Report 97-205

Coastguard rigid inflatable rescue craft *UDC Rescue*

loss of buoyancy pontoons

Wellington Harbour entrance

11 October 1997

Abstract

At about 1600 on Saturday, 11 October 1997, the Wellington Coastguard rigid inflatable craft *UDC Rescue* was engaged on a routine patrol near the entrance to Wellington Harbour, when the craft suffered a failure of the bags that secured the buoyancy bladders to the hull, resulting in two of the four bladders separating from the craft. Two crew were transferred to an assisting vessel and the skipper and one remaining crew member were able to beach the craft without further damage. Nobody was injured in the incident. Factors contributing to the bag failure included degradation of the bag fabric, weakening of the bag fabric by the stitched seams and water invading the bags after the securing tongue detached. Because of safety actions taken before and after the incident, no safety recommendations were deemed necessary.

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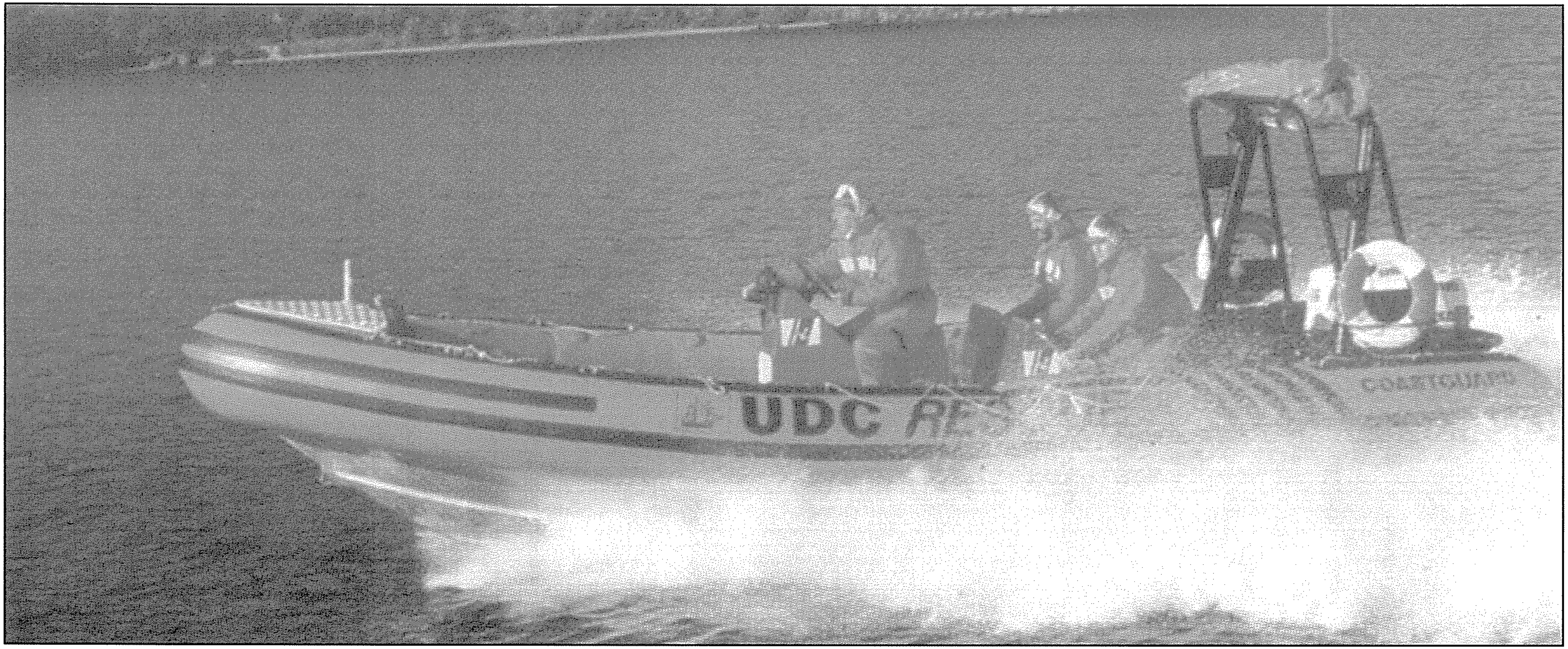

UDC Rescue

Transport Accident Investigation Commission

Marine Incident Report 97-205

Craft particulars:

Name:	*UDC Rescue*
Type:	Naiad 7.5 m rigid inflatable rescue craft
Class:	Not classed (exempt from survey)
Construction:	Welded aluminium rigid hull with buoyancy pontoons consisting of inflated rubber bladders enclosed in, and secured by, fabric-reinforced PVC bags
Built:	In Picton by Naiad Inflatables (NZ) Ltd in 1989
Owner/operator:	Wellington Volunteer Coastguard Incorporated
Propulsion:	Two 150 HP, OMC, two-stroke outboard motors
Speed:	40 knots (maximum) 25 knots (cruise)
Length (over all): Breadth: Weight (actual):	7.5 m 2.85 m 2300 kg

Location:	Barrett Reef, Wellington Harbour entrance channel
Date and time:	Saturday, 11 October 1997 at about 1600[1]
Persons on board:	Crew: 4 Passengers: nil
Injuries:	Nil
Nature of damage:	Severe to pontoon system
Inspector in Charge:	Captain Tim Burfoot

[1] All times are NZDT (UTC + 13 hours) and are expressed in the 24 hour mode.

1 Factual Information

1.1 History of the voyage

1.1.1 At about 0845 on Saturday, 11 October 1997, crew members of the Wellington Volunteer Coastguard arrived at the Coastguard Centre at Evans Bay. The crew comprised six persons: the skipper, three boat crew, one shore radio operator and one general hand. Apart from the skipper, no person was designated to any particular task for the day. The duties were rotated depending on the experience and the training requirement of each crew member.

1.1.2 *UDC Rescue* was to be the in-service craft for the day. Other Coastguard personnel had left to crew the second and recently commissioned *Spirit of Wellington* rescue craft on a public relations trip around the coast to Mana, in Porirua Harbour. Some of the crew were to change between the two vessels during the day to maximise crew training on the new craft.

1.1.3 The first two *UDC Rescue* crew members to arrive at the base used a check list to assist them in making a detailed check of the craft and its equipment. They had conducted checks together on two previous occasions. As was usual, one called each item on the check list while the other made the check. All the items on the check list were ticked and no deficiencies were noted.

1.1.4 One of the 31 items on the check list was "hull inflatable bags and cover" which had a note beside it "correctly inflated". The person conducting the check stated that he used the standard test for checking the bag inflation, which was to press each pontoon with the palm of his hand and noting the depth of depression (normally 1 to 2 cm). The inflation of each pontoon was considered by him to be correct, therefore no adjustment was made to the pressure that day.

1.1.5 The pontoons were given a cursory check for signs of damage. The person making the check did not specifically check the arrangements which secured the outer bags to the aluminium hull. He was not aware of the significance of the securing tongue at the bow but was aware of its existence. He stated that he would have noticed if it was not secured to the hull because it would have been hanging down in full view.

1.1.6 Several of the other crew members, some of whom were aware of the importance of securing the tongue at the bow, also stated that during launching, and at several times throughout the day, they did not notice the tongue hanging down, as they would have expected if it was not secured.

