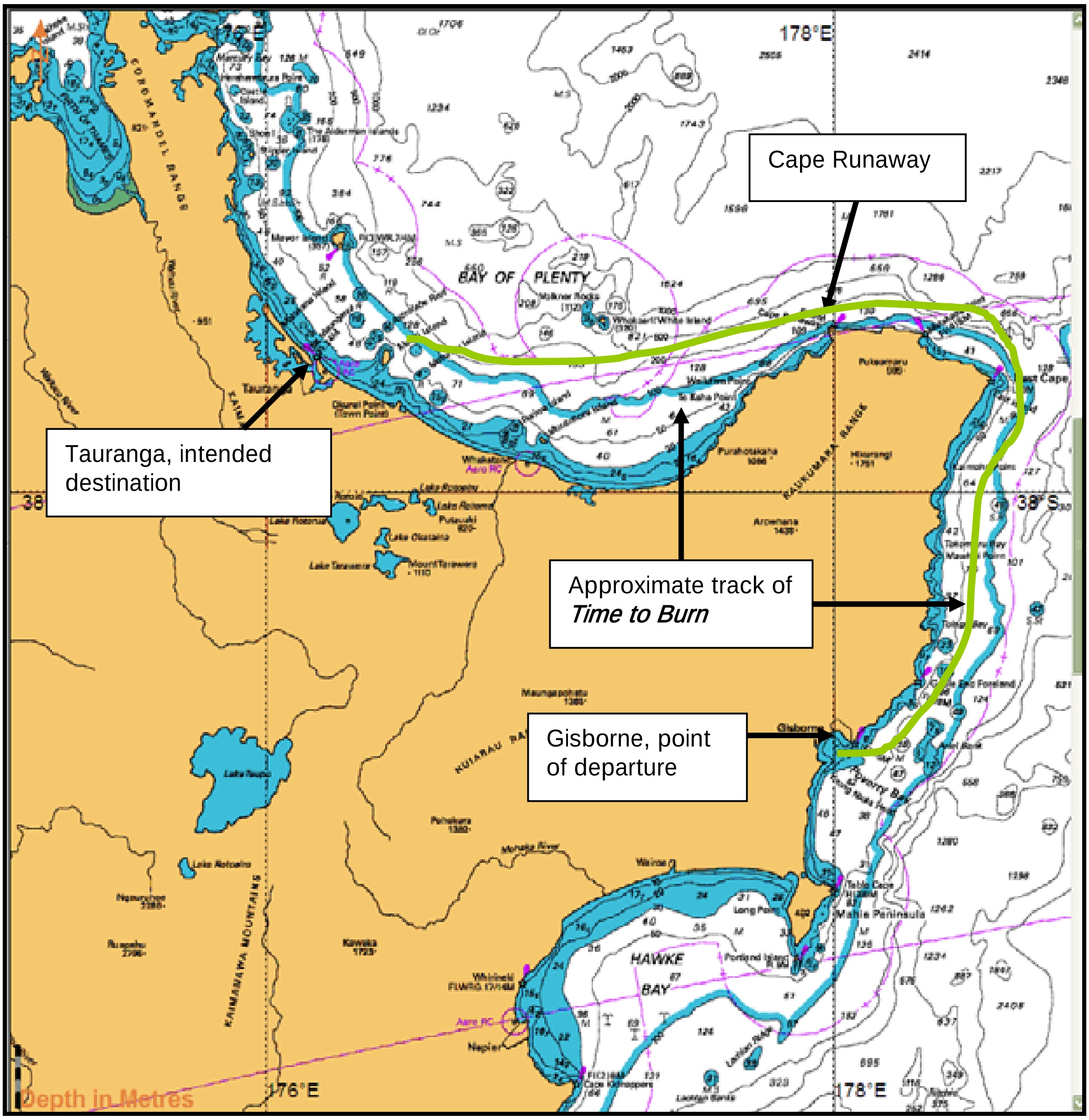

Figure 1
Extract of chart NZ23 New Zealand North Island, showing the approximate track of ***Time to Burn*** from Gisborne. (See figure 2 for detail on the vessel position off Tauranga.)

2.8 At approximately 0515 hours the surviving crewmember was below navigating when he felt the boat suddenly slow down to a speed of approximately 4 knots. He stated it was a strange feeling and he initially thought the vessel may have hit a net. He stated: *"I was just about to come up and say we'll jibe and the boat slowed, it was like a car just braking at a stop sign".*

2.9 He came on deck and asked the skipper, who was at the helm, if anything was wrong. He also checked overboard with a flashlight but could see nothing unusual.

2.10 ***Time to Burn*** continued on course for approximately 100 m and then turned 90° onto her port side with the carbon fibre mainsail laying on the surface of the sea.

2.11 The skipper joined the crewmember in the cabin and both men, who were in full wet weather gear, immediately donned two of the eight coastal NZS 401 lifejackets on board ***Time to Burn.***

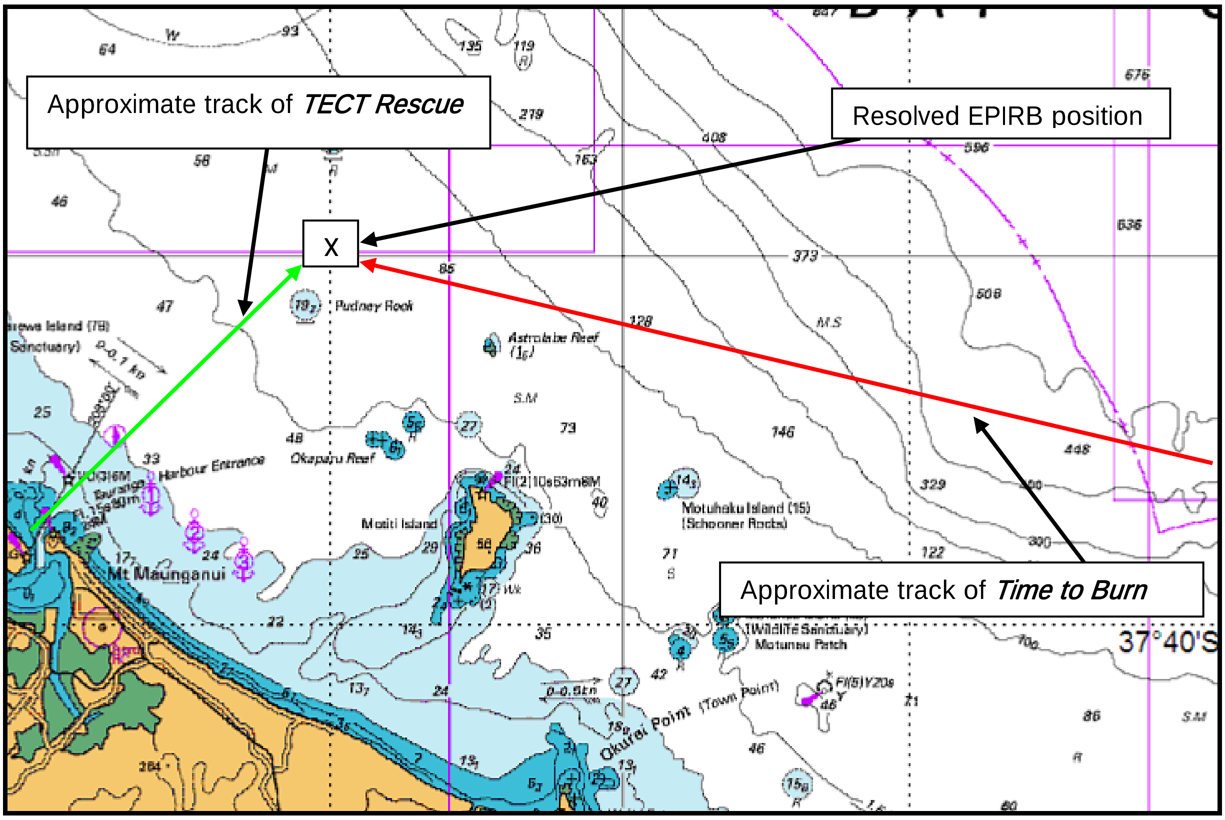

Figure 2
Extract of chart NZ54, showing approximate track of ***Time to Burn***, ***TECT Rescue*** and resolved EPIRB position.

2.12 Also at this time the crew tried to contact emergency services to alert them of ***Time to Burn's*** situation.

2.13 The surviving crewmember stated they made a Mayday call from within the cabin on a hand-held VHF radio that was stored with other emergency items in an emergency grab bag. They also manually activated both of ***Time to Burn's*** EPIRBs. One was a registered 406 MHz beacon, and the other a 121.5/243 MHz beacon. When subsequently recovered from the coastline the 121.5/243 MHz beacon was found with the switch on the "off" position. They also activated two marine distress rocket flares. An attempt to activate a third out-of-date flare failed because it was defective. Attempts to communicate using their cellphones were unsuccessful owing to one phone having a flat battery and the other having the battery fall out.

2.14 The following key events are taken from the search and rescue (SAR) logs, showing in chronological order some of the distress calls made by ***Time to Burn*** as received by the emergency services.

0522 hours – Rescue Coordination Centre New Zealand (RCCNZ) received an unlocated (no position information) distress alert from a 406 MHz EPIRB.[3] The beacon was registered to *Time to Burn*.[4]

0525 hours – RCCNZ contacted the Maritime Operations Centre (MOC) advising them of an EPIRB signal registered to *Time to Burn* /ZMZ2965 for the yacht based in Napier. RCCNZ advised that the detection was from a stationary satellite, so no position was available until the next orbiting satellite pass at 0630 hours. MOC searched its vessel database for *Time to Burn*. At that time MOC had not heard any radio traffic to indicate that *Time to Burn* was in distress.

0533 hours – Plenty Maritime Radio (PMR)[5] received a Mayday call on VHF channel 16: *"Mayday, Mayday, Mayday, Mayday anyone read over".* PMR reported that the signal was broken and hard to copy. PMR requested the station in distress to identify themselves, give their position, the nature of their distress and the number of people on board.

In addition, at 0533 hours RCCNZ spoke with one of the vessel owners, who was ashore, on an emergency contact number registered to the 406 MHz EPIRB. The owner advised RCCNZ that *Time to Burn* was en route from Gisborne to Tauranga with two people on board.

0534 hours – PMR received a broken message that sounded like a person saying: *"We got three"* peep ……… signal broken, then sounded like: *"Two people on board, we're not sinking, can you get someone to us immediately mate"*. PMR requested the vessel's position. Nothing heard. The surviving crewmember stated he could not recall hearing PMR's request for a position. This may be explained by the fact that the transmission was made from within the vessel cabin close to water level, where transmission and reception may have been compromised.

0534 hours – PMR broadcasted a call to all stations advising of the distress call and requested any station with further information to please advise. At about the same time MOC phoned RCCNZ to advise them of the distress call received on PMR VHF channel 16. RCCNZ advised MOC they believed it may be *Time to Burn* because of EPIRB transmissions received.

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3 The 406 MHz EPIRB in this incident was not a model fitted with a Global Positioning System (GPS). The satellite detection system comprises orbiting satellites and geo-stationary (or fixed) satellites. The orbiting satellites pass over the New Zealand region approximately every 1–2 hours. These satellites can calculate a position for a distress beacon transmitting without a GPS or pick up the message from a distress beacon with GPS information attached. The geostationary satellites can "see" beacons in the New Zealand area transmitting with or without GPS at most times but cannot calculate any position information – it must be supplied by the beacon, ie the beacon must be fitted with GPS. In this case the first satellite to detect the beacon was a geo-stationary satellite so it could not provide any location information, simply report that an alert had been generated somewhere within its vast field of view. The second alert was supplied by an orbiting satellite and so was able to provide a reasonably accurate position for the alert. The searching helicopter and aircraft could then "home" onto the transmitting beacon once they were in the general area using the transmissions made by the beacon.

4 All 406 MHz distress beacons have a unique identification code that can be registered with SAR authorities to identify the user and provide potentially vital information in the event of a distress situation about the vessel or craft, the users, contact details etc. RCCNZ manages and operates the database for New Zealand distress beacon users to register their beacons. The beacon in this incident was registered and did allow RCCNZ to contact persons ashore who could provide some details of the vessel and its intended routing.

5 PMR and other stations on the New Zealand coastline continuously monitor VHF channel 16, the international distress, safety and calling frequency for the maritime mobile VHF radiotelephone service.

Once the initial distress call had been made, the crew remained in the cabin for sufficient time to fire distress flares. Shortly after the flares were fired *Time to Burn* fully capsized. The skipper was able to immediately exit through the companionway, however, the crewmember was unable to escape owing to the force of water ingress. It was only after the cabin had flooded, and after a third attempt, that was he able to reach the surface.[6] Before escaping he was able to breathe from an air pocket in the cabin. Once out both he and the skipper found themselves at the stern of the vessel at day-break, holding onto the exhaust pipe.

0541 hours – RCCNZ contacted MOC to advise that the Police had a report of two red flares off Motiti Island in Tauranga. Immediately after this MOC broadcasted a distress relay advising all traffic that red flares had been sighted off Motiti Island.

0543 hours – RCCNZ requested the Police Communications Centre – North (Northcom) to page Tauranga Coastguard to initiate the call out procedure for launching the Coastguard vessel.

0544 hours – RCCNZ paged the Tauranga Energy Consumer Trust rescue helicopter requesting them to take off as soon as possible in order to search for the location of *Time to Burn*. At about the same time RCCNZ also arranged for a fixed wing aircraft to be launched from Taupo to assist in the search for the vessel.

0601 hours – Coastguard advised RCCNZ that the crew for the Coastguard rescue vessel had been alerted and were proceeding to the Coastguard station to ready the boat for launch. Once launched it would take approximately 30 minutes to reach the area off Motiti Island where the reports indicated red flares had been seen.

0610 hours – SAR helicopter airborne.

About 0634 hours – The local Coastguard vessel *TECT Rescue* was launched from Tauranga.

0635 hours – Fixed wing SAR aircraft airborne.

0636 hours – The next satellite pass occurred and generated a second alert from the 406 MHz EPIRB transmissions. This alert gave a location for the distress at the position 37° 30'S 176° .20'E. RCCNZ gave this position to the aircraft, helicopter and Coastguard vessel. This was the first time that the agencies involved had a definite position to work with. (See figure 2 for resolved EPIRB position.)

0655 hours – The fixed wing SAR aircraft and the SAR helicopter, guided by the satellite generated EPIRB transmission position and homing onto the beacon, sighted *Time to Burn* with one person on the hull and another in the water.

0707 hours – RCCNZ contacted Coastguard who advised that their vessel *TECT Rescue* was 6 nautical miles south of the reported position and would proceed there as soon as possible.

After *Time to Burn* was sighted, the Coastguard vessel *TECT Rescue* was guided to *Time to Burn's* position. At about 0735 hours *TECT Rescue* arrived on scene and rescued the survivor and recovered the skipper's body.

0738 hours – The crewmember and the body of the skipper were on board *TECT Rescue*, which was making its way back to Tauranga.

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6 The crewmember estimated that it took him about 10 minutes to exit the cabin.

2.15 During the in water survival period, prior to the arrival of ***TECT Rescue***, both men struggled to hold onto the slippery hull. While the crewmember was attempting to secure a line over the hull, the skipper's lifejacket started slipping over his head. The crewmember assisted the skipper, to the best of his ability, with his lifejacket on a number of occasions by slipping it back over his head and clipping the straps in place. He then attempted to find a line to use as a crotch strap, to prevent the skipper's lifejacket from slipping up, and tried to use a running backstay[7] line to secure him to the hull, to no avail.

2.16 Despite the crewmember's best efforts the skipper continued to struggle. Subsequently, the crewmember observed the skipper floating face-down in the water with his lifejacket still on. This was about 30 minutes after the ***Time to Burn*** had capsized. The crewmember was unable to render further assistance owing to the sea conditions and his physical state. The crewmember used sea survival techniques he learnt on a course run by Yachting New Zealand/Coastguard Education such as adopting the single huddle position when in the water to conserve energy and body heat. The crewmember managed to scramble onto the hull prior to the rescue boat arriving.

2.17 While on the hull the crewmember saw what he assumed to be a discarded spinnaker in the water near the hull.

[7] Adjustable sections of rig running from the top section of the mast to both sides of the stern.

3. COMMENT AND ANALYSIS

Boating experience and knowledge

3.1 Both people on board were experienced yachtsmen.

3.2 The skipper had extensive experience, had sailed with the co-owners for 14 years, and was reported to be a strong swimmer.

3.3 The surviving crewmember has sailed keel boats for most of his life and had in excess of 20,000 ocean miles of experience. He had completed a sea survival course.

Autopsy

3.4 The autopsy report recorded the skipper's cause of death as drowning.

Weather

3.5 The skipper of the Coastguard rescue vessel stated that there were 1½ m seas when the rescue and recovery took place. The surviving crewmember estimated the seas were about 1 m.

3.6 MetService weather data recorded at 0500 hours on 31 August 2008 for Tauranga indicated the wind was south east at 6 knots with a maximum reading of 10 knots.

Time to Burn's history

3.7 *Time to Burn* was designed by Brett Bakewell-White, a well known Auckland yacht designer. The vessel was a 12.5 m (42' ft) ¾ rig racing cruiser with a displacement of 6,800 kg. *Time to Burn* was a one-off design with no sister ships built to that design.

3.8 The vessel was launched in 1994, and at the time of launch she was considered to be an advanced racing cruiser design.

3.9 *Time to Burn* had successfully won a number of racing series, including twice winning the Two Handed Round the North Island Race.

3.10 In 2000 *Time to Burn* was fitted with a new "Z" keel by the original owner, to increase her racing performance.

3.11 The Z keel is so named because the leading edge cants forward from the point where it attaches to the hull. Most keels are either vertical in relation to the hull or, traditionally, cant aft. (See photograph 3 showing *Time to Burn* and its keel.)

Photograph 3
(Courtesy of Hunter Marine Surveying Ltd) ***Time to Burn*** on a traditional cradle.

3.12 The Z keel was constructed and welded onto the keel plate by Fergusson Welding (1985) Ltd (Fergussons) in Auckland. Fergussons is a well known engineering firm frequently commissioned by owners and designers to construct keels. Before construction Fergussons consulted welding engineers who advised the keel plate was to be preheated prior to welding. Fergussons stated this was done to prevent the welds from being brittle and at risk of failure. Fergussons said the welding method was Metal Inert Gas (MIG) with flux core.

3.13 The keel with keel plate attached was then transported for fitting to the hull by Lloyd Stevenson Boat Builders (Stevensons). Stevensons is a well known Auckland boatbuilding firm who originally built ***Time to Burn***.