1.1.7 At about 0900 the skipper arrived at the base. He asked his crew if the boat check had been completed and was told that it had, and that everything was satisfactory. The skipper signed the check sheet. The crew launched *UDC Rescue* shortly after and the craft remained at the wharf while routine maintenance and crew training was conducted.

1.1.8 During the day *UDC Rescue* made three excursions within the harbour, two of which involved assisting vessels in difficulty. The crew described each excursion as unremarkable. They had no recollection of any event that could have damaged their craft in any way.

1.1.9 The fourth excursion for the day was to be a routine patrol out to the Wellington Harbour entrance. *UDC Rescue* departed the base wharf at about 1550 and headed out of Evans Bay into a north-west wind, 20 to 30 knots, with gusts to 40 knots. The sea in Evans Bay was a short one-metre chop that was causing some spray back over the craft. The skipper had the con and three crew were seated immediately behind him. The skipper had both motors running at 3900 to 4000 rpm.

1.1.10 As *UDC Rescue* rounded Point Jerningham and began to run with the wind and sea, the skipper eased the throttles back to about 3800 rpm which was known to give a speed of 25 to 28 knots. The skipper and crew commented that the ride out towards the harbour entrance was "dry" and that the craft was not slamming onto the waves.

1.1.11 The sea near the harbour entrance had risen to a 1 to 1.5-metre chop running with the outgoing tide. A half-metre opposing swell (barely noticeable) was coming into the harbour from Cook Strait.

1.1.12 At about 1600, in a position midway along and on the east side of Barrett Reef, *UDC Rescue* had crested a wave, surfed with it, and pushed into the back of the next wave when the crew heard a dull report from the bow and saw the forward inner buoyancy bladder on each side of the craft simultaneously burst out of the outer securing covers (bags). The crew described the bladders as having "peeled up and back from the bow".

1.1.13 The skipper immediately began to throttle back on both engines, but did so gradually to avoid the craft settling down by the bow when it came off the plane. Once the engines were down to an idle, and the craft was off the plane, the skipper turned *UDC Rescue* around and pointed the bow into the wind and sea while he assessed the situation and considered his options.

1.1.14 The aft bladder on each side of the craft was still secured to the hull by the remains of the bags and, at the bow, the torn remains of the bags were draped around the hull and remained attached by their boltropes. The radio operator used the very high frequency (VHF) radio to call the Coastguard base and report the incident. After consulting with the base, the crew retrieved the two forward bladders and *UDC Rescue* proceeded at about four knots back up the channel towards Seatoun Beach, where it had been arranged for the craft to be retrieved onto its trailer.

1.1.15 As *UDC Rescue* proceeded up the channel into the wind and sea, the craft began to take a little spray over the bow. The skipper was keen to not allow water to accumulate inside the craft so he increased the rpm on both outboard motors to raise the bow and allow any water to drain out through the freeing ports aft.

1.1.16 A few seconds after increasing speed the water pressure caused the damaged bags to separate at the bow. The starboard side bag slid aft out of the boltrope track and was lost to the sea before the crew had time to grab it. The starboard aft bladder remained attached to the hull by its inflation valve.

1.1.17 The crew made a call to the Wellington Harbour Radio and requested assistance. An inbound fishing vessel deviated to the scene and two crew were transferred from *UDC Rescue* to the fishing boat. The skipper and one remaining crew member remained on board and continued towards Seatoun Beach, keeping in the relative calm provided by the wake of the fishing vessel.

1.1.18 A short while later, the Wellington Police Launch took over the escort from the fishing vessel and escorted *UDC Rescue* to Seatoun Beach, where it was retrieved and taken back to the Coastguard base without further incident.

1.2 Vessel information

1.2.1 *UDC Rescue* was a purpose built 7.5 m Naiad rescue craft constructed mainly from aluminium. The craft configuration was open, with a centre console conning station. Directly behind the conning station were two twin-seat consoles: one housing the radio station, and the other the navigation station. The craft typically carried a crew of four, including the skipper.

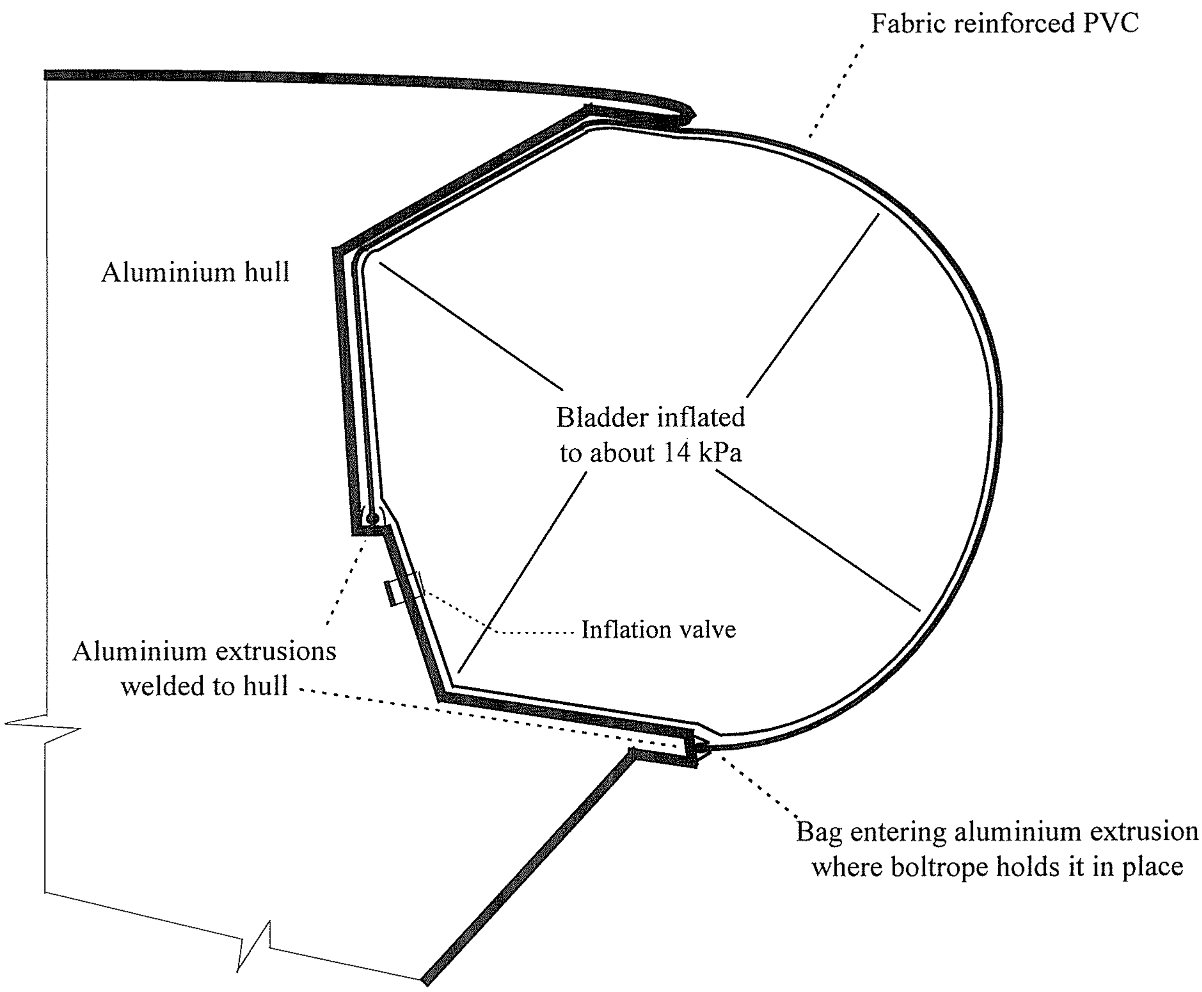

Figure 1
Cross section through pontoon arrangement near the bow
(diagram not to scale)

1.2.2 Communications equipment included two VHF radios: one fitted and one portable. Navigation equipment included one magnetic compass and a global positioning system (GPS) receiver.