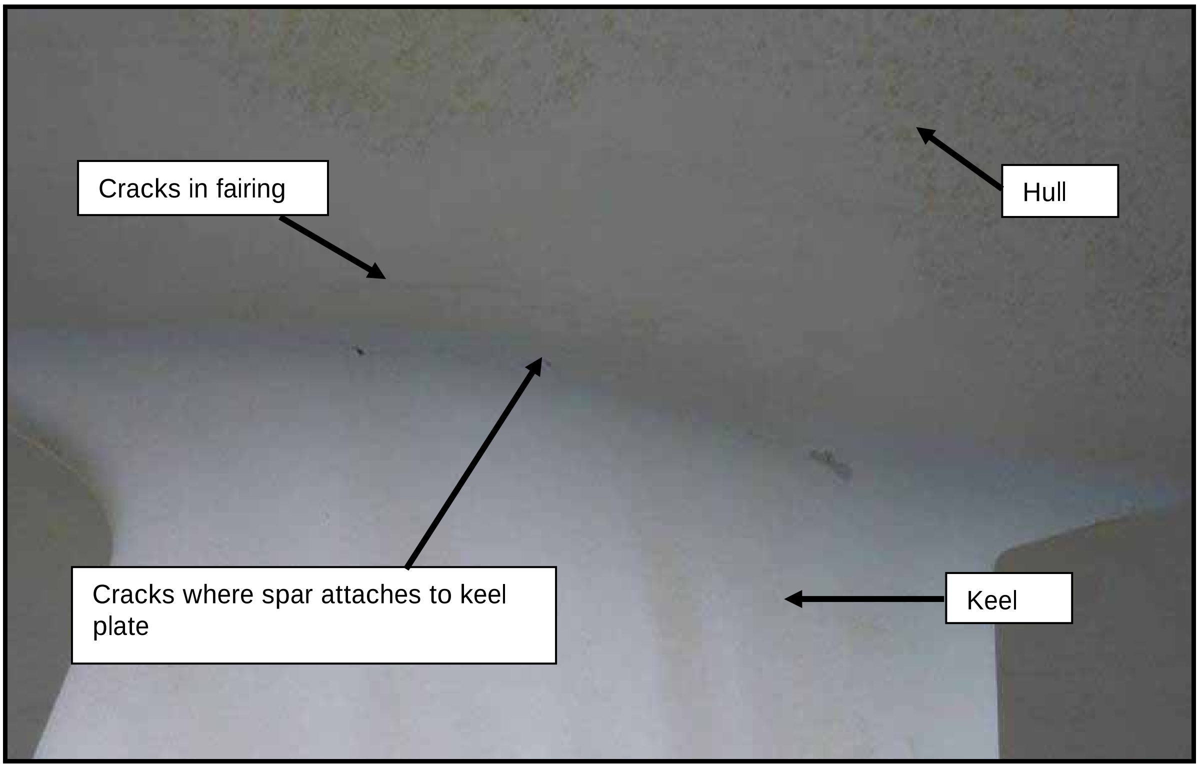
3.14 The four owners of ***Time to Burn*** bought the vessel in 2003 with the intention of racing and cruising. The vessel raced successfully in a number of coastal and offshore races. No survey was commissioned prior to purchase.

3.15 In 2005, 2 years after purchase, ***Time to Burn*** lost a rudder after a collision with an unknown object. The rudder was replaced by Stevensons shortly after the accident.

3.16 In October 2006 the rudder was lost again after the vessel struck a whale off Coromandel in the outer Hauraki Gulf.

3.17 The owners stated that the Z keel bulb was also damaged by the collision with the whale. Close examination of the keel showed some cracks in the approximate area where the keel plate was set in the hull. Whether these cracks were caused by impact with the whale can not be determined. Cracks in fairing are not uncommon where keels attach to hulls. The impact was substantial, with damage to the keel bulb. (See photograph 4 of cracks in the fairing taken after impact with the whale and photograph 5 showing damage to the lower keel.) Accordingly, the possibility that damage was caused to other sections of the keel can not be ruled out.

3.18 On this occasion Stevensons again replaced the rudder and repaired the damage to the keel's fairing on the Z keel. (See photograph 5 of damage to the keel.) The fairing was not removed to examine the main structural components of the keel.



Photograph 4
(Courtesy of Hunter Marine Surveying Ltd) ***Time to Burn's*** keel showing cracks in the outer fairing after the impact from the whale.

Photograph 5
(Courtesy of Hunter Marine Surveying Ltd) Damage to the lower keel.

3.19 After the repairs to the rudder and damaged sections of keel fairing *Time to Burn* continued to be involved in racing and cruising without incident.

3.20 In January 2008 the vessel was slipped in Napier and surveyed to Yachting New Zealand (YNZ) Category 2 standards, as required prior to competing in the Two Handed Round the North Island Race. The inspection was carried out by a certified YNZ inspector. The checklist completed at the time did not raise any structural deficiencies in the hull. The inspection was conducted when the vessel was on a traditional cradle, which placed the full weight of the vessel on the keel. Subsequently, approximately 3 months prior to the accident, *Time to Burn* was slipped on the same slip in Napier where a 50 mm crack, 5 mm deep in the fairing was observed on the starboard side of the hull, where the keel attached to the keel plate. This was noted by the owners, however, it was not considered sufficiently serious to warrant further inspection.

3.21 *Time to Burn* was again scheduled to be slipped in July 2008 to replace the anodes and water blast the hull.

3.22 The Napier slipway was inoperable, so the owners sailed the vessel in rough conditions to Gisborne in late July where a travel lift was available.[8]

3.23 While in the travel lift the owners observed movement in the keel. The bottom of the keel was moving sideways 20 mm and was described as vibrating in the travel lift.

3.24 Concerns about the condition of the keel led to a decision to leave the vessel in Gisborne. The crew returned to Napier and sought advice from the vessel's designer and Tauranga boat builders Southern Ocean Marine Ltd on what needed to be done.

3.25 The designer discussed by telephone the matter of the loose keel with the skipper for the Napier to Tauranga trip. The skipper described the cracking and movement in the keel. The designer asked if the keel bolts had been checked during ownership and was told they had not been.[9]

3.26 The designer told the skipper the loose keel was due to either loose keel bolts or a structural problem in the keel. He suggested that tightening the keel bolts might rectify the problem. In a second conversation some days prior to departure the skipper asked the designer for plans of the keel that had been promised earlier. The designer asked if the vessel would be transported by road. He was told the trip would be by sea and that the keel bolts would be tightened before departure. The skipper added that he would be putting the liferaft in the cockpit for the trip owing to his concerns about the keel.

3.27 An offer by the designer to examine the keel before departure was declined. He commented that the extent of the cracks and movement at the root of the keel was not fully disclosed to him. Presuming that tightening the keel bolts would make the vessel safe to sail, the owners decided to sail for Tauranga where an inspection could be made and, if necessary, the keel repaired.

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8 Travel lifts lift most modern design keel vessels with lifting strops on the hull fore and aft of the keel. Because the keel is hanging from the hull with no pressure from the weight of the vessel any movement in the keel is easy to detect. On traditional cradles, such as the one used by the owners in Napier, movement can not be as easily detected. Travel lifts had been used to lift *Time to Burn* on numerous occasions before with no looseness in the keel detected.

9 Keel bolts on *Time to Burn* were a series of 13 bolts that extended from the top of the keel plate up through the hull. They were bolted in position and held the keel plate on to which the keel was attached. They were accessible for inspection and tightening from within the hull by removing sections of floorboard.

3.28 The skipper consulted Southern Ocean Marine Ltd who also advised that the keel bolts should be tightened before departure. On the day before departure the crew achieved turns of 1/8 to 1/4 to the keel bolt nuts. This was done with the vessel in the water, so it was not possible to determine if there was any reduction in keel movement, as would have been possible if the vessel was suspended in the travel lift. The turns were achieved by using a substantial lever bar.

3.29 The options of transporting the vessel by road or removing the mast for the trip to make *Time to Burn* more stable in the event of keel failure were not considered. Despite receiving plans from the designer and all the owners looking at them, the survivor commented that he was not aware of the method used to attach the keel to the keel plate. He thought it would never fall off and said he would not have gone on the trip had he been aware of how the keel was attached.

The design criteria for racing yachts and their keels

3.30 The *Guide for Building and Classing Offshore Racing Yachts* – 1994 edition – was developed jointly by the International Technical Committee (ITC) of the Offshore Racing Council and the American Bureau of Shipping (ABS). This standard has been internationally recognised as the required standard for yacht design since it was first developed by the ITC (1978–1979 and 1979–1980).

3.31 ABS withdrew the plan approval process some years ago, however, many international coastal and offshore race committees continue to require that vessels comply with ABS standards.

3.32 An ISO (International Organisation for Standardisation) international small craft industry validation study: ISO/DS-12215-9 Hull Construction – Scantlings – Part 9 is currently underway to develop new standards for small craft construction. It is supported by the International Sailing Federation (ISAF), European Boating Association (EBA), and the Royal Yachting Association (RYA). A consultative process from October 2008 to March 2009 obtained international feedback on vessel construction, including fixed keels.

3.33 The new standard was put in place on 1 June 2009 and should provide for technical advances in keel design and construction that were not envisaged when the ABS guides were drafted.

3.34 The designer of *Time to Burn's* keel stated that the vessel, including the keel, was designed to ABS standards. He explained that the version of the ABS rule used in the design at the time did not have a requirement for grounding.

Time to Burn's keel design

3.35 In simple terms, *Time to Burn's* keel plate, on which the keel structure was welded, was secured to the vessel's hull by bolting it to the hull. The keel plate was held in place by steel bolts. (See figures 3 and 4 and photograph 6 showing keel bolts.)

3.36 The keel comprised three basic parts: the keel plate (the part that bolts to the hull), the rectangular hollow section spar (the part that is fixed to the keel plate), and the bulb (the bulb is fixed to the hollow spar forming the bottom of the keel). The rectangular hollow section spar was connected to the keel plate by welding it to the plate.