1.2.3 When *UDC Rescue* was built in 1989, it was powered by a single inboard diesel engine driving a single stern-leg propeller. In 1995, on-going problems with the drive train within the stern-leg prompted the Wellington Coastguard to substitute two outboard motors for the diesel engine. The transom of *UDC Rescue* was rebuilt to accept two 150 HP, OMC, two-stroke outboard motors with counter-rotating propellers. The new propulsion configuration gave a top speed of about 40 knots and a cruising speed of about 25 knots.

1.2.4 Rigidity and performance of the craft was provided by the rigid aluminium hull, the pontoons providing reserve buoyancy and a softening of the ride only. The rigid hull was constructed with an extended reverse chine[2] for increased turning performance and support when on the plane. The chine extended all the way forward to increase the lift in this area and helped deflect water away from the pontoon attachment. Water collecting on the internal deck drained away via two freeing ports in the transom. If heeled, the craft had sufficient stability to return upright without the aid of the pontoons (this was an observation and not subject to test).

1.2.5 Four rubber buoyancy bladders, two on each side, extended along the entire length of the craft. The four bladders were secured in place by a single set of removable outer covers (bags) constructed from fabric reinforced polyvinyl chloride (PVC). The bags were attached to the hull by polypropylene ropes (boltropes) sewn into their upper and lower edges and fed into an aluminium extrusion that was welded to the hull; in much the same way as an awning is attached to a caravan. The boltropes ran from aft to forward on either side, stopping at the edge of a securing tongue at the bow.

1.2.6 Built into the hull of *UDC Rescue* were two 200-litre fuel tanks, one for each outboard motor, and an enclosed buoyancy chamber.

1.2.7 An antenna arch over the stern of the craft housed an automatic, pressure activated inflating bag for self righting the craft in the event of a capsize.

1.2.8 The bladders and bag arrangement (pontoons) were supported in an aluminium half-round recess at the bow and for about one metre on each side at the stern. The remainder of the pontoons rested in a quarter-round recess. (See Figure 1.)

1.2.9 The rubber bladders were meant to be inflated to a recommended pressure of 14 kPa via valves that protruded through, and were secured inside, the hull. There were no pressure relief valves fitted to the bladders to avoid over-inflation, although these were available as an optional extra.

1.2.10 When fitted correctly the bags were pulled back tight against the aluminium hull at the bow, leaving a minimal gap for water to enter between the bag, the bladder and the hull, should the bow bury into a wave. A tongue was provided at the front of the bags which was secured to the hull at the bow using a self-tapping bolt. The purposes of the tongue were: to stop the bags creeping forward with the internal pressure exerted by the inflated bladders, and to cover the inevitable small gap which would be present even when the bags were correctly fitted.

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[2] The camber of the bottom plate changes direction downwards where the bottom plate meets the side plates.

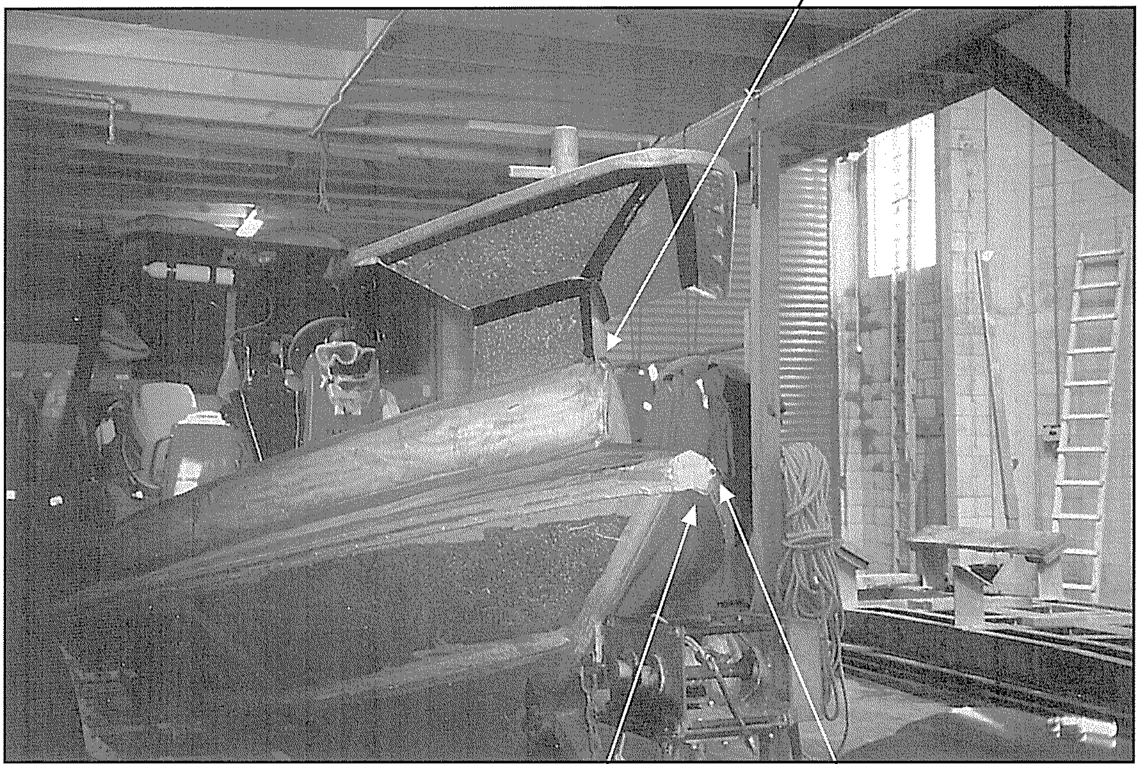


Figure 2
Photograph showing the arrangement at the bow of *UDC Rescue* without its buoyancy pontoons

1.2.11 If the tongue was not secure this would:

- remove a defence designed to deflect water away from the gap between the bag and the hull,
- allow the bags to creep forward,
- open a gap for water to force up into the bags, and
- allow more movement of the pontoons around the end of the extrusions.

1.2.12 A combination of the above factors would place more pressure on the bag fabric at the bow. (See Figures 2 and 3.)

1.3 Damage to the craft

1.3.1 The bags were torn starting from where the lower boltrope terminated either side of the tongue at the bow. The tears progressed back through the fabric to about midships on both sides, just past where the two forward bladders butted onto the aft bladders. The two forward bladders separated from the hull, wrenching out their inflation valves as they went.

1.3.2 Initially the bags remained joined at the bow; however, on the homeward journey the bags appeared to have filled with water and the drag this created caused a rearward force on the bags sufficient to tear the two sides apart near the bow. The starboard bag then slid aft out of the boltrope track and was lost before the crew could retrieve it. The tattered remains of the port bag, together with the securing tongue, remained attached to the craft by the boltropes. The two aft bladders remained attached to the hull, the port one partially enclosed by the bags; the starboard one only by its inflation valve.