3.37 The transverse loading (left and right) of the keel was distributed across a relatively small area that measured 11 cm between the points where the spar was welded to the keel plate. The vertical web plates of 12 mm steel provided only fore and aft support. (See photograph 8 showing the weld failure where the spar was welded to the keel plate.)

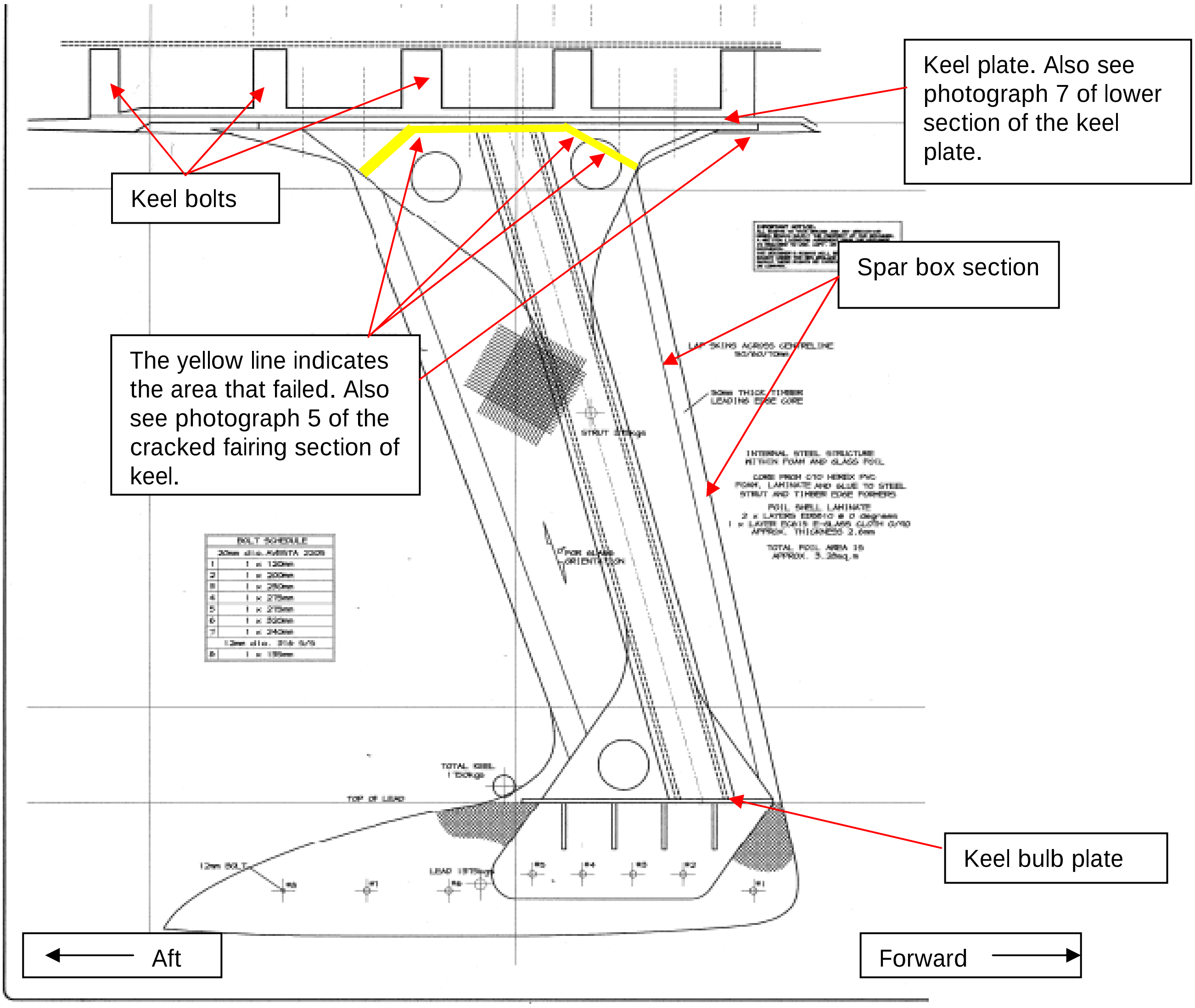


Figure 3
A plan drawing of *Time to Burn's* keel.

Note: This diagram is neither to scale nor design; it is for a simple visual representation of the design of the keel, keel plate, spar, and the keel bulb (excluding fairing).

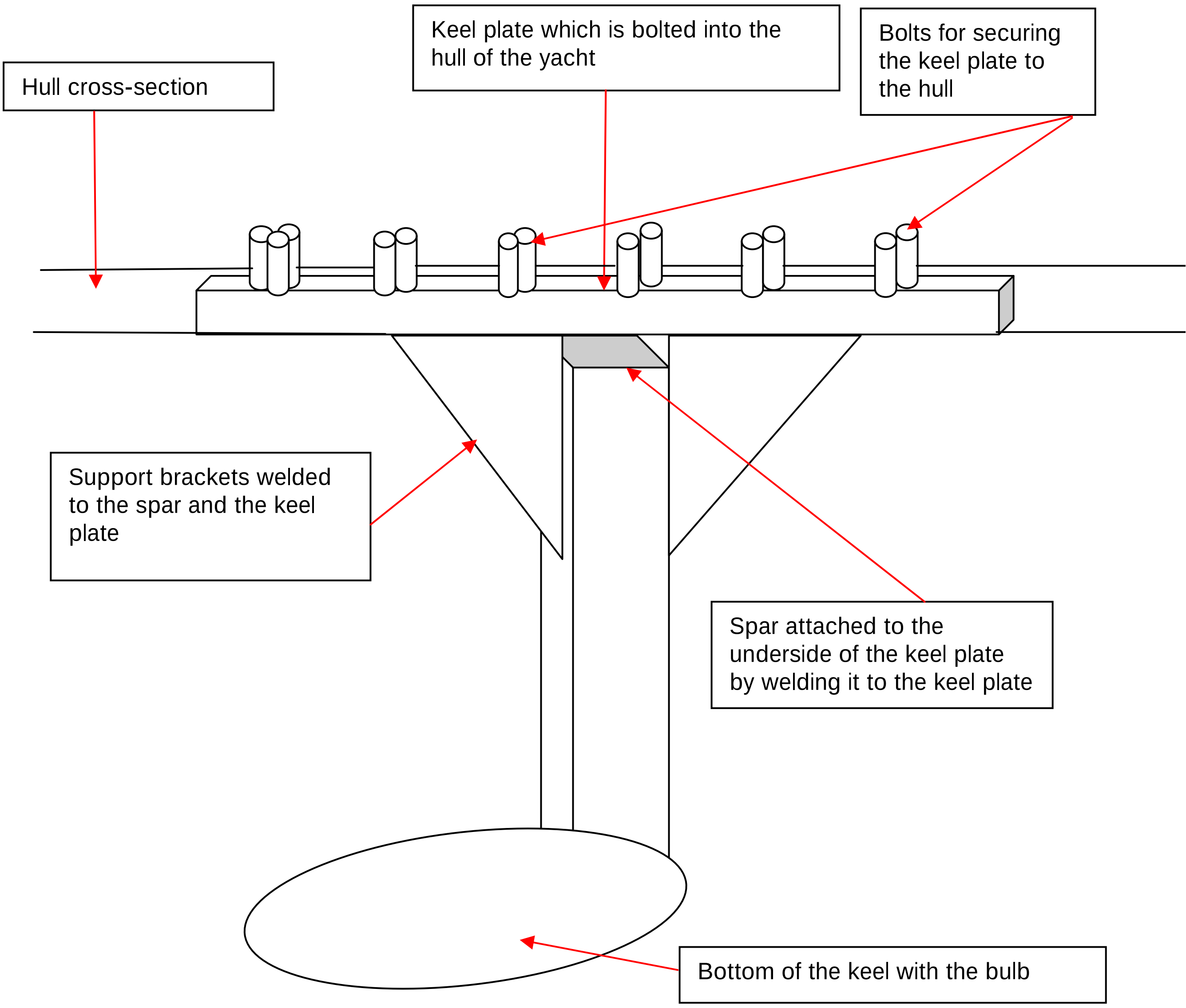
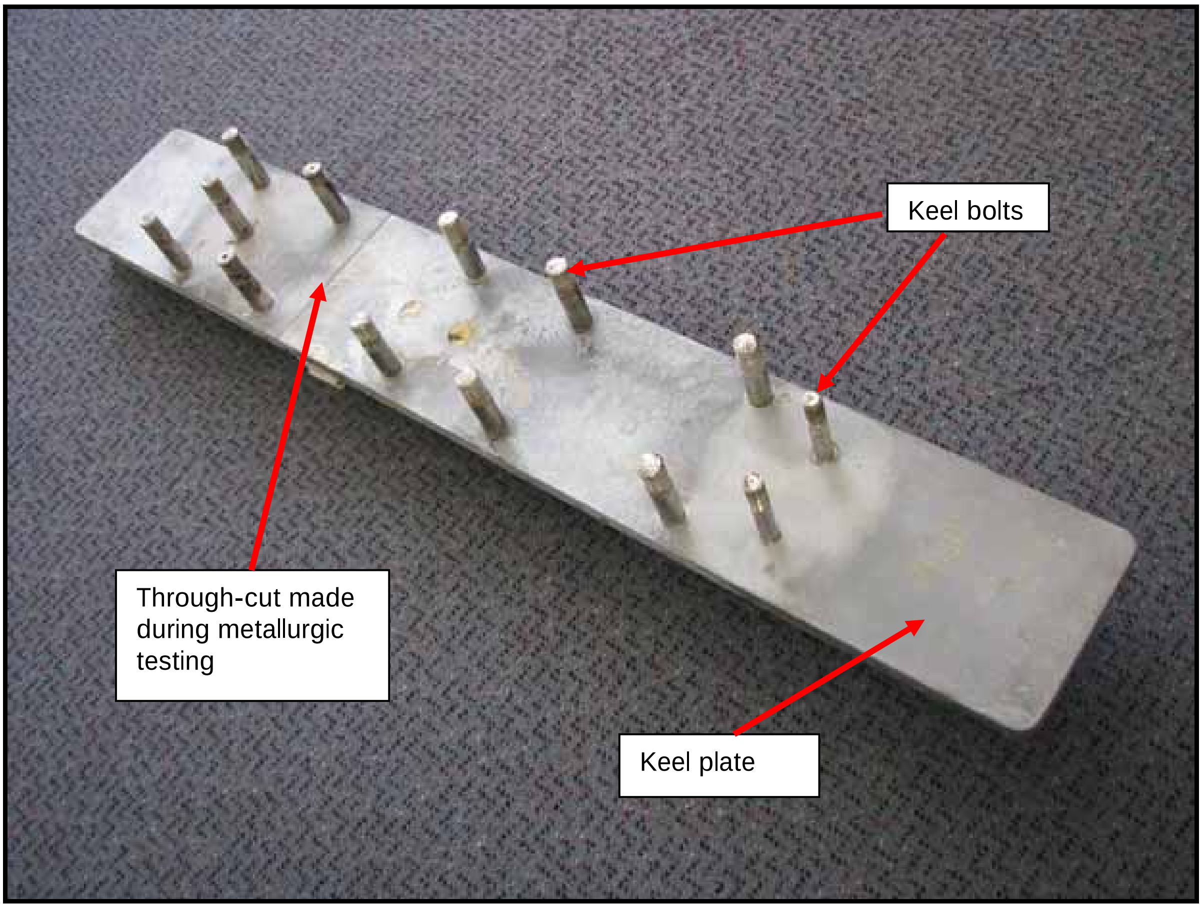