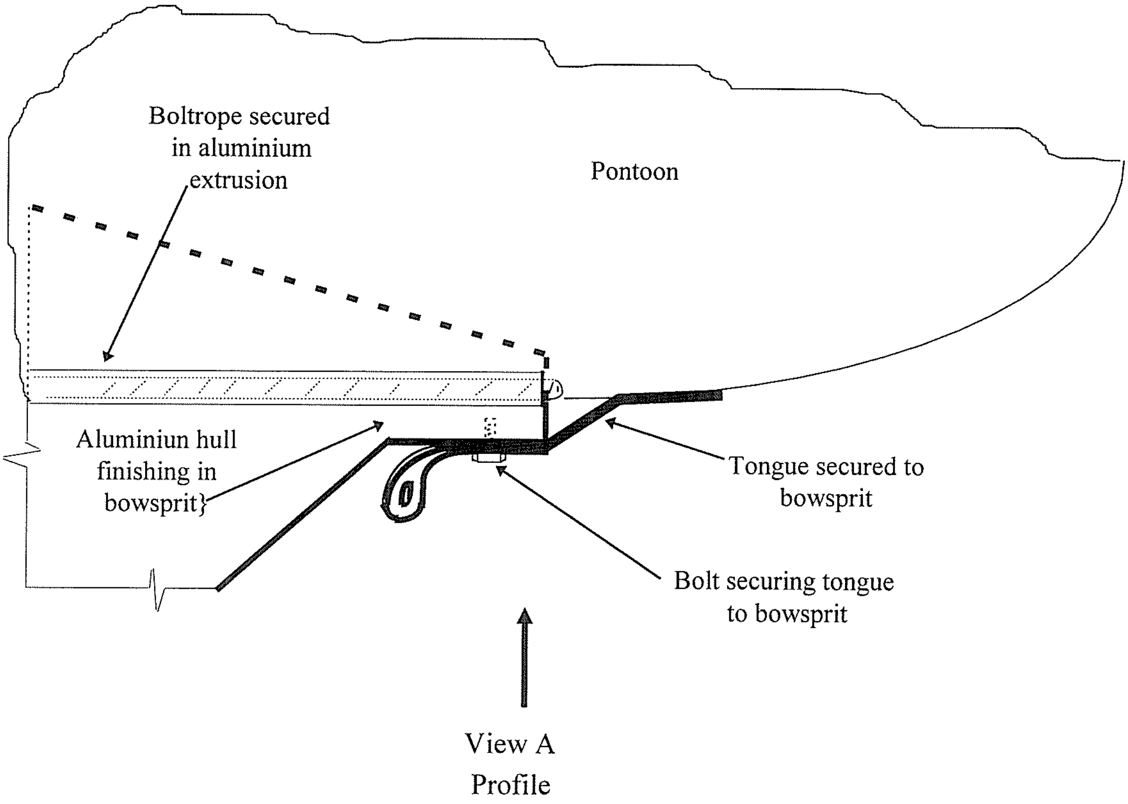
1.3.3 The aluminium plate under the bowsprit, onto which the tongue had been secured by a self-tapping bolt, was extensively corroded. The self-tapping bolt was missing. The two metal grommets that were normally set into the tongue, and through one of which the bolt was normally secured, were both missing. When the craft was new, the original bolt hole was tapped, with a normal bolt screwed into it.

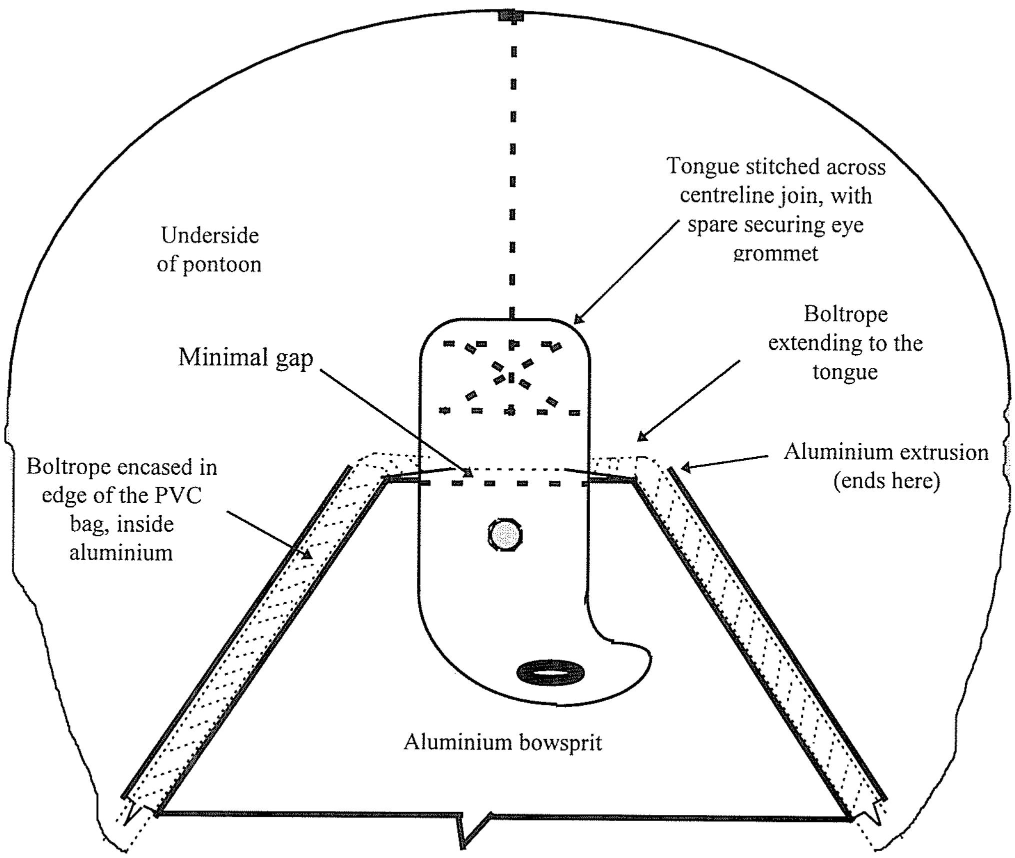
1.4 History of Naiad bag manufacturing

1.4.1 When Naiad first began manufacturing bags for their craft they used a fabric called Nylex Camlon Ripstop which was fabricated from PVC spread-coated over a woven nylon base fabric incorporating a rip-stop weave. The tear strengths of new fabric in warp and weft[3] directions were 700 and 600 Newton per 5 cm (N/5 cm) of fabric respectively. The tensile strengths of the fabric in warp and weft were 2700 and 2200 N/5 cm respectively.

1.4.2 When built, *UDC Rescue* was fitted with a set of bags constructed from the Nylex fabric. A second set of bags made from the same fabric was supplied shortly after to reduce down-time should the original bags have required servicing.

[3] Warp is the arrangement of the main threads in a fabric. Weft is the threads that are woven across the warp to complete the fabric. The warp is usually stronger than the weft.





View A looking up under the pontoons, at the bow

Figure 3

***UDC Rescue* bag securing arrangement at the bow (diagrams not to scale)**

1.4.3 Some time in 1991, Nylex stopped producing the Camlon Ripstop fabric, so Naiad, after experimenting with several other fabrics, switched to using a new fabric, Heywinkle 5551, manufactured in Germany. The 5551 material used a stronger polyester base fabric but did not have the ripstop weave incorporated into it. Consequently, the 5551 fabric had a lower tear strength than the Nylex (550 and 500 N/5 cm warp and weft) but a higher tensile strength (4200 and 4000 N/5 cm warp and weft). This meant that bags constructed from Heywinkel 5551 fabric were stronger in tension, but more prone to failure in tear if a tear in an area of high load was not repaired.

1.4.4 In March 1996, the Commission investigated an accident that involved a similar bag failure on a 12.6 m Naiad used for commercial whale watching. The bags on that craft were constructed from the Heywinkel 5551 fabric. The report concluded that the fabric at the start of the tears "had been torn for some time, awaiting only a moderate force to initiate total failure of the craft inflated buoyancy system."

1.4.5 In 1996, Naiad recognised that Rigid Inflatable Boats (RIBs) were being pushed by their operators to greater extremes. This was partly due to the ability of the craft to ride well in rough seas and their increasing use in commercial and rescue operations. The search began for a stronger fabric to keep up with the increasing demand.

1.4.6 By the time of the incident involving *UDC Rescue*, a new fabric had been found that exceeded the specifications of the two previously used fabrics. The new material used a polyester base fabric and had a tear strength of 1360 N/5 cm in both warp and weft (2.5 times greater than the Nylex) and a tensile strength of 7580 N/5 cm (almost twice that of the Heywinkle). The material was available in lesser weights with corresponding reduced tear and tensile strengths.

1.4.7 The overseas manufacturer of the new fabric manufactured for export in large quantities only. To make it economically viable to import the new fabric, Naiad was in consultation with other New Zealand manufacturers who used similar fabric for their products.

1.4.8 The new fabric became available for Naiad bag manufacturing at about the time of the *UDC Rescue* incident.

1.4.9 The original bags manufactured for Naiad craft had all stitched seams. In 1996 Naiad, having recognised that their craft were being increasingly used for demanding tasks, set about rectifying the problem whereby the stitched seams weakened the fabric and created a natural path for a tear to follow once it had been initiated.

1.4.10 At the time of the 1996 whale watching accident, Naiad was using glue, rather than stitching, to encase the first 20 cm of the boltrope near the tongue at the bow. This improved the strength in the area and lessened the likelihood of a tear, if initiated, following the stitched seam.

1.4.11 In 1997, a further improvement was made with the purchase of a PVC welding machine which could produce welded[4] seams. At the time of the *UDC Rescue* incident all Naiad bags were being constructed using the new welding technique. The only seam that remained stitched was the join right at the front. This join was covered with an additional glued layer of fabric.

1.4.12 The Commission's report on the 1996 whale watching accident also concluded that the fact that the boltrope stopped short of the tongue at the bow: robbed the fabric near the tongue of the strength that the boltrope should have been providing, "caused the fabric to be 'worked' more heavily at the weak point" and encouraged the fabric to split at the termination of the boltropes.

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[4] The two edges of the fabric are heated and compressed together, bonding the two PVC coatings into one.

1.4.13 Soon after the release of the report the bag manufacturer started making the boltrope continuous across the bow and down both sides of the bags.

1.5 Personnel information

1.5.1 The skipper of *UDC Rescue* did not hold a formal marine qualification. He had been involved in small boats since the age of twelve and owned his own boat at the time of the incident. He had been with the Wellington Coastguard for seven years, starting off as boat crew, and working his way up to skipper, a position he had held for one and a half years.

1.5.2 One of the three boat crew had been with the Coastguard for about two and a half years, one for about 13 months and the other for about four months.

1.5.3 The operations controller had been with the Coastguard for about five years. He started as boat crew and after about one year was made skipper. From the onset, he took an interest in the maintenance of the craft and began to assist the current operations controller. He took over the operations controller position in 1996, about one year before the incident.

1.5.4 The crew member who made the morning boat check had been with the Coastguard for about three months. He held a Commercial Launchmaster Certificate and had been instructed on how to conduct the boat check on two occasions previously.

1.5.5 The crew member who was calling the check list while the boat check was made, had been with the Coastguard for four years. He was the one who had instructed the crewman who was making the checks.

1.6 Survey and maintenance information

1.6.1 *UDC Rescue*, being owned by the Wellington Volunteer Coastguard, which was an affiliate of the Royal New Zealand Coastguard Federation, was exempted by the Maritime Safety Authority (MSA) from the requirements of Part X of the Maritime Transport Act (Construction, Survey and Equipment) and from the requirements of the Shipping (Manning of Restricted Limit Ships) Regulations 1986.

1.6.2 The exemption was subject to the following:

- that the craft remained owned by the Wellington Coastguard,
- that MSA-approved appointed safety officers (small-craft inspectors) considered the craft to be fit for its intended use,
- that it was equipped with an adequate number of life-jackets for its normal crew complement and appropriate safety equipment (as specified by the safety officer), and
- that the craft was not used for hire or reward.

1.6.3 Maintenance was conducted on an as-required basis. The outboard motors were serviced under warranty by a recognised service outlet. Other maintenance or the need for repairs was identified by either the boat crews, or the operations controller.

1.6.4 Boat crews could carry out repairs and maintenance if it fell within their area of expertise (possibly related to their vocation). Any work of significance that involved a certain level of expenditure was referred to the operations controller, who would arrange to have it completed.

1.6.5 Maintenance issues were often discussed at skippers' meetings under the chairmanship of the operations controller. The appointed safety officers were occasionally called in to give advice on maintenance affecting the safety of the craft.

1.6.6 The requirement for, or making of, minor repairs was noted on the craft check sheet, and in the daily log. All significant maintenance done was recorded by the operations controller in the maintenance log, which had been in existence for about two years. Prior to that, records of maintenance were spread through various other publications.

1.6.7 The time in service for each set of bags had not been recorded; however, staff recalled that the original set that was fitted to the craft was in use for most of the time prior to 1995, when *UDC Rescue* underwent the conversion to outboard motors. After the conversion, the second set of bags was put into service and remained on the craft until the time of the incident.

1.6.8 Minor repairs to the bags around the stern were made by the operations controller. Some improvement in the type of glue used, and gluing technique, was evident from the various small repairs inspected. The bags had only one repair made near the bow. That repair, which was on the starboard side and back from the stem, was made about two years before the incident. The repair had been inspected regularly by the boat crews and the operations controller, and noted as being secure.