Figure 4
Visualisation of keel structure.



Photograph 6
Upper-section of keel plate.

Examination of the remaining part of *Time to Burn's* keel

3.38 MNZ commissioned a naval architect and a metallurgy[10] report. (See Appendix 3: Failure Investigation Report, and Appendix 4: Naval Architect's Report.)

3.39 The naval architect was to examine *Time to Burn's* designer's keel design specification and calculations and establish if the design of keel was in accordance with ABS standards.

3.40 The metallurgy expert was to analyse the remaining keel part, establish the mechanism of failure and make recommendations to prevent such failure in the future.

Summary of the reports

- The naval architect's report concluded that keel design in terms of athwart ships calculations complied with ABS standards.
- The fore and aft calculations, however, were substantially below those required. The required strength modulus was 751 cm^3 whereas the design was for 397 cm^3.
- The metallurgy report concluded that the physical causes of the *Time to Burn's* keel failure were:

10 Branch of science concerned with the properties, production and purification of metals.

- Inappropriate design
  "underspecified weld type/strength of the most critical and stressed spar/horizontal plate joint, which was not taken into account in Spar strength calculations; cut-off circles reduced the Vertical Plates strength and created a shortcut for fracture propagation".
- Inappropriate welding
  "presence of leg lengths even smaller than underspecified 6mm; un welded and interrupted seams; lack of Root fusion accompanied with Throat length less than underspecified 4.3 mm; absence of pre and post-heating".
- The predominant weld facture mode is shear[11] overload (plane-stress mode) with multiple initiation sites; albeit, there are a few locations that resemble fatigue, their total fracture surface is less than ~1%.
- The vertical plates fracture mode is likely to be a combination of tensile overload (plane-strain mode), shear fracture (plane-stress mode) in form of double-shear plane (distinct centreline between two is visible), which could result from alternate bending, and fatigue (less than ~ 1%, though).
- The designer commented that the weld between the spar and the top plate was not specified and that the metallurgy report is incorrect on this point. He said it was intended that the full strength weld note apply to all welds relating to the main keel spar. In relation to the weld between the spar and the keel plate, however, he commented the specification was ambiguous on the drawing and as such was an oversight.
- He further explained that an older obsolete version of the ABS rule used when ***Time to Burn*** was designed did not have a requirement for grounding and that this explains why the fore and aft calculations did not comply with the 1994 rule used by the naval architect which has this component. With the design approval process from ABS no longer in place this was not brought to the attention of the designers at the time.

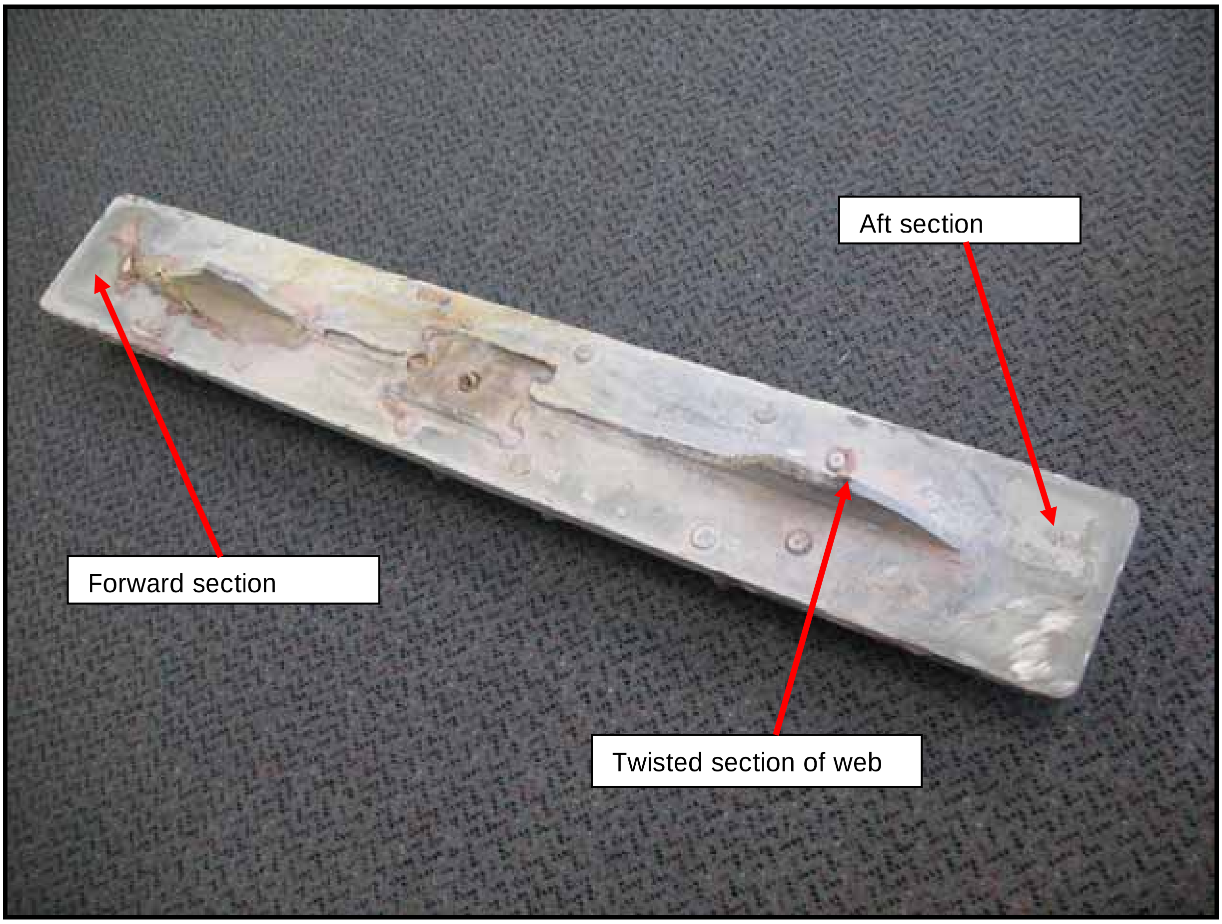
3.41 The metallurgy report suggested that prior and post welding heat treatment was not applied to the keel plate. In commenting on the draft report the manufacturer stated that the keel plate was definitely pre-heated although post-heating may not have been done.

3.42 The reports recommended:

Review the compliance requirements for:

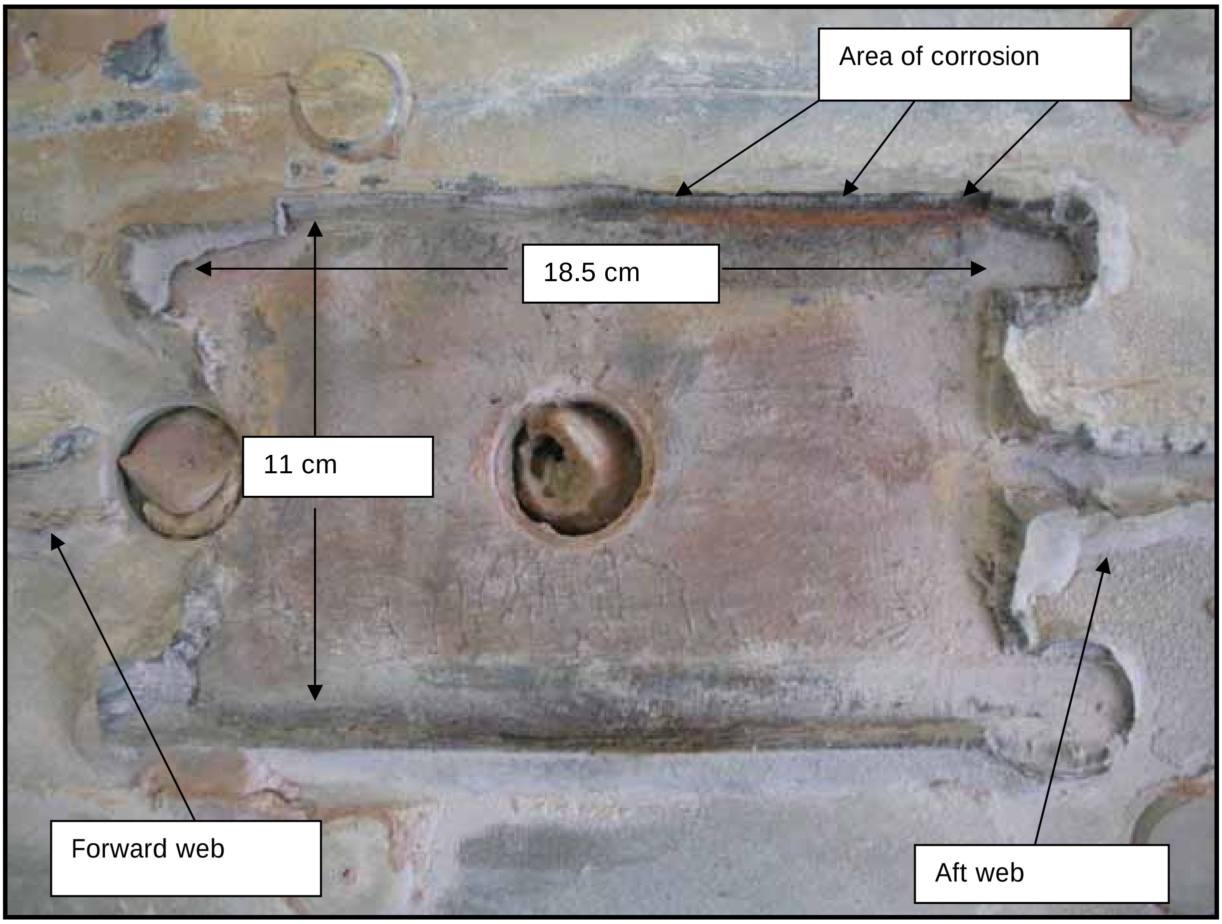
- racing yacht keels' design
- racing yacht keels' manufacturing/welding, including quality control
- racing yacht keels' maintenance and safety procedure.

[11] Break off or cause to break off, owing to a structural strain.



Photograph 7
Under-section of keel plate.

3.43 When first viewed, the section of the weld on the port side of the rectangular hollow RHS spar where it attached to the keel plate showed signs of corrosion that suggested a section of weld may have been compromised prior to the capsize. (See photograph 8 of failed section of keel plate.)



Photograph 8
The weld failure where the spar was welded to the keel plate.

3.44 In the opinion of the MNZ investigator, it is not unreasonable to speculate that the weld failure may have started with the collision with the whale in 2006.

3.45 With one section of the weld compromised this may have caused additional pressure on other sections of weld. As a result, latent incremental degradation of the remaining intact sections of weld occurred causing the spar section to detach from the keel plate.

3.46 The remaining section of web on the keel plate has been twisted. (See photograph 7.) This indicates it may have been the last section to fail. The reduction in speed described by the survivor may well have been caused by the failure of the forward section of weld, allowing the keel to twist sideways (most likely to port, as indicated by the angle of twist in the remaining aft section of web). This would have caused the vessel to slow down as described until the aft section tore through under the pressure. Once this occurred, the stability of ***Time to Burn*** was compromised and resulted in its eventual capsize.

3.47 Once a keel detaches most sailing vessels become unstable and subject to capsize owing to the weight of the mast and pressure exerted on the sails by the wind. One option available to the owners was to remove the mast, place internal ballast in the hull and motor the vessel to Tauranga. Without the weight of the mast and sail pressure it is unlikely the vessel would have capsized in the event of the keel becoming detached from the hull. The other option would have been to truck the vessel to Tauranga.

Other factors considered

3.48 *Time to Burn's* berth in Napier allowed the keel to touch bottom at low water. At low spring tides the vessel sat on the seabed with the water level a few centimetres below the waterline. The berth was examined and the bottom, on analysis, was found to be soft mud[12].

3.49 Contact with the seabed is not desirable, however, it is a relatively common scenario on many tidal berths and does not usually cause structural damage to keels unless additional factors are involved, such as:

- Exposed berth subject to rough sea conditions causing the vessel to pound on the seabed.
- Tidal berth where the rise and fall is such that at low water there is minimum buoyancy supplied to the hull resulting in the keel sustaining the main weight of the yacht.

3.50 *Time to Burn* was not subject to the abovementioned conditions at her berth so it is unlikely that the vessel's keel coming in contact with the seabed was a part of its failure.

3.51 Entry into the Napier marina is not possible at low tide with deep drafted vessels. The owners stated that *Time to Burn* had touched on the seabed on occasion while negotiating the entrance at low water, however, contact was at slow speed.

3.52 Damage to keels is more likely to be the result of a high impact collision with the seabed or an object in the water. Having said that, contact with the seabed at any speed is not desirable, and may in some cases lead to the keel's structure being weakened. MNZ can not rule out that on other occasions the keel may have been subject to strain for which it was not designed.

3.53 The survivor commented that he thought the sudden slowing down of the vessel might have been caused by hitting a discarded sail, although he was unable to observe anything when he looked over the side. When he was in the water he recalled seeing a sail that he believed was a spinnaker. He considered it unlikely that it could have been one of the sails on board, all of which, with the exception of the mainsail, were stowed below deck in sail bags in the forward sail stowage compartment.

3.54 Sails caught in the water create considerable drag when attached to a vessel. The possibility that the pressure created by a discarded sail on the keel further weakened the keel causing it to detach should not be discounted.

3.55 Cracks in the fairing in areas of keel subject to stress are not uncommon. It is often not indicative of structural failure, although cracks should serve as a warning that further inspection is warranted. Composite faring material such as that used on *Time to Burn* can be relatively rigid. When interfaced with dissimilar material such as steel, cracking can occur due to flexing in a seaway. This is especially the case with keels constructed with RHS spars. These can be more subject to flex than traditional keels.

3.56 Both the designer and builder stated that when *Time to Burn* was constructed the method of attaching the RHS spar by a single weld to the keel plate was common practice. Now it is common practice to cut slots in the keel plate, enabling external and internal welding of the RHS spar to the keel plate.

[12] An MNZ investigator used a lead line to take a sample of the seabed around the general location of *Time to Burn's* berth. Each sample indicated that the seabed was soft mud.

3.57 While the naval architect's report stated that the keel design was not in full compliance with ABS guidelines due to the fore and aft modulus requirements being well below those required, it is important to consider that the initial failure may well have been due to the transverse section failing which was well within ABS modulus requirements.

3.58 The tightening of keel bolts is commonly carried out in situations where keels become loose and as part of regular maintenance over extended periods. The advice given to the owners based on the information given by the skipper was reasonable in the circumstances.

Time to Burn's survival equipment

3.59 *Time to Burn* was well equipped with sea survival equipment. In any sea survival situation it is paramount that emergency equipment is stowed for immediate use and used in accordance with the manufacturer's instructions. This enables the people on board to have a maximum chance of surviving should they find themselves in a sea survival situation.

3.60 Equipment carried by *Time to Burn* is described below.

Liferaft

3.61 *Time to Burn* had one liferaft on board – an eight-man RFD seasaver + 8R liferaft – stored in a valise. It was packed to YNZ Category 1 standard and had been serviced by RFD on 15 January 2008. It was due for re-service in January 2010. In the YNZ checklist the designated storage place was in the cockpit.

3.62 The liferaft carried the following sea survival equipment:

- ration – half kilo
- water sachet – 500 ml
- red hand flare
- parachute distress rocket
- torch and spare batteries
- tablets – anti-seasickness.

3.63 A liferaft, if carried, is a primary piece of survival equipment for the following reasons:

- Once inside, the raft offers good protection from the wind, rain and sea, and helps to prevent the onset of hypothermia.
- It is a far safer environment than floating in the sea, and reduces the likelihood of drowning.
- It is a large search target, which is advantageous in a SAR situation.
- Liferafts are brightly coloured, making them easy to spot by SAR vessels and aircraft.

3.64 Throughout the trip the liferaft was stowed below deck near a table just above the keel. The survivor stated it was normally stowed in the cockpit, however, it impeded crew movement and for this reason was stowed below. After the vessel lay on its side the table came out of its mounts and, together with other items, obstructed access to the liferaft. This made it impossible to get it clear and up on deck for deployment.

Lifejackets

3.65 NZS 5823:2005 sets the standards in New Zealand for lifejackets. Among other requirements for offshore or coastal races, YNZ requires vessels to have on board lifejackets with crotch straps that comply with NZS 5823:2005 (or 2001) and also comply with YNZ Category 1 or 2 standards. One inflatable lifejacket compliant with Category 1 and 2 standards was on board, however, the crew both elected to don the coastal lifejackets type 401 that were on board.