1.6.9 Following the whale watch accident, the MSA produced a Marine Notice (Boats) which warned owners and surveyors of rigid inflatable craft of several structural and operational factors of special relevance to the safe operation of such craft. Two of those factors were as follows:

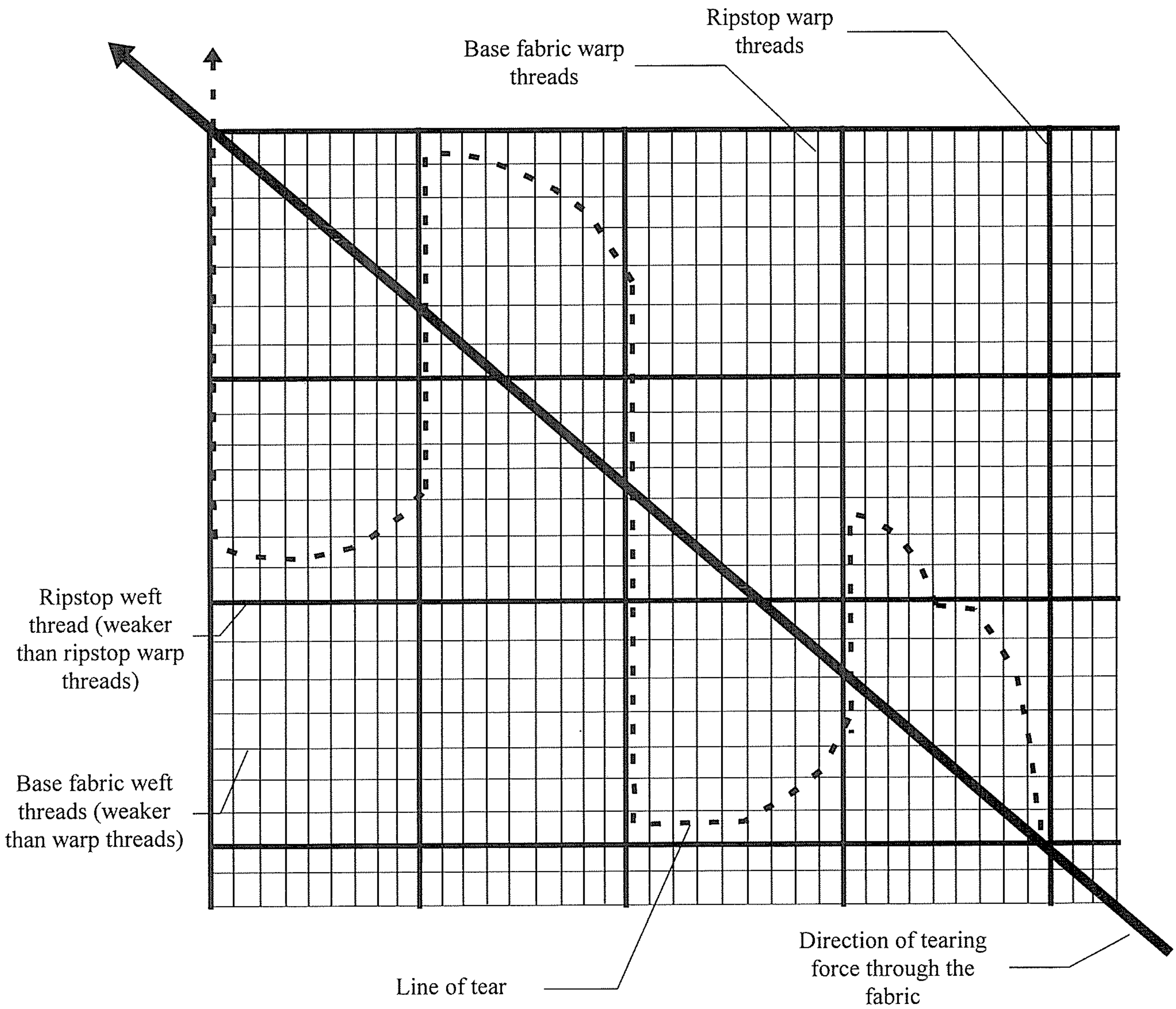
- that the securing arrangement of the inflatable pontoons to the hull should be regularly checked; in particular the tag (where fitted) at the bow, and
- the master should check that the bolt securing the tag at the bow was in place and secure before every voyage.

1.6.10 The Wellington Coastguard received the notice and it was discussed at the next skippers' meeting. The notice was left on the notice board at the base for several weeks for crews to read. The operations controller highlighted the above points on the notice and labelled the notice "Boat Check".

1.6.11 No change was made to the boat check sheet to reflect the new information. The crew who made the boat check the morning of the incident had not read the notice.

1.7 Tests and research

1.7.1 What remained of the bags was removed from the vessel and taken for testing and analysis. The remains consisted of the complete port side of the bags, the join at the bow, a small section of the starboard side of the bags at the join, and the tongue.



The dotted line represents an exaggerated representation of how the saw-tooth tear phenomenon occurs in a fabric that incorporates ripstop threads and has stronger warp threads. The tear will tend to follow the line of the stronger warp threads as the weaker weft threads give first. The warp threads start to break once the tear moves away from the natural line of force that is causing the tear.

Figure 4
Exaggerated view of how a tear may progress through the base fabric

1.7.2 A detailed inspection of the bags was made by the manufacturer. His observations relating to the intact part of the bags included the following:

- in spite of the age of the bags, they appeared to be in good condition,
- there was no obvious signs of wear in the normally prone areas,
- the stitching was intact in all areas,
- there was minimal colour degradation,
- the grab ropes and their attachments were all in good condition,
- the cone end was intact with no sign of detachment, and
- some minor repairs, which were generally of a poor quality, had been made to the bags; however, none of those repairs appeared to have contributed to the bag failure.

1.7.3 The Commission's marine inspectors and an independent technical officer from a textile research institute made a detailed examination of the tear primarily to establish where the tear started from and in which direction it progressed.

1.7.4 It was possible to determine the direction of the tear by the form it took as it progressed through the base fabric and in particular, through the ripstop weave (See Figures 4 and 5). The tear started at the boltrope end, near the tongue, and progressed aft to just past midships where the forward and aft bladders met inside the bags. The direction of the tear changed several times along its length.

1.7.5 From its start, the tear went through the double layer of fabric (where the edge was folded over to encase the boltrope) and into the main body of the bag for about 3 cm before it changed direction and progressed down to the stitched seam. The tear followed the stitched seam for about 14 cm before changing direction back up into the main body in a saw-tooth pattern. From there, the tear deviated into the stitched seam twice more, but maintained its general rearward direction.

1.7.6 The two nickel-plated brass eyelets surrounding the bolt holes in the tongue were missing; however, there was no evidence of them having been torn out by force. According to Coastguard staff, the eyelets had been missing for some time and a washer had been used in their place to stop the head of the bolt pulling through the fabric. The imprint of a large washer was visible in the PVC coating around the first hole in the tongue.

1.7.7 When the boat was retrieved following the incident, the tongue of the bags was not attached to the hull. As the securing of the tongue to the aluminium hull was considered essential on larger Naiad craft, for reasons outlined in section 1.2 of this report, an inspection of the metal in the area where the bolt was intended to be secured was made by an independent metallurgist to determine if the bolt securing the tongue was in place at the time of the incident.

1.7.8 The metallurgist's report included the following comments:

- there were two holes in the aluminium where the tongue would normally be attached (one 10 mm and the other 2 to 3 mm across),
- around both holes, but particularly the larger one, there was extensive corrosion of the surrounding aluminium alloy hull,
- immediately adjacent to the larger hole, general corrosion resulted in loss of the entire hull thickness (the depth of the metal loss decreased with distance from the hole),
- corrosion damage was restricted within close proximity to the bolt holes,

2.3 Analysis of the torn bag fabric leaves little doubt that the bag failure was initiated at the bow, at the termination of the boltrope on either side of the tongue. There was no evidence to suggest that the tears had been present in the fabric for any significant time before total failure occurred. The tears were fresh in appearance, with no fraying or ingrained dirt present.

2.4 Following the line of the tear back through the fabric, it appears that the initial direction of tear was upwards and towards the rear of the craft. The direction is consistent with the failure occurring when the pontoons at the bow were partially buried in the wave, as described by the *UDC Rescue* crew.