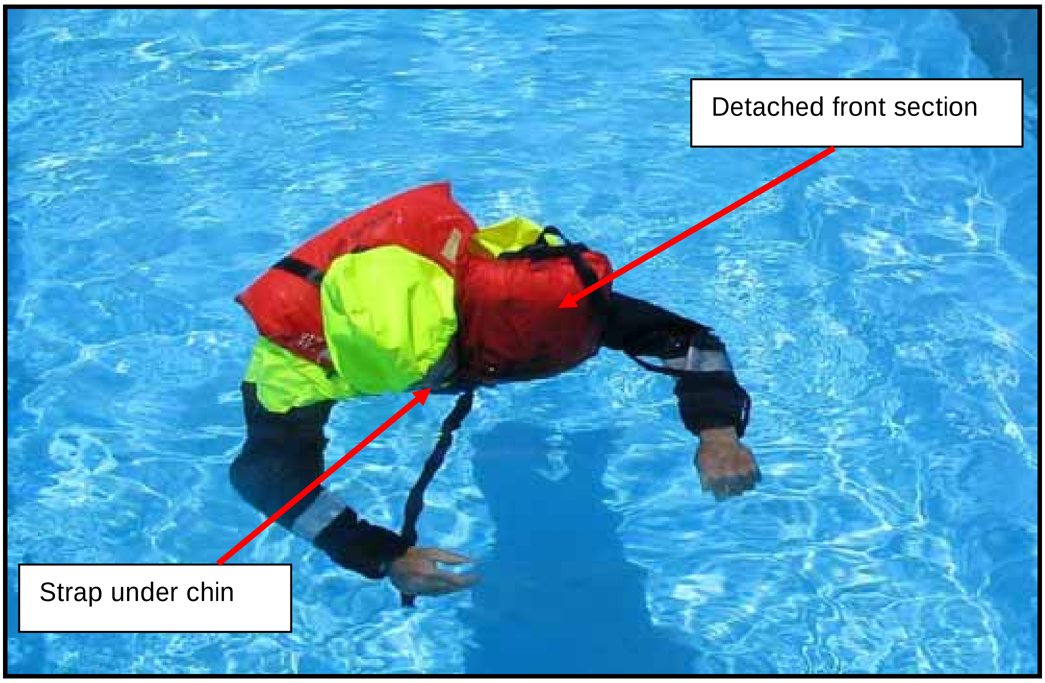
3.66 The crew opted to wear the 401 offshore lifejackets after previously experiencing failures with inflatable lifejackets. The offshore lifejackets are described as suitable for persons 40 kg and over with buoyancy exceeding 100 newtons[13]. The lifejackets were approved to NZS 5823. (See photographs 12 and 13 of the coastal lifejackets.)

3.67 Examination of the two lifejackets worn by the crew, neither of which had crotch straps, could not explain how, if properly donned, the straps and clips could loosen or become detached. If donned without the straps passing under the armpits as required, the lifejacket can ride up as described by the survivor and the skipper of the Coastguard rescue vessel.

3.68 The lifejackets worn by the skipper and survivor of *Time to Burn* were examined by MNZ. An examination by MNZ investigators and lifejacket specialists found both of the lifejackets were in good order with no apparent defects. It was not possible to determine which of the two was worn by the skipper, however, both lifejackets appeared to be identical, in good order with no apparent defects. One of the lifejackets was tested in calm conditions in salt water with an 84 kg male wearing wet weather gear. It was found that when the lifejacket was securely fastened and with the tester simulating unconsciousness facing downwards, the lifejacket turned him onto his back with his head and airways clear of the water. This is what the 401 lifejacket is designed to do.

3.69 The same test was conducted with the jacket incorrectly fastened. It was found that the front section came loose from the chest with the strap going under the wearer's chin. The wearer remained face down in the water allowing the airways to be submerged under the water. (Photograph 9 shows an MNZ investigator testing an incorrectly fastened lifejacket.)

[13] Newtons are a measure of force, 100 newtons (100N) is equivalent to 10 kilogram of buoyancy



Photograph 9
Salt water trial of incorrectly fitted lifejacket.

3.70 The rescue vessel crew advised that on arrival at the scene the skipper's lifejacket straps were loose and under his chin.

3.71 The Coastguard skipper commented that the front section of the lifejacket was partially loose, allowing it to ride up and preventing it from holding the skipper's head clear of the seas.

3.72 The Coastguard crew also observed that the lifejacket itself was loose. It became detached from the skipper's body when they were retrieving the body.

3.73 In the darkness and confusion it is possible that the skipper failed to put his arms through the straps that fit under the armpits and instead donned the lifejacket with the straps over his shoulders. This factor combined with the sea conditions could explain why, despite the efforts of the survivor to tighten the straps, the lifejacket came loose.

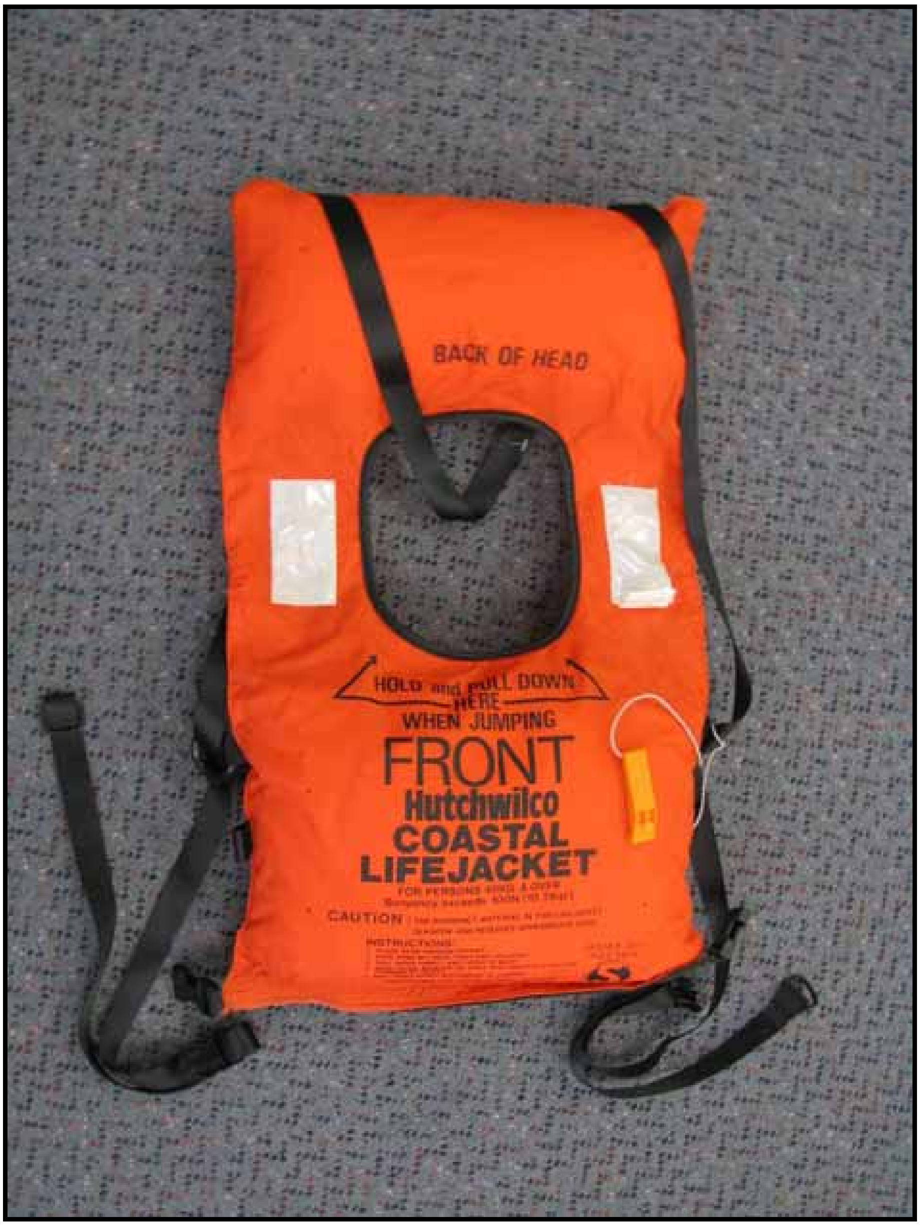
3.74 The survivor also commented that the skipper may have donned his lifejacket incorrectly with the front section of the jacket toward his chest. If this was the case this may have caused the skipper to floated face down after losing consciousness.

3.75 A properly fitted lifejacket is vital in situations where people in the water become tired, hypothermic or lose consciousness. (See photographs 10 and 11 of correctly and incorrectly fastened lifejackets.)

Photograph 10
Correctly fitted lifejacket.

Photograph 11
Incorrectly fitted lifejacket.

3.77 In 2007 YNZ regulations extended the requirement to have lifejackets with crotch straps to Category 3 limits. Previously this requirement was limited to Categories 1 and 2.



Photograph 12
One of the coastal lifejackets worn by the crew.

Photograph 13
Information on one of the coastal lifejackets worn by the crew.

Clothing worn

3.78 The survivor stated that the skipper was wearing Musto brand offshore protective clothing with warm clothing underneath.

3.79 The crew of the recue vessel commented that the skipper was fully clothed and in sea boots when recovered. Owing to his saturated clothing rescuers had some difficulty bringing his body on board.

3.80 The clothing worn was appropriate for the conditions experienced by the crew of the vessel at the time of the accident.

Ability to indicate distress

3.81 It is always good practice to assess the associated risk with any maritime activity and develop a contingency plan to mitigate such risks. In the maritime environment, you can find yourself in the water suddenly. One of the key factors to survival is the ability to communicate your position to emergency services by the fastest means available. In the opinion of the MNZ investigator, ***Time to Burn*** was well prepared and equipped to communicate a distress situation. The owners had on board an emergency grab bag containing a waterproof hand-held VHF radio. They also had a fixed VHF radio communication unit on board.[14]

[14] Fixed communication units are those physically attached to the vessel as opposed to a unit such as a hand-held VHF that can be operated from different locations on board as well as off a vessel.