2.5 The several changes in direction which the tear took after the initial tear would have been the result of the water action at 28 knots peeling the bladders back while they were flailing up and down. The force required to pull the inflation valves out of the forward bladders as they departed the craft, and the skipper's quick action in reducing speed, reduced the progress of the tear so that it stopped on both sides of the craft just past the junction where the forward bladders met the aft bladders inside the bags. The inflation valves for the aft bladders (being at their forward end) would have resisted the tendency for them to peel back like the forward ones.

2.6 There is no evidence to suggest that the bags were over inflated at the time of the incident. The pontoons were checked that morning and reported to have been "normal" (using the hand test method). It was a sunny, but not overly warm day. The vessel was on the water and the pontoons were being continually covered with sea spray. The air pressure in the pontoons would have had to increase fourfold before exerting enough stress on the boltrope seam to cause it to fail in the manner evident in post-incident testing, and in any event the tears were initiated across the seam rather than along it.

2.7 For water to enter the bags and cause hydraulicing there must have first been an opening for it to enter. The tongue was not secured to the hull when *UDC Rescue* was retrieved after the accident. There was no evidence of the securing bolt having been torn out of the surrounding metal; conversely, the corrosion material surrounding the bolt hole suggests that the load bearing capacity of the bolt was low, and that the bolt probably worked loose during the excursions prior to the incident trip. Once the bolt dropped out, the bags would have been free to creep forward, opening a gap at the bowsprit for water to invade the bags.

2.8 The extensive corrosion of the aluminium under the bowsprit is evidence that the tongue was normally secured. Although no-one physically bent down and looked under the bowsprit to check the tongue securing on the morning of the incident, it would appear from the testimony of several of the crew that the tongue was not hanging down in view.

2.9 The following were latent factors which contributed to the bag failure:

- the natural weak point around where the boltrope ended at the tongue,
- the stitched seams providing a convenient start point for failure,
- the degradation of the bag fabric with age (as evidenced by post incident testing), and
- the reducing load bearing capacity of the bolt securing the tongue due to galvanic corrosion.

2.10 In spite of the above factors the bags were able to sustain normal working loads until the securing bolt released, which probably resulted in water entering the bags under pressure and exceeding the breaking point of the fabric at the weakest point.

2.11 The following design improvements, and technology being used in manufacturing Naiad bags at the time of the incident involving *UDC Rescue*, represents a significant improvement in some of the above factors:

- the continuous boltropes, removing the natural weak point,
- welded seams of increased strength, and
- the use of a stronger fabric.

2.12 However, the tongue still needed to be secured at the bow.

2.13 It would not have been evident to the person making the morning check of *UDC Rescue* that the bolt holding the tongue in place had limited load bearing capacity, by simply looking at the tongue. Only by removing the bolt, or tugging on the tongue, could it have been determined; however, it is of concern that the lessons learnt from the whale watch report (the MSA notice) did not filter down to the crew making the boat check. As the boat check list had not been changed, the crew had no way of knowing what they were supposed to be checking on the pontoons other than "correctly inflated".

2.14 Also of concern is that the skipper, the person in charge of the craft and its crew, was not required to conduct his own check of the boat before starting operations for the day. For an organisation where so many different crews are engaged, with a variety of levels of experience with boat operation and maintenance, it would be prudent for skippers to conduct their own checks, even if they were in addition to those made by the crew.

2.15 The *UDC Rescue* was generally well maintained and maintenance was being recorded, albeit not all in the same document. Being a volunteer organisation, the Wellington Coastguard used the available vocational skills of the crew members to carry out maintenance and repairs where they could. To ensure a high standard of repair and maintenance, and to keep a level of continuity within the maintenance system, a more structured approach to maintenance would be more effective.

3. Findings

Findings and any safety recommendations are listed in order of development and not in order of priority.

3.1 *UDC Rescue* was exempt from survey but complied with the terms of its exemption at the time of the incident.

3.2 *UDC Rescue* was exempt from the requirements of the Shipping (Manning of Restricted Limit Ships) Regulations 1986, but was adequately crewed at the time of the incident.

3.3 The speed that *UDC Rescue* was being driven at in the sea conditions present at the time of the pontoon failure was within the normal operating parameters for the craft.

3.4 The bags containing the inner bladders failed at the bow because of the focus of stresses at the termination of the boltrope either side of the securing tongue. The progress of the tear aft for just over half the length of the craft allowed the forward bladder on each side to peel away from the craft due to the wave pressure.

3.5 The tongue that secured the bags to the hull at the bow, which was attached to the hull by a single self-tapping bolt, appeared to be in place at the time *UDC Rescue* was launched on the morning of the incident.

3.6 Galvanic corrosion between the securing bolt and the aluminium hull had reduced the load bearing potential of the bolt to a level whereby the natural flexing of the pontoons caused the bolt to drop out at some time during the day of the incident.

3.7 With the tongue not attached, the bags would have been free to creep forward, and a gap open through which water could invade the bags.

3.8 The hydraulic effect of water invading the bags when the bow partially submerged into a wave, created additional stress across the seam sufficient to exceed the breaking point of the fabric at its weakest point, where the boltropes terminated.

3.9 The natural weak point in the seam where the boltropes terminated, the weakening of the fabric caused by the stitching within that seam, and the reduced strength of the fabric due to ageing, were latent failures contributing to the final bag failure.

3.10 Continuous boltrope, welded seams and stronger available fabric, were design and technology advances which had just become available at the time of the incident involving *UDC Rescue,* that would have helped guard against the latent failures that were present, and would probably have prevented the incident.

3.11 The visual inspection made of the securing tongue and bolt, ensured that it was in place, but was not sufficient to check that it was secure.

3.12 Lessons learned from the similar accident involving the whale watch boat were received by the Wellington Coastguard, but were not disseminated effectively to the crews performing the boat checks.

3.13 The actions of the skipper in putting the bow of *UDC Rescue* to wind and sea and assessing his options, was appropriate. The subsequent actions of the skipper, crew and assisting vessels was well thought out and prevented injury or further damage to the vessel.

3.14 The loss of the starboard side of the bags was unfortunate, but would not have further compromised the safety of the craft, as *UDC Rescue* was capable of floating in a stable condition without its pontoons.

4. Safety Actions

4.1 The Operations Support Officer for the Royal New Zealand Coastguard Federation conducted an internal inquiry into the incident. His recommendations from the enquiry were as follows:

4.1.1 Owners of Naiad rigid hulled inflatable vessels should ensure that every three months the outer bag securing tab bolt is removed and the bolt and hole inspected for corrosion. A suitable anti-corrosion paste should be applied before re-assembly.

4.1.2 Because of the ongoing development of newer fabric materials available for inflatable craft outer bags, and given the conditions they may have to work in, it would be prudent to ensure that Naiad dedicated rescue vessel outer bags are replaced with new bags at least every five years.

4.2 The Commission endorses the implementation of the above recommendations; however, because of the new technology and design improvement, there may not be a need to replace the bags every five years, but rather have them inspected by the manufacturer after five years (or before if the operator has any doubts as to their serviceability), and depending on this inspection, the life of the bags may be extended for a further agreed period. The re-inspection procedure could be repeated until such time as an informed decision is made to terminate the life of the bags.

4.3 As a result of the incident, the Wellington Volunteer Coastguard completed a major review of their policy, procedure and instruction manuals, and several changes were made to improve certain aspects of their operation.

4.4 A more structured three-level approach to maintenance has been adopted whereby it is stated at what level each item of repair and maintenance falls, and who is authorised to carry out items at each level. All repair and maintenance is now being recorded in a common log book.

4.5 The check list for *UDC Rescue* has been modified to improve clarity and usability. The boat check is usually made by the newer crew members under the guidance of one with more experience. This procedure is adopted to make new recruits familiar with all aspects of the craft. Skippers have been reminded that by signing the boat check sheet they are acknowledging that the checks have been made and the boat is "fit for purpose". The skippers themselves should at least make a brief walk-around to ensure that is the case.

4.6 *UDC Rescue* is to be fitted with a new set of bags constructed from the new stronger fabric, with all welded seams and a continuous boltrope. The front securing tongue is to be supplemented by a retrofitted securing arrangement which Naiad have offered to owners of existing Naiad craft.

4.7 Before the *UDC Rescue* incident occurred, Naiad craft were being constructed with a different bow arrangement which allowed a neater fit of the bags where the bowsprit used to be, thereby reducing the likelihood of water invading the bags.

4.8 The MSA produced a letter headed "Advice to owners/operators of rigid inflatable boats". The letter was sent out to all known owners/operators of Naiad boats over 6.8 m in length. Each letter was accompanied by the Marine Notice previously issued following the whale watch accident. The MSA Marine Notice and letter have been reproduced in Annex A to this report. It should be emphasised that although the letter was sent to Naiad owners/operators only, much of the content applies equally to other types of rigid inflatable boats.

5. Safety Recommendations

5.1 In light of the safety actions, no safety recommendations were deemed necessary.

18 February 1998

Hon. W P Jeffries
Chief Commissioner

Annex A

MSA letter

Advice to Owners/Operators of Rigid Inflatable Boats

In the past eighteen months, two notable accidents, involving the use of rigid inflatable boats (RIBs) have occurred in New Zealand waters.

Investigations that were conducted by the Maritime Safety Authority (MSA) into the first of these accidents revealed, amongst other things, the importance of ensuring that the outer pontoon covers, including the tag at the bowsprit, should be critically inspected for signs of wear and damage at regular intervals. A Marine Notice, dated June 1997, a copy of which is attached hereto, sets out the lessons that were learned from this accident.

Investigations arising out of the second accident have underlined the importance of the owners/operators of RIBs ensuring, before each voyage, that *the bolt securing the tag to the bow is in place and secure*. In this accident, extensive corrosion was found to the area of the bowsprit of the aluminium alloy hull, due to galvanic coupling between the hull and the bolt and brass eyelet used to secure the tag to the bowsprit. This reduced the load bearing capacity of the fastening (i.e. the bolt, tag and bolt hole), putting additional strain on the outer pontoon cover and resulting in its eventual failure.

In view of the above, the MSA recommends that at intervals of approximately every three months, the owners/operators of RIBs should remove the bolt and critically inspect both the bolt hole and surrounding area for signs of corrosion. Owners/operators are instructed to note that copper containing alloys, such as brass or bronze, are the worst materials to place in contact with aluminium alloys, causing severe galvanic corrosion of the aluminium based material. Steel or stainless steel bolts are likely to accelerate corrosion of the aluminium alloy whilst themselves being protected from corrosion due to the galvanic coupling. In an attempt to retard the rate of corrosion, owners/operators are recommended to use an anti corrosion paste or gel. Finally. Owners /operators are particularly instructed to note that self tapping bolts must never be used to secure the tag.

Where owners/operators are unsure about the integrity of the outer pontoon covers and/or their attachment to the rigid hull, they are strongly recommended to contact the manufacturers for advice.

MSA Marine Notice Boats 10/June/1997

Rigid Inflatable Craft

The owners and operators of Naiad or other rigid inflatable craft are alerted to a number of structural and operational factors which are special relevance to the safe operation of such type of craft. It is MSA's belief that the failure to take all such factors into account contributed to the accident with the whale watch passenger vessel "*Uruao*" in March 1996.

1) A competent person should inspect and approve all pontoon cover repairs before their re-use. All damage should be documented in a register maintained and regularly monitored by the owner/management as appropriate.

2) Pre-voyage safety procedures should be put in place to include a check that the bolt securing the tag (where fitted) on the pontoon to the hull forward, is in place and secure.

3) The master should ensure that the bolt securing the tag is in place and secure before any voyage.

4) The company employing approved surveyors who undertake the survey of Naiad craft should issue appropriate instructions to their surveyors which take into account the special features of rigid inflatables which set then apart from the conventional hulls and require special inspection.

5) Surveyors should treat the pontoon as an integral part of the hull and note that its condition and means of attachment to the hull require particular attention.

6) The manufacturer should issue documented instructions to all existing and every new owner of this type of craft relating to the care, repair, attachment and maintenance of the pontoons.

7) The manufacturers and operators of these craft should note the importance of subdivision of inflatable compartment areas such that:

- if one compartment is lost or damaged, others will remain intact offering essential buoyancy
- any boltropes should have breaks or strengthening patches at intervals along their length to arrest any prospect of rips
- tags, where fitted, should be secured and documented on a check list as having been inspected and found satisfactory prior to each trip commencing
- the pontoon cover should be critically inspected by the master for wear and tear damage and documented on a check list as having been inspected and found satisfactory prior to each trip commencing.

8) Masters who operate rigid inflatable craft risk endangering the connection between the rigid hull and its inflatable pontoons if they regularly drive them into large waves at high speeds.

This notice applies to all Naiad or other inflatable craft and supplements the advice previously given on an individual basis to owners of 12.6m Naiads following the above accident

Glossary of marine abbreviations and terms

aft	rear of the vessel
beam	width of a vessel
bilge	space for the collection of surplus liquid
bridge	structure from where a vessel is navigated and directed
bulkhead	nautical term for wall
cable	0.1 of a nautical mile
chart datum	zero height referred to on a marine chart
command	take over-all responsibility for the vessel
conduct	in control of the vessel
conning	another term for "has conduct" or "in control"
deckhead	nautical term for ceiling
dog	cleat or device for securing water-tight openings
draught	depth of the vessel in the water
EPIRB	emergency position indicating radio beacon
even keel	draught forward equals the draught aft
freeboard	distance from the waterline to the deck edge
free surface	effect where liquids are free to flow within its compartment
focsle	forecastle (raised structure on the bow of a vessel)
GM	metacentric height (measure of a vessel's statical stability)
GoM	fluid metacentric height (taking account the effect of free surface)
GPS	global positioning system
heel	angle of tilt caused by external forces
hove-to	when a vessel is slowed or stopped and lying at an angle to the sea which affords the safest and most comfortable ride
Hz	hertz (cycles)
IMO	International Maritime Organisation
ISO	International Standards Organisation
kW	kilowatt
list	angle of tilt caused by internal distribution of weights
m	metres
MSA	Maritime Safety Authority
NRCC	National Rescue Co-ordination Centre
point	measure of direction (one point = 11¼ degrees of arc)
press	force a tank to overflow by using a pump

SAR	Search and rescue
SOLAS	Safety Of Life At Sea convention
sounding	measure of the depth of a liquid
SSB	single-side-band radio
statical stability	measure of a vessel's stability in still water
supernumerary	non-fare-paying passenger
telegraph	device used to relay engine commands from bridge to engine room
ullage	distance from the top of a tank to the surface of the liquid in the tank
VHF	very high frequency
windlass	winch used to raise a vessels anchor