Time to Burn's ability to indicate distress

3.82 *Time to Burn* was equipped as follows:

- Fixed and hand-held VHF. New Zealand's coastline has VHF coverage extending to all inshore and most coastal limits. A 24-hour a day listening watch is kept on channel 16.
    - Owing to the vessel capsizing, it was not possible for the occupants of *Time to Burn* to transmit a distress message on the fixed communications unit.

  A waterproof hand-held VHF is highly recommended safety equipment for all vessels.

  Whilst these do not usually have the range of a fixed VHF due to the antenna being lower they are nevertheless essential safety equipment in situations where a fixed VHF is rendered inoperable. They enable survivors to call for assistance in a number of different scenarios, for example from a liferaft or from the shore.

3.83 The transmission range of all VHFs is line of sight, however, this can be considerably extended via repeater stations that are positioned around much of New Zealand's coastline.

3.84 In some cases line of sight can be less than 10 miles, however, repeater stations enable communication between vessels of up to 70 miles. The transmission point on hand-held units is usually lower than on fixed VHF units, where the antenna is on top of masts or the vessel structure. As a consequence range can be limited. Also when transmission is from inside a hull, as was the case with *Time to Burn*, reception can be compromised. This would explain why garbled signals were received from *Time to Burn*.

- Fixed MF/HF (SSB) SEA 222 model. Marine SSBs have ranges of several thousand miles when atmospheric conditions are suitable.
    - Owing to the vessel capsizing it was not possible for the occupants of *Time to Burn* to transmit a distress message on the SSB.

- EPIRB
    - There were two EPIRBs on board: a 406 MHz non-GPS unit and a 121.5/243 MHz unit.

3.85 The survivor said that both EPIRBs were activated. Both the 406 MHz and the121.5/243 MHz units were not initially able to provide reliable position data until the signal was cross-referenced with a second orbiting satellite. These units can take up to 2 hours before orbiting satellites can provide an initial position. Units with GPS capability are usually able to provide RCCNZ with an almost immediate position within metres of the transmission point as opposed to up to 2½ nautical miles for non-GPS capable 406 MHz units.

3.86 Both EPIRBs were recovered on Matakana Beach near Tauranga. The 406 MHz EPIRB was transmitting, however, the 121.5/243 MHz EPIRB was turned off when recovered.

3.87 One of the owners, who holds an Ocean Yachtmaster qualification, discussed safety matters with the skipper prior to departure and advised him to prioritise activating the 406 MHz EPIRB above other forms of communication in the event of an emergency. Both he and the survivor were not aware that the 406 MHz model on board did not provide an immediate position to RCCNZ when activated. He incorrectly believed *Time to Burn's* position would be relayed within 5–10 minutes of activation.

3.88 Marine distress flares. The YNZ inspection listed ***Time to Burn*** as having on board:

- four red parachute flares
- two red hand flares (or spotlight)
- two orange smoke flares.

3.89 The survivor believed two rocket flares were set off. These were reported to RCCNZ by the Police at 0537 hours.

3.90 Other means of communication:

- foghorn
- flashlights
- two cellphones.

3.91 The survivor stated that they attempted to use their cellphones, but they failed to operate. Mobile phones are useful aids to communication, but they are not designed for a marine distress situation and should not be relied on as a sole means of communication. Where possible, mariners operating in coastal and inshore areas should communicate distress on VHF and MF/HF (SSB) radio. Other vessels monitoring distress channels are often able to offer a more immediate rescue.

3.92 While cellphones have effectively allowed mariners to communicate distress on many occasions, limitations such as coverage and signal unavailability make them a backup option rather than a primary means of communication[15].

3.93 It is paramount in a distress situation that basic information is relayed to the SAR services. This aids the SAR services to identify the vessel in distress, the nature of the distress, the position of the distress, and the number of people on board.

3.94 In the marine environment there is an international standard for communicating distress. The MNZ publication *Radio Handbook for Coastal Vessels* covers how to make a distress call, among other things. The following is a correct example of sending a distress:

- MAYDAY, MAYDAY, MAYDAY
- This is, [Vessel name by 3] *Vessel Name, Vessel Name*, *Vessel Name*
- MAYDAY, *Vessel Name*
- [Position]
- [Nature of distress]
- Number of persons on board
- OVER

3.95 From the SAR radio logs it is not apparent that the correct method of communication for a distress was used by ***Time to Burn***, namely, the vessel's name and position. It is important for all boat users to remember that in the event of a distress the basic information must be relayed to SAR services.

[15] Refer to MNZ publication: *Radio Handbook for Coastal Vessels* – a guide to maritime communications in New Zealand.

4. FINDINGS

4.1 *Time to Burn* was well equipped with appropriate safety equipment for a coastal voyage.

4.2 The crew knew the keel was compromised but nevertheless chose to sail the vessel from Gisborne to Tauranga.

4.3 Acting on professional advice the crew focused their attention on tightening the keel bolts.

4.4 Insufficient understanding of how the keel was attached to the hull led to the crew's incorrect belief that tightening the keel bolts would rectify the looseness in the keel.

4.5 The tightening of the keel bolts had no effect on the loose keel as the structural defect did not involve the keel bolts.

4.6 The decision to secure the liferaft below deck, from where it was virtually impossible to deploy in the event of capsize, was a contributing factor in the loss of the skipper.

4.7 Corroborative evidence indicated that the skipper's lifejacket was not properly secured and may not have been correctly donned. This also was a contributing factor in his loss.

4.8 The inability of the crew to provide their position delayed the time it took to be rescued.

4.9 The method of fixing the keel to the keel plate relied solely on single run of weld on the exterior of the keel plate. There was no secondary means of attachment. This placed the vessel at risk in the event of weld failure.

4.10 The Failure Investigation (Metallurgy) Report highlighted a number of factors that caused the keel to fail. These included:

- The single 6 mm fillet weld specified on stressed and critical joints was inadequate (Appendix 1: Failure Investigation Report – page 22).
- The keel design did not specify if the required 300 MPa steel referred to UTS or yield strength (Appendix 1: Failure Investigation Report – page 20).

4.11 The naval architect's report stated *Time to Burn's* keel design was not in full compliance with ABS guidelines as the fore and aft modulus requirements were well below those required (Appendix 2: Naval Architect's Report – page 1).

4.12 This accident highlights:

- The importance of having a hand-held waterproof VHF radio on board, in the event fixed communications units are rendered inoperable after a capsize or sudden sinking.
- The need to provide basic information such as the vessel name and position as soon as possible to SAR services.

5. SAFETY RECOMMENDATIONS

5.1 Designers and boat owners should ensure sound design and engineering standards are followed in design and construction. This is crucial where high loads are distributed over relatively small sections of hull.

5.2 Although many vessels comply with ABS standards and have safety factors calculated in excess of those standards, it is important for all owners of modern racing and cruising vessels to be aware of the vulnerability of these design standards, especially when additional loads are placed on keels through dynamic forces such as extreme seas, grounding or hitting objects in the water.

5.3 Where any sign of failure is detected, a thorough examination of welds and the method of attachment to the keel and hull is necessary. Modern technology allows welds to be x-rayed at a reasonable cost. Owners are encouraged to use such technology.

5.4 Where any sign of failure is detected, either by cracks in the fairing or looseness, removal of fairing to examine potential areas of failure should be carried out.

5.5 Yachts can be expected to occasionally encounter objects such as logs and whales. Whenever a keel sustains an impact the possibility of damage to the keel and fastenings should be considered and checks made. This is particularly important in relation to fin keels with small keel to hull joint areas.

5.6 Any vessel that sustains a substantial impact should consider heading for the nearest port to have the keel examined before continuing on its voyage.

5.7 After severe impact to a keel a thorough examination is necessary of welds and any means of attaching the keel to the hull. Fatigue cracking in fairing can, in some cases, be indicative of structural failure beneath.

5.8 If there is any doubt about the integrity of the keel the vessel should not be taken to sea until it is thoroughly examined and any required repairs have been carried out.

5.9 Whenever possible liferafts should be strategically stored on the deck or cockpit and be ready for instant deployment.

5.10 Harnesses and lifejackets with crotch straps should be on board and worn by all people on deck especially when sailing at night and in rough conditions.

5.11 The survivor believes the sea survival course run by Yachting New Zealand/Coastguard Education saved his life. It is highly recommended that mariners who intend to sail in coastal or offshore waters attend such a course.

5.12 Mariners are urged to act on the added safety benefit of equipping vessels with EPIRBs fitted with GPS capability that allows rescue authorities to establish a position of the vessel in distress without delay.

5.13 Lifejackets must be properly secured in accordance with manufacturer's requirements. All people on board should be familiar with the type of lifejackets on board and be able to don them quickly in the event of an emergency. To this end, drills involving all crew donning lifejackets should be carried out on a regular basis.

5.14 It is recommended that the safety issues identified in this report be passed on to the marine industry.

6. ACTION TAKEN

6.1 Following this accident YNZ published the following mandatory regulations for offshore and coastal cruising:

Race category
1 2 3 4 5

9.2 Keels where the method of attachment to the hull is by a welded join:

(a) The design must meet a recognized standard such as ISO (recommended) or ABS and the drawings must specify material and welding details.

(b) Welding must be carried out by a certificated welder.

(c) Welding must be adequately tested by non-destructive means (ie x-ray, crack testing, ultra sound) and a certificate issued.

All documents, designs, calculations, certificates etc. related to the above must be made available to yacht inspectors when required